A Survey of PreventiveMaintenance Practicesin Malaysian SMEs Manufacturing Organizations

HALIM MAD LAZIM,
Universiti Utara Malaysia
mlhalim@uum.edu.my

CHE AZLAN TAIB
Universiti Utara Malaysia
c.azlan@uum.edu.my

HENDRIK LAMSALI
Universiti Utara Malaysia
hendrik@uum.edu.my

MOHAMED NAJIB SALLEH
Universiti Utara Malaysia
najib@uum.edu.my

CHANDRAKANTAN SUBRAMANIAM
Universiti Utara Malaysia
chandrakantan@uum.edu.my

ABSTRACT

Maintenance of machines has become critical aspect in the manufacturing environment. The new technology leads to lesser maintenance works which can improve daily operations and production. Maintenance programs must be given a priority in order to prevent unscheduled production stoppages. Preventive maintenance can help to avoid any potential stoppages and disruptions of equipment from occurring in their daily operations. Preventive maintenance (PM), utilises total employee involvement in the maintenance activities. Operators and all employees should be actively involved in a maintenance programme to avoid any disruptions, breakdowns, stoppages and failures. Thus, the involvement in maintenance programs can help to improve manufacturing performance. In the highly competitive manufacturing industries, the ability and reliability of equipment that well-maintained is very important in order to achieve desired performance. Some studies argue that further research is required in the area of maintenance and operations management. This study investigates the extent of PM practices in the Malaysian Small and Medium Enterprises manufacturing organizations and the relationship between PM practices and performance. The hypotheses were analysed using Smart PLS and some important findings were discussed. The results imply that PM practices significantly improved manufacturing performance. For instance, PM strategy was positively and significantly related to financial, innovation and organizational capabilities. Few insignificant findings found, i.e. planned maintenance is insignificant with financial and organizational capabilities.

Key Words: Preventive, Maintenance, SMEs, Performance, Manufacturing

Satu Kajian Amalan Penyelenggaraan Pencegahan di Organisasi Pembuatan PKS Malaysia

ABSTRAK

Penyelenggaraan mesin telah menjadi aspek kritikal dalam persekitaran pembuatan. Teknologi baru membawa kepada kerja-kerja penyelenggaraan yang lebih rendah yang dapat meningkatkan operasi dan pengeluaran harian. Program penyelenggaraan mesti diberikan keutamaan untuk mengelakkan penghentian pengeluaran yang tidak berjadual. Penyelenggaraan pencegahan boleh membantu mengelakkan sebarang halangan dan gangguan peralatan yang mungkin berlaku dalam operasi harian mereka. Penyelenggaraan pencegahan (PM), menggunakan jumlah penglibatan pekerja dalam aktiviti penyelenggaraan. Pengendali dan semua pekerja harus terlibat secara aktif dalam program penyelenggaraan untuk mengelakkan sebarang gangguan, kerosakan, stoppages dan kegagalan. Oleh itu, penglibatan dalam program penyelenggaraan dapat membantu meningkatkan prestasi pembuatan. Dalam industri perkilangan yang sangat berdaya saing, keupayaan dan kebolehpercayaan peralatan yang terpelihara dengan baik adalah sangat penting untuk mencapai prestasi yang diinginkan. Sesetengah kajian berpendapat bahawa penyelidikan lanjut diperlukan dalam bidang pengurusan penyelenggaraan dan operasi. Kajian ini menyiasat tahap amalan PM dalam organisasi perkilangan Perusahaan Kecil dan Sederhana Malaysia dan hubungan antara amalan dan prestasi PM. Hipotesis dianalisis menggunakan Smart PLS dan beberapa penemuan penting dibincangkan. Hasilnya menunjukkan bahawa PM mengamalkan prestasi perkilangan yang lebih baik. Sebagai contoh, strategi PM secara positif dan signifikan berkaitan dengan keupayaan kewangan, inovasi dan organisasi. Beberapa penemuan tidak penting yang ditemui, iaitu penyelenggaraan yang dirancang tidak penting dengan keupayaan kewangan dan organisasi.

Kata Kunci: Pencegahan, Penyelenggaraan, PKS, Prestasi, Pembuatan

INTRODUCTION

Malaysian government has identified Malaysian manufacturing sector has great potential, thus in its Vision 2050 blue print the Malaysian government was allocate more incentive to boost the manufacturing performance for up-scaling (Ahmad and Ahmad, 2015 and Aun, 2017). The manufacturing organizations are looking forward to produce products that can be delivered to the customers timely. On other hand manufacturing organizations always ensure their products must be in good quality and meet all the requirements set by the customers. In adding,Wang, (2002) and Sloan, (2008) has state that the goal of every organization is to deliver goods or deliver services through efficiency of the production or service delivery process. This because if the manufacturing organization was using an expensive asset such as machine or any equipment that used to produce goods or service and those machine was break down due to unsuspected it can significantly slow down production or increase the number of defective products (Sloan, 2013). Machines and equipment used in the production floor must be in good condition thus eliminate the possibility of unnecessary stoppages and affect the quality of products produced. In order to avoid such incidents, therefore proper maintenance strategy must be adopted. Preventive maintenance is one of the strategy that can be very useful for manufacturing organizations in order to ensure all machines and equipment are working to their best condition (Nahas, 2017). Preventive maintenance is one of the widespread maintenance activities that have been apply by many industries. These maintenance has been identified as “activities that conducted on predetermined intervals or based on stipulated conditions that intended to diminish or prevent the chances of failure or the degradation of the functioning of an inventories” (Chen, 2013). Basically, the preventive maintenance concepts involve the activity to extend the performance of maintenance activities toward the prior situation that will thwart the breakdown of equipment (Barone, and Frangopol 2014). On other hand Kobbacy and Murthy (2008) express the key target of maintenance as "optimization of total asset life cycle of the machine or engine which maximizing the stability and durability of the resources and equipment to produce the desired level of products, with the mandatory quality and specifications, in a timely manner”. Manufacturing organizations must work systematically to avoid any disruptions in the productions lines thus unable them to fulfill customers’ demand. The advancement of new technology and globalization affect manufacturing organizations in ensuring smooth daily operations. The pressure to ensure equipment operates without breakdowns, stoppages, failures and so forth has become a major concern for maintenance staff in the manufacturing organizations (Carannante, Haigh and Morris, 1996). Breakdowns of equipment can be considered to be a precarious maintenance issue than can hinder smooth daily operations. The environment of maintenance work has changed significantly in recent years, especially in manufacturing companies where more maintenance tasks have been given to operators especially basic daily cleaning, checking and lubricating (Panayides, Andreou and Louca, 2015). Waeyenbergh and Pintelon (2007) highlighted that maintenance has now become a strategic tool to increase competitiveness rather than simply an overhead expense that must be controlled. Moreover, maintenance spending constitutes a large part of the operating budget of companies with large investments in equipment(Salonen and Deleryd, 2011).Nourelfath and Châtelet, (2012) has stated that the preventive maintenance is an tactical production planning approach that employed to handle product integration and also could be use for the use of parallel system integrated with dependent components. In adding Yu-Lan et al.,(2009) has stated that the preventive maintenance is an efficient solution to the optimal production and maximize the organization profit under certain demand. In a study did by Lo and Yu,(2013) and Kim, Lim and Park, (2015) found that the preventive maintenance activity was successfully minimize the total operating cost of organization and also upgrade and optimize the second-hand machine trough periodic inspection/upgrades and the optimal improvement that constantly maximize the profit of the Manufacturing organization. Generally there are two types of maintenance it was corrective and preventive maintenance (Stenström, Norrbin, Parida and Kumar, 2016). The weakness of corrective maintenance it’s don’t have explicit decision on when to schedule next maintenance and this maintenance activity only carried out after machine failure and this strategy was basically ignoring the possibility of machine breakdowns (Basten and Van Houtum, 2014).

LITERATURE REVIEW

Performance is a measuring tool that helps us to understand what are the current status about our products, services, and the processes that help us to take an necessary action and intelligent decisions on understand, manage, and improve in the organizations (Nelson and Cooprider, 1996; Bial, 2004). On other hand, Cua, McKone, and Schroeder (2001) and Pont, Furlan, and Vinelli (2008) have confirmed that the performance has the capable to measure both financial and non-financial improvement in lean environment. Withidyothin (2014) identifies whether the performance of a machine affects production capacity, at the final outcome he declare that firm's has a same production capacity with the existing machine which is an important part of a supply chain network.

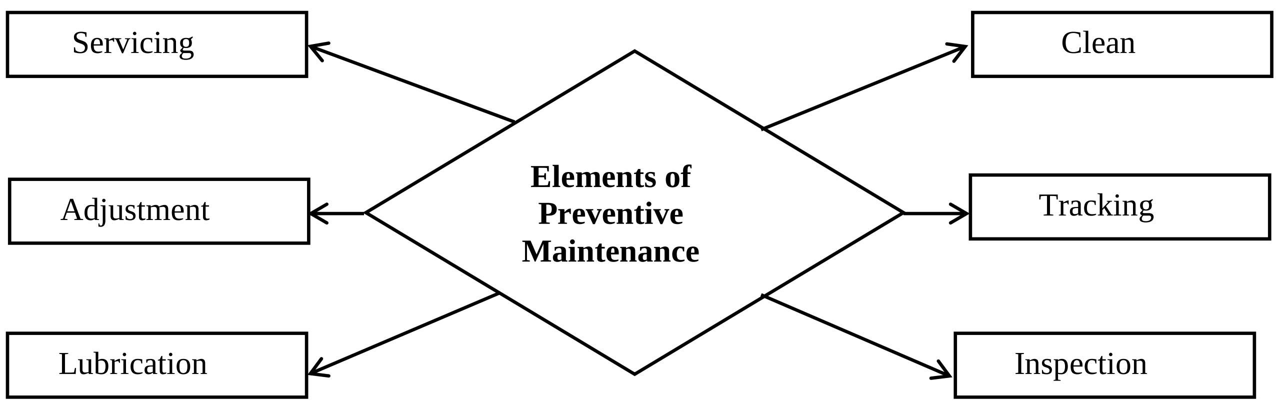
After review of various study the researchers found that most scholars and companies are use the performance to measure on costs, quality, quantity, cycle time, efficiency, productivity of products, services, and processes as long as ways to measure those things have existed. To address this matter Goold and Quinn (1990) argued that performance help to evaluate the effectiveness on the speed of change and the measurability of performance. In addition, Camp (2013) and Schechner (2013)state that performance is a process of measurements for a specific process of stimulate ideas and reinforce the notion.

Moss, Alho, and Alexander (2007) stated that performance measurement was used to quantify the efficiency and effectiveness in order to improve the productivity. On other hand, Neely (1999) classified performance measurement into four it was cost, time, flexibility and quality. However there were only two indicators that mainly used in make decision it was cost and non-cost. The cost was purposely used to measures strategic decision meanwhile non-cost was measures vital effect of day-to-day operation. However Tangen (2003) stated that cost measures are the most popular measurement which used to indicate business performance.

Preventive maintenance (PM) is a regular and systematic inspection, cleaning, and replacement of worn parts, materials, and systems. Preventive maintenance helps to prevent failure of parts, materials, and systems by ensuring that they are in good working order. A preventive maintenance plan is developed based on the needs of the equipment. In PM, the system which is highly likely to exhibit a demobilising fault is replaced before that failure is allowed to occur. The most common forms of this policy are scheduled PM and condition-based maintenance (CBM) (Eti, Ogaji and Probert, 2006). In scheduled PM policy, some components may be over maintained that is replaced prematurely. Thus, if the condition of the item can be monitored continuously or even frequently, PM actions will be implemented only when failure is judged to be forthcoming. Performance-parameter analysis, vibration monitoring, thermography, oil analysis or ferrography are some condition-monitoring techniques that are involved in CBM.

Qualified and well-trained machine operators and maintenance technicians are the driving force behind any effective maintenance measurement system. Mostly, preventive maintenance tasks are handled directly by operators instead of the on-site maintenance technical staff. Thus, flexible, co-operative and a shared responsibility approach among production and maintenance personnel is required to promote operator ownership and free up maintenance personnel to perform more technically challenging maintenance works (Yam et. al, 2000). The human factor represented by maintenance technicians and other related staff is the backbone of the maintenance system in any organization. The effectiveness of the different facets of the performance system is very much dependent on the competency, training, and motivation of the overall human factor in charge of the maintenance system (Ljungberg, 1998). In this context, factors such as, years of relevant work experience on a specific machine, personal disposition, operator reliability, work environment, motivational management, training and continuing education, are all relevant factors which tend to impact the effectiveness of the performance of the maintenance system (Cabahug, et al., 2004). The close cooperation and coordination between the maintenance technicians and machine operators is very critical, as it influences service quality and, in turn, the extent of satisfaction with the rendered services. In this context, repeated visits to repair equipment for the same problem result in operator dissatisfaction (Ardalan et al., 1992). The attitude, conduct and personality of maintenance personnel are critical to the effectiveness of the maintenance effort (Goh, and Tay 1995; and García Arca, and Carlos Prado Prado 2008). Preventive maintenance, therefore, is a very important ongoing accident prevention activity, which should be integrate into the operations/ product manufacturing process. Furthermore, to be competitive on both a national and a global basis, organizations must adopt a forward-thinking approach in developing their preventive maintenance management strategies. Maintenance strategy will help an organization to better control its processes and also provide a guidance how the quality of the end product. Applying superiority maintenance strategies will not only support and sustain quality and productivity, but also become a drive for continuously improving the effectiveness of organization operation. According to Fredriksson, and Larsson (2012), maintenance strategy is “the management method used in order to achieve the maintenance objectives”. Bergman and Klefsjö (2010) assert the content in the maintenance strategy is a mix of techniques and/or policies which depends on factors such as the nature of the plant, the maintenance goals or the equipment that will be maintained, the work environment and the work flow patterns. Rastegari and Salonen (2013) highlight that “the strategy reflects the organizations conception of its intended long – term goal and the approach to achieve it”. Maintenance strategies are a means of transforming business priorities into maintenance priorities (Salonen, 2011). Planned maintenance has two loops: Planning, scheduling, Execution and Follow up make up the first loop while second loop consists of work identification and performance analysis elements (Muchiri et al. 2011). Planned maintenance process is measured by schedule compliance i.e. the percentage of work orders completed during the scheduled period before the late finish or required by date. World class maintenance should achieve more than 90% during execution (Kumar et. al, 2013).).The aim of the planned maintenance is to allow equipment operators and maintenance engineers to analyse the cause of equipment failures and develop a planned maintenance system to repair or modify the equipment to improve maintainability and planned maintenance typically involves the work conducted by skilled maintenance engineers, but the aim is to transfer the tasks to the equipment (Baglee and Knowles 2010). There are various concepts associated with effectiveness of maintenance activities has been developed, but the two common concepts discussed in literature as, Reliability Centered Maintenance (RCM) and Total Productive Maintenance (TPM) (Rastegari and Salonen, 2013). TPM was established to maximize equipment effectiveness or improving overall efficiency through a comprehensive productive- maintenance system covering the entire life of the equipment, spanning all equipment related fields and the participation of all employees from all levels, to promote productive maintenance through motivation management or voluntary small- group activities (Al-Turki, 2011). Meanwhile Reliability Centred Maintenance is the process of determining the most effective maintenance approach. It is developed toensure that systems continue to do what their users require in their present operating context and generally used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance.Successful implementation of RCM will lead to increase in cost effectiveness, reliability, machine uptime, and a greater understanding of the level of risk that the organization is managing. Takada et al., (2017) suggest the error prediction system that enable employees to operate preventive maintenance function on a real time basis. Maintenance in its narrow meaning includes all activities related to maintaining a certain level of availability and reliability of the system and its components and its ability to perform to a standard level of quality. It includes activities related to maintaining spare part inventory, human resources and risk management (Al-Turki, 2011).

Figure 1: Elements of Preventive Maintenance (Dhillon, 2002).



Based on Figure 1 we can see that there is six elements in preventive maintenance was indicating that these was lead to the Preventive maintenance applications that vary in the practical execution. However the practical execution of the elements heavily depended on importance and types of the machine. Principally, the frequent scheduling of machine maintenance is essential to the production process and economically sensible (Mobley, 2002). The years of a component corresponded with total up-time. The decisions to identify the optimal policies are suitable for a component with severe of failure modes, where the failures will incur huge losses and the unit replacement required at each failure situations (Nakagawa, 2006; Mobley 2002). The unnecessary repairing tasks can be diminish or eliminate, the serious machine failures can be inhibited and the negative impacts towards maintenance operation also could be reduced (Mobley, 2002).Preventive maintenance is one of the feasible technique to prevent the defects and faults due to the expenses spent on preventive maintenance are lower than the faults and defects costs has to borne by the organization. Scholar have been debated on the right figure percentage from total maintenance task should be bound by preventive maintenance. Many authors possess heterogeneous opinions and suggestions on the topic, but there are general agreements among them that opined that preventive maintenance should form a major fraction from overall maintenance tasks.

METHODOLOGY

This study employed a cross-sectional approach in order to examine the relationship of PM practices and performance among SMEs in Malaysia. The sampling technique utilized for the present study is simple random sampling. A total of more than 250 self-administered questionnaires were distributed through enumerators to respondents who were managers of quality, operations, plants, engineering and those who were familiar with PM in the SMEs. This study was conducted in a non-contrived setting following Sekaran and Bougie (2016), who stated that: 'correlational studies are always conducted in the non-contrived setting' (p.204). As an effort to increase the response rate the study increased its amount of questionnaire sent and personal telephone calls were made to the respective respondents to participate in this study by the enumerators. The research team also sent out reminder notes to the respondents reminding them to participate in the present study. Some field trips were made and notes were taken based on observations to strengthen the discussion of the results obtained. This helps to explain certain phenomenon better and ascertain the findings. The quantitative based study very much depends on the representativeness of the samples therefore sampling was done with caution. The population of this study was drawn from the manufacturing companies registered under the Federation of Malaysian Manufacturers' (FMM) Directory 2014. The sampling procedure for this research is based on the sampling frame of manufacturing companies in the (FMM Directory, 2014) directory and the number of SMEs were decided using the total of permanent staff in that particular organization. For instance, Small Medium Corporation (2014) has given definition of SMEs in manufacturing sector, sales turnover not exceeding RM50 million or full-time employees not exceeding 200 workers. The respondents of this study were maintenance, productions, operations and quality managers as well as persons who were able to provide answers to questions on PM related practices and performance. Brah and Chong (2004) state that operations and quality management managers are the most appropriate individuals to provide maintenance related information, especially PM or total productive maintenance.

FINDINGS

There were 142 of questionnaires returned for analysis out of the 250 questionnaires being distributed which resulted in 56.8% response rate. Out of the 142 retrieved questionnaires, nineteen were not usable due to poorly fill and did not have adequate data suitable for further processing. According to Bryman and Bell (2007); and Fowler et al., (2002) these questionnaires can be discarded. The final 123 responses were used for further analysis which resulted in 49.2% response rate for final analysis. This rate is considered adequate because it agrees with some underlying assumptions for data analysis. Firstly, the total number of usable questionnaire agrees with Bartlett et al., (2001) suggestion that for a regression type analysis, the sample size should fall between five and ten times the number of independent variables. Secondly, for the Partial Least Squares (PLS) program that is to be used for the main analysis, Chin and Newsted (1999) suggested a minimal number of between 30 and 100 cases. Therefore, this sample size is good for further analysis. TABLE 1 illustrates the response rate of the study.

Table 1: Response Rate of the Study

Description of Samples	Number	Percentage
	Size of Companies	
Small	15	12.20
Medium	108	87.80
	Types of Industries	
Electrical and Electronics	20	16.26
Automotive	96	78.05
Rubber based and Plastics	7	5.69
	Years of Operations	
Below 10 years	101	82.1
More than 10 years	22	17.9
	Type of Companies	
Local Owned	68	55.28
Joint Venture	55	44.72

Based on table 1 above we can see summary of descriptive statistic of respondent. There are total 123 usable questionnaire was identified. From this response rate majority of the respondent was from medium size company which total 108 (87.80%) company meanwhile only 15 small size company was participate in this study. On other hand when refer to type of industry the automotive industry was major participator in this survey which 78.05% form total response rate and followed by Electrical and Electronics industry which total 20 company and Rubber based and Plastics 7 company. However when refer to years of operation the researcher found that 82.1% company has less than 10 years of operation experience in this country. Despite only 17.9% or 22 company has stated they operate more than 10 years. In addition summary of type of companies was indicating that half of the respondent was locally owned which was 55.28% or total 68 company and only 55 company form total response rate was identified as Joint Venture Company.

Table 2: The Response Rate

Status	Number of Questionnaires	Response Rate
Distributed	250	100.00%
Returned	142	56.8%
Usable	123	49.2%

The process of data screening and cleaning/treatment is required and involves checking for errors in the data collected (Pallant, 2007). These errors take the form of missing data or out of range data (values that fall outside the range of possible values for a scale). It was therefore important for the researcher to check on these and handle them accordingly. According to Ma and Zhong (2016) it is recommended to handle missing values with imputation by replacing missing values using the remaining values of the data. To obtain accurate model specifications, the mean can be used for the imputation (Sekaran, and Bougie 2016). Using the mean to replace missing values also leads to more reliable results than casewise deletion (Parwoll and Wagner, 2012).). Based on this recommendation, a few cases of missing values which were identified were replaced accordingly using the mean values of the items. This was done as the number of missing values did not pose any statistical threat to the analysis phase of this study. In addition to the above treatment, tests on normality was not done because the PLS is a distribution-free approach. It also uses the usual maximum likelihood estimation method, which assumes multivariate normality (Lohmöller, 1989). Since the PLS factors are orthogonal, the issue of multicollinearity is not a problem. Factorial validity is another important in the context of establishing the validity of latent constructs (Gefen and Straub 2005). According to Anderson and Gerbing (1988), two elements of factorial validity can and must be measured when using PLS for data analysis. These two elements are convergent validity and discriminant validity, which Straub et al., (2004) described as components of a larger scientific measurement concept known as construct validity. Construct validity affirms to how well the results gotten from the use of the measure fit the theories around which the test is designed (Sekaran, and Bougie (2016). The issue to be addressed here is if the instrument explains or has a strong connection with the concepts as theorized. The researchers examined the factor loadings and cross loadings in TABLE 3 to ascertain if there are problems with any particular items. A cut off value of 0.5 (being significant) as suggested by (Hair et al., 2016) was used in this regard. In view of this, if any items which has a loading of higher than 0.5 on two or more factor, then they will be deemed to be having significant cross loadings. Therefore, based on TABLE 3, it is concluded that construct validity is confirmed. The next analysis done by the researchers was to test the convergent validity.

Table 3: Construct Validity

Construct	Item	Loadings/ Weight	AVE[a]	CR[b]
Financial	FINANCIAL1	0.827	0.736	0.893
	FINANCIAL3	0.856		
	FINANCIAL5	0.890		
Innovation	INNO3	0.746	0.674	0.861
	INNO4	0.886		
	INNO6	0.825		
OC	OC1	0.892	0.732	0.891
	OC3	0.828		
	OC4	0.846		
Planned Maintenance	PLANNEDMAINTENANCE1	0.834	0.683	0.895
	PLANNEDMAINTENANCE2	0.901		
	PLANNEDMAINTENANCE3	0.848		
	PLANNEDMAINTENANCE7	0.711		
PM Strategy	PMSTRATEGY10	0.865	0.792	0.884
	PMSTRATEGY9	0.914		
PM Team	PMTEAM2	0.766	0.663	0.908
	PMTEAM5	0.855		

PMTEAM6	0.795
PMTEAM7	0.751
PMTEAM9	0.896

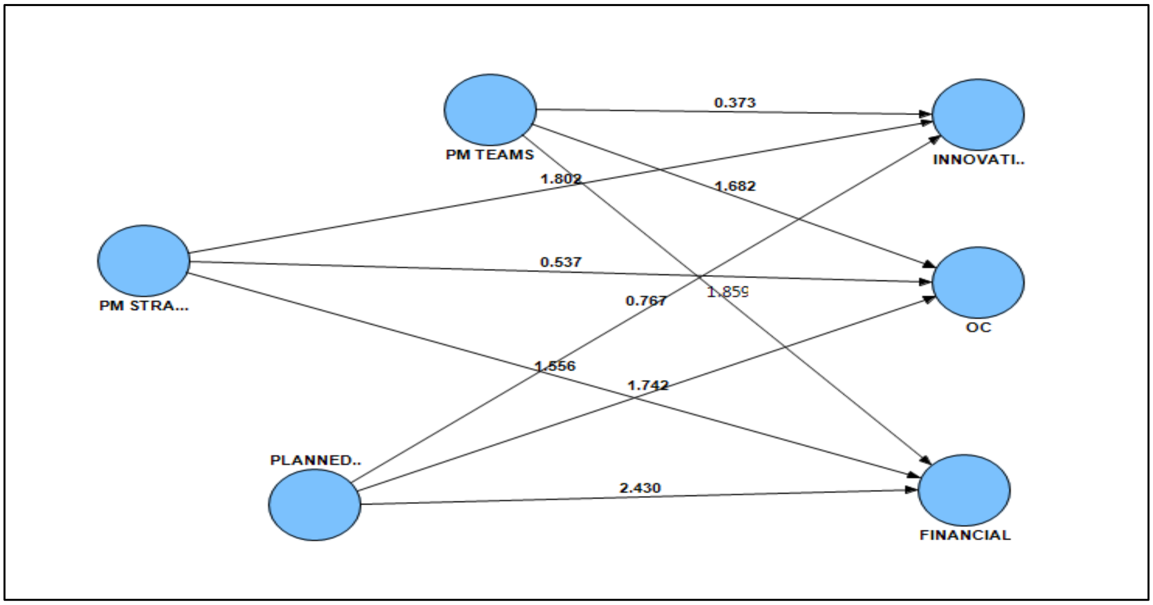
This is the degree to which multiple items measuring the same concept are in agreement. As suggested by (Hair et al. (2016), the factors loadings, composite reliability and average variance extracted was used to assess convergent validity. Based on the presentation in TABLE 2 and TABLE 4, the loadings converge very well and exceed the recommended 0.5 value as recommended by Hair et al., (2016). The composite reliability (CR) values in TABLE 2 which ranged from 0.861 to 0.908 exceeded the recommended value of 0.707 by Hair, et al. (1998) and Chin (1998).

Table 4: Convergent Validity

	FINANCIAL	INNOVATION	OC	PM	PM STRATEGY	PM TEAMS
FINANCIAL	**0.858**					
INNOVATION	-0.079	**0.821**				
OC	-0.056	-0.151	**0.856**			
PM	-0.207	-0.090	0.143	**0.826**		
PM STRATEGY	-0.139	0.182	0.054	-0.014	**0.890**	
PM TEAMS	0.162	-0.048	-0.145	0.054	-0.001	**0.815**

Hypothesis 1, 2 and 3 respectively postulated that there would be a relationship between planned maintenance to manufacturing performance namely financial, innovation and organizational capabilities. The results indicated that planned maintenance is related to both financial (β = -0.219, p > 0.01) and organizational capabilities (β = 0.152, p > 0.05) however planned maintenance is not related to innovation. Thus hypothesis 1 and 3 were supported while hypothesis 2 was rejected. On a similar vein hypothesis 4, 5 and 6 postulated that there would be a relationship between preventive maintenance strategy and manufacturing performance namely financial, innovation and organizational capabilities. The results also indicated that planned maintenance strategy is only related to innovation (β = 0.181, p > 0.05) and not related to financial and organizational capabilities. As such hypothesis 5 is supported while hypothesis 4 and 6 was rejected. While hypothesis 7, 8 and 9 postulated that preventive maintenance teams would be related to manufacturing performance namely financial, innovation and organizational capabilities. The result indicated that preventive maintenance team is related to both financial (β = 0.173, p > 0.05) and organizational capabilities (β = -0.153, p > 0.05) however planned maintenance team is not related to innovation. Thus hypothesis 7 and 8 was supported and hypothesis 9 was rejected.

Figure 2 : Structural Model



CONCLUSION

PM strategy focuses on overall equipment effectiveness, continuous improvement activities to prevent equipment deterioration, total employee participation, teamwork and small group philosophy (Nakajima, 1988) as well as safety and environmental issues (Eti, et al., 2004). The focus on PM strategy is an apparent benefit and has become the main importance among the participating manufacturing companies. It is essential to draw up a systematic and thorough strategic plan to ensure more opportunity for improvements. PM could essentially help to minimise the deterioration of equipment, hence improving performance as highlighted by various researchers, for instance (Ahmed et al., 2004; Ahmed, et al., 2005; Ahuja, and Khamba 2007; Ahuja and Khamba 2008; Seth and Tripathi 2005). Meanwhile, PM teams are led by a manufacturing manager and also include maintenance managers, workshop delegates, quality department delegates, manufacturing delegates, and technician or maintenance service delegates (Ferrari et al., 2002). The possibility of PM teams might not be efficient enough to contribute to innovation due to the PM team usage in the SMEs lack of substantial fund to ensure team effectiveness.

As noted by (Chan et al., 2005) based on their case study, work habits and communication especially for production lines and different shifts could affect the morale of PM team development. The possible assumptions to be drawn from this study are that the communication and leadership of PM team are not clearly perceived by those at operator level and other departments. The PM team has been perceived as unable to formulate actions that can effectively help to reduce costs, to increase quality, improve delivery reliability and improve human and equipment flexibility as well. An effective planned maintenance can also contribute to productivity improvements by the restoration of deteriorating equipment to maintain basic equipment condition, decrease minor stoppages and reduce set-up time (Nakajima, 1988; Ahuja, and Khamba, 2008;De Jonge, Teunter, et al. 2017). Planned maintenance is a formal programme that not only makes sure proper time-based maintenance and condition-based maintenance work properly but also that all employees will be well informed about quality and progress (Nakajima, 1988). Moreover, through planned maintenance all related scheduled maintenance works are designed accordingly in order to avoid breakdowns of equipment (Mattern, et al., 2016). The on-going awareness and education programmes about on-time delivery of products to customers must be planned and executed effectively. As a concluding remark, PM practices certainly very beneficial to improve performance of SMEs manufacturing organizations.

REFERENCES

Ahmad, R. (2017). Reliability analysis comparison on punching tool sets due to different maintenance decisions: a case study from the pulp manufacturing industry.*The International Journal of Advanced Manufacturing Technology*: 1-11.

Ahmad, Z. A. and Z. Ahmad. (2015). Malaysian mega science framework: the need for social impact and sustainability assessment. *SHS Web of Conferences, EDP Sciences*.

Ahmed, S., M. Hj. Hassan, et al. (2005). TPM can go beyond maintenance: excerpt from a case implementation.*Journal of Quality in Maintenance Engineering*, 11(1): 19-42.

Ahmed, S., M. Hj. Hassan, et al. (2004). State of implementation of TPM in SMIs: a survey study in Malaysia.*Journal of Quality in Maintenance Engineering*, 10(2): 93-106.

Ahuja, I. and J. Khamba. (2007). An evaluation of TPM implementation initiatives in an Indian manufacturing enterprise. *Journal of Quality in Maintenance Engineering*, 13(4): 338-352.

Ahuja, I. and J. Khamba. (2008). An evaluation of TPM initiatives in Indian industry for enhanced manufacturing performance.*International Journal of Quality & Reliability Management*, 25(2): 147-172.

Al-Turki, U. (2011). A framework for strategic planning in maintenance.*Journal of Quality in Maintenance Engineering*, 17(2): 150-162.

Anderson, J. C. and D. W. Gerbing. (1988). Structural equation modeling in practice: a review and recommended two-step approach. *Psychological bulletin*, 103(3): 411.

Ardalan, A., J. Hammesfahr, et al. (1992). Total quality control: the repair facility. *Industrial Management & Data Systems*, 92(8): 7-10.

Aun, L. H. (2017). Malaysia's transformasi nasional 2050 brings bold new style, but to what End?

Baglee, D. and M. Knowles. (2013). Maintenance strategy development in the UK food and drink industry.*International Journal of Strategic Engineering Asset Management*, 1 1(3): 289-300.

Barclay, D., C. Higgins, et al. (1995). The partial least squares (PLS) approach to casual modeling: personal computer adoption ans use as an illustration.

Barone, G. and D. M. Frangopol. (2014). Reliability, risk and lifetime distributions as performance indicators for life-cycle maintenance of deteriorating structures.*Reliability Engineering & System Safety*, 123: 21-37.

Bartlett, J., J. Kotrlik, et al. (2001). Exploring factors associated with research productivity of business faculty at national association of business teacher education. Published Report.

SMEs: the development of an integrated approach.*Control and Cybernetics*,39(1): 275-303.

Basten, R. & G. Van, H. (2014). System-oriented inventory models for spare parts.*Surveys in Operations Research and Management Science*, 19(1): 34-55.

Bergman, B. & B. Klefsjö. (2010). Quality from customer needs to customer satisfaction, studentlitteratur AB.

Bial, H. (2004). The performance studies reader, *Psychology Press*.

Bilmes, J., K. Asanovic, et al. (2014). Optimizing matrix multiply using PHiPAC: a portable, high-performance, ANSI C coding methodology. *ACM International Conference on Supercomputing 25th Anniversary Volume, ACM*.

Brah, S. A. & W. K. Chong. (2004). Relationship between total productive maintenance and performance. *International Journal of Production Research,* 42(12): 2383-2401.

Bryman, A. & E. Bell. (2007). Planning a Baglee, D. and M. Knowles (2010). Maintenance strategy development within research project and formulating research questions. *Business research methods*: 75-92.

Bullinger, H. J. & W. Menrad. (2002). Changes in remuneration practice in production: success factors of sustainable remuneration systems for innovative concepts of work organization.*International Journal of Production Research,* 40(15): 3955-3971.

Cabahug, R. R., D. J. Edwards, et al. (2004). Classifying plant operator maintenance proficiency: examining personal variables. *Building Research & Information,* 32(2): 119-127.

Camp, R. C. (1989). Benchmarking: the search for industry best practices that lead to superior performance. *ASQC/Quality Resources*.

Camp, R. C. (2013). Benchmarking: the search for industry best practices that lead to superior performance, Milwaukee, Wis.: *Quality Press; Quality Resources*, 1989.

Carannante, T., R. Haigh, et al. (1996). Implementing total productive maintenance: a comparative study of the UK and Japanese foundry industries.*Total Quality Management,* 7(6): 605-612.

Carlson, M.(2013). Performance: A critical Introduction Routledge.

Chin, W. W. and P. R. Newsted. (1999). Structural equation modeling analysis with small samples using partial least squares. *Statistical strategies for small sample research,* 1(1): 307-341.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling.*Modern methods for business research,* 295(2): 295-336.

Chan, F., H. Lau, et al. (2005). Implementation of total productive maintenance: a case study. *International Journal of Production Economics*, 95(1): 71-94.

Chen, Y.C. (2013). An optimal production and inspection strategy with preventive maintenance error and rework.*Journal of Manufacturing Systems* 32(1): 99-106.

Compeau, D., C. A. Higgins, et al. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study.*MIS quarterly*: 145-158.

Cua, K. O., K. E. McKone, et al. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance.*Journal of Operations Management,* 19(6): 675-694.

Dal Pont, G., A. Furlan, et al. (2008). Interrelationships among lean bundles and their effects on operational performance. *Operations Management Research* 1(2): 150-158.

De Jonge, B., R. Teunter, et al. (2017). The influence of practical factors on the benefits of condition-based maintenance over time-based maintenance.*Reliability Engineering & System Safety*,158: 21-30.

Dhillon, B. S. (2002). Engineering maintenance: a modern approach.*CRC Press*.

Eti, M. C., S. Ogaji, et al. (2006). Development and implementation of preventive-maintenance practices in Nigerian industries.*Applied Energy*, 83(10): 1163-1179.

Eti, M. C., S. Ogaji, et al. (2004). Implementing total productive maintenance in Nigerian manufacturing industries. *Applied Energy*, 79(4): 385-401.

Fredriksson, G. and H. Larsson (2012). An analysis of maintenance strategies and development of a model for strategy formulation-a case study. Göteborg: Chalmers University of Technology.

Ferrari, E., A. Pareschi, et al. (2002). TPM: situation and procedure for a soft introduction in Italian factories. *The TQM magazine*, 14(6): 350-358.

FMM Directory. (2014):Malaysian industries-supplying the world with competitive products and services. Kuala Lumpur: federation of Malaysian manufacturers.

Fornell, C.& D. F. Larcker. (1981). Evaluating structural equation models with unobservable variables and measurement error.*Journal of Marketing Research*: 39-50.

Fowler, Jr., F. J., P. M. Gallagher, et al. (2002). Using telephone interviews to reduce nonresponse bias to mail surveys of health plan members. *Medical care*, 40(3): 190-200.

García, A. J. and J. Carlos Prado Prado. (2008). Personnel participation as a key factor for success in maintenance program implementation: a case study.*International Journal of Productivity and Performance Management* 57(3): 247-258.

Garg, A. & S. Deshmukh. (2006). Maintenance management: literature review and directions.*Journal of Quality in Maintenance Engineering*, 12(3): 205-238.

Gefen, D. & D. Straub. (2005). A practical guide to factorial validity using pls-graph: tutorial and annotated example.*Communications of the Association for Information systems*, 16(1): 5.

Ghazali, Z. (2017). Plant turnaround maintenance leading and plant turnaround maintenance performance in Malaysian process based industry: the mediating role of team alignment. *Global Business and Management Research*,9(1s): 8.

Goh, M. and G. H. Tay. (1995). Implementing a quality maintenance system in a military organization. *International Journal of Quality & Reliability Management*, 12(4): 26-39.

Goold, M. and J. J. Quinn. (1990). The paradox of strategic controls. *Strategic Management Journal*, 11(1): 43-57.

Gössinger, R., H. Helmke, et al. (2017). Condition-based release of maintenance jobs in a decentralised production-maintenance system–an analysis of alternative stochastic approaches. *International Journal of Production Economics*, 193: 528-537.

Hair, Jr, J. F., G. T. M. Hult, et al. (2016). A primer on partial least squares structural equation modeling (pls-sem).*Sage Publications*.

Hair, J. F., W. C. Black, et al. (1998). Multivariate data analysis, *Prentice Hall Upper Saddle River, NJ*.

Halinski, R. S. and L. S. Feldt. (1970). The selection of variables in multiple regression analysis. *Journal of Educational Measurement*, 7(3): 151-157.

Jenewein, W. and F. Morhart. (2008). Navigating toward team success. team performance management: *An International Journal*, 14(1/2): 102-108.

Kang, H. R., H. D. Yang, et al. (2006). Factors in team effectiveness: cognitive and demographic similarities of software development team membershuman relations 59(12): 1681-1710.

Kumar, J., V. Soni, et al. (2013). Maintenance performance metrics for manufacturing industry. *Int J Res Eng Technol*, 2(2): 136-142.

Kumar, U., D. Galar, et al. (2013). Maintenance performance metrics: a state-of-the-art review.*Journal of Quality in Maintenance Engineering*, 19(3): 233-277.

Ketokivi, M. A.&Schroeder, R.G. (2004). Manufacturing practices, strategic fit and performance a routine-based view. *International Journal of Operations and Production Management*, 24(2), 171−191.

Kim, D. K., J. H. Lim, et al. (2015). Optimal maintenance level for second-hand product with periodic inspection schedule. *Applied Stochastic Models in Business and Industry*, 31(3): 349-359.

Kobbacy, K. A. H. & D. P. Murthy. (2008). Complex system maintenance handbook.*Springer Science & Business Media*.

La Fata, C. M. & G. Passannanti. (2017). A simulated annealing-based approach for the joint optimization of production/inventory and preventive maintenance policies. *The International Journal of Advanced Manufacturing Technology*: 1-11.

Liyanage, J. P. (2007). Operations and maintenance performance in production and manufacturing assets: the sustainability perspective. *Journal of Manufacturing Technology Management*, 18(3): 304-314.

Ljungberg, Õ. (1998). Measurement of overall equipment effectiveness as a basis for TPM activities. *International Journal of Operations & Production Management*, 18(5): 495-507.

Lohmöller, J. B. (1989). Predictive vs. structural modeling: PLS vs. ML. latent variable path modeling with partial least squares.*Springer*: 199-226.

Lo, H. C. & R. Y. Yu. (2013). A study of quality management strategy for reused products. *Reliability Engineering & System Safety*, 119: 172-177.

Ma, X. & Q. Zhong. (2016). Missing value imputation method for disaster decision-making using k nearest neighbor. *Journal of Applied Statistics*, 43(4): 767-781.

Mattern, H., M. Scheffer, et al. (2016). Simulation-based analysis of maintenance strategies for mechanized tunneling projects. *World Tunnel Congress, 2016*.

Miller, D. E. & J. T. Kunce. (1973). Prediction and statistical overkill revisited. *Measurement and evaluation in guidance*, 6(3): 157-163.

Moubray, J. *Reliability-centred maintenance* (2nd Ed.).(1997) Oxford: Butterworth- Heinemann,

Mobley, R. K. (2002). An introduction to predictive maintenance, Butterworth-Heinemann.

Muyengwa, G. & Y. N. Marowa (2015). Analyzing adoption of maintenance strategies in manufacturing companies. *International Association for Management of Technology*: 25.

Naeem, H. & M. F. Azam. (2017). Leadership styles in the maintenance industry of UAE: afocus group analysis. *European Scientific Journal*, *ESJ* 13(7).

Nahas, N. (2017). Buffer allocation and preventive maintenance optimization in unreliable production lines. *Journal of Intelligent Manufacturing*, 28(1): 85-93.

Nakagawa, T. (2006). Maintenance theory of reliability, *Springer Science & Business Media*.

Nakajima, S. (1988). Introduction to TPM:Total productive maintenance (Translation).*Productivity Press, Inc.*, 1988: 129.

Nakajima, S. (1989). TPM development program: implementing total productive maintenance.*Productivity press*.

Neely, A. (1999). The performance measurement revolution: why now and what next? *International Journal of Operations & Production Management*, 19(2), 205−228.

Nelson, K. M. & J. G. Cooprider. (1996). The contribution of shared knowledge to IS group performance. *MIS quarterly*: 409-432.

Nourelfath, M.& Châtelet, E. (2012). Integrating production, inventory and maintenance planning for a parallel system with dependent components. *Reliability Engineering & System Safety*, 101, 59-66.

Pallant, J. F. (2007). SPSS survival manual: A step-by-step guide to data analysis with SPSS, *New York: McGraw-Hill.*

Panayides, P. M., Andreou, P. C., & Louca, C. (2015). The impact of vertical integration on inventory turnover and operating performance. *International Journal of Logistics Research and Applications.*

Parwoll, M. and R. Wagner. (2012). The impact of missing values on pls model fitting. challenges at the interface of data analysis, computer science, and optimization, *Springer*: 537-544.

Patankar, M. S. & J. C. Taylor. (2008). MRM training, evaluation, and safety management. *The International Journal of Aviation Psychology*, 18(1): 61-71.

Rankin, W., R. Hibit, et al. (2000). Development and evaluation of the maintenance error decision aid (MEDA) process. *International Journal of Industrial Ergonomics*, 26(2): 261-276.

Rastegari, A. & A. Salonen. (2013). Strategic maintenance management: form ulating maintenance strategy. *Proceedings of the26th International Conference of Condition Monitoring and Diagnostic Engineering Management*, Helsinki, Finland.

Reason, J. & A. Hobbs. (2017). Managing maintenance error: a practical guide, *CRC Press*.

Richard, C., P. Tse, et al. (2000). Enhancement of maintenance management through benchmarking. *Journal of Quality in Maintenance Engineering*, 6(4): 224-240.

Rose, A., B. M. Deros, et al. (2011). Lean manufacturing best practices in SMEs. *Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management*.

Roux, O., D. Duvivier, et al. (2013). Optimization of preventive maintenance through a combined maintenance-production simulation model. *International Journal of Production Economics*, 143(1): 3-12.

Salari, N. & V. Makis. (2017). Optimal preventive and opportunistic maintenance policy for a two-unit system. *The International Journal of Advanced Manufacturing Technology*, 89(1-4): 665-673.

Salonen, A. (2011). Strategic maintenance development in manufacturing industry, Mälardalen University.

Schechner, R. (2017). Performance studies: an introduction.

Sekaran, U. & R. Bougie. (2016). Research methods for business: a skill building approach, John Wiley & Sons.

Seth, D. & D. Tripathi. (2005). Relationship between TQM and TPM implementation factors and business performance of manufacturing industry in Indian context. *International Journal of Quality & Reliability Management*, 22(3): 256-277.

Shirose, K. & P. Press. (1996). TPM for Supervisors. SteinerBooks.

Sloan, T. (2008). Simultaneous determination of production and maintenance schedules using in-line equipment condition and yield information. *Naval Research Logistics (NRL)*, 55(2), 116-129.

Sloan, T. W. (2013). Yield-based production and maintenance scheduling of multi-product, multi-stage manufacturing systems under review.

Small Medium Corporation. SME Definition (2014, September 20). Retrieved November 10, 2014, from http://www .smecorp.gov.my/index.php/en/policies/2014-12-21-09-09-49/sme-definition 2014.

Stenström, C., P. Norrbin, et al. (2016). Preventive and corrective maintenance–cost comparison and cost–benefit analysis. *Structure and Infrastructure Engineering*, 12(5): 603-617.

Straub, D., M.-C. Boudreau, et al. (2004). Validation guidelines for IS positivist research. *The Communications of the Association for Information Systems*, 13(1): 63.

Swanson, L. (2001). Linking maintenance strategies to performance. *International Journal of Production Economics*, 70(3): 237-244.

Takada, E., T. Kobayashi, et al. (2017). Monozukuri navigation system to deliver outstanding quality and efficiency. *FUJITSU Sci. Tech. J*, 53(4): 70-76.

Tangen, S. (2003). An overview of frequently used performance measures. *Work study*, 52(7): 347-354.

Taylor, J. C. (2000). Reliability and validity of the maintenance resources management/technical operations questionnaire. *International Journal of Industrial Ergonomics*, 26(2): 217-230.

Temme, D., H. Kreis, et al. (2006). PLS path modeling: a software review, SFB 649 discussion paper.

Teresko, J. (1992). Time bomb or profit center? *Industry Week*, 241(3): 52-57.

Waeyenbergh, G. & L. Pintelon (2002). A framework for maintenance concept development. *International Journal of Production Economics*, 77(3): 299-313.

Wang, C. H. and S. L. Hwang. (2004). A stochastic maintenance management model with recovery factor. *Journal of Quality in Maintenance Engineering*, 10(2): 154-165.

Wang, H. (2002). A survey of maintenance policies of deteriorating systems. *European Journal of Operational Research*, 139(3), 469-489.

Withidyothin, C. (2014). The financial feasibility of modernizing production machinery. *Journal of Supply Chain Management*, 8(2).

Yu, L., J., Z. H., & Wen, R. (2009). Integrating flexible-intervalpreventive maintenance planningwithproductionscheduling.*International Journalof Computer Integrated Manufacturing*, 22(12):1089–101.

Zhou, M. Q., J. Alho, et al. (2007). Performance measurement action research. *Journal of Facilities Management*, 5(4): 290-300