แนวทางการจัดการงานบำรุงรักษาในภาคธุรกิจอุตสาหกรรมให้มีประสิทธิภาพ

GUIDELINES FOR EFFICIENT MAINTENANCE MANAGEMENT IN INDUSTRIAL SECTOR

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาลักษณะการดำเนินงานทั่วไปของการจัดการงานบำรุงรักษาในภาคธุรกิจอุตสาหกรรม เพื่อศึกษาแนวทางการจัดการงานบำรุงรักษาในภาคธุรกิจอุตสาหกรรมให้มีประสิทธิภาพ และพัฒนาแบบจำลองสมการโครงสร้างแนวทางการจัดการงานบำรุงรักษาในภาคธุรกิจอุตสาหกรรมให้มีประสิทธิภาพ ผู้วิจัยใช้วิธีการวิจัยแบบผสม (Mixed-methodology research) ดำเนินการวิจัยเชิงคุณภาพด้วยเทคนิคการสัมภาษณ์เชิงลึก (In-depth interview) และการสนทนากลุ่ม (Focus-group discussion) กับผู้เชี่ยวชาญที่เลือกแบบเฉพาะเจาะจง (Purposive sampling) ส่วนการวิจัยเชิงปริมาณ โดยใช้แบบสอบถามในการเก็บข้อมูลจากผู้บริหารที่รับผิดชอบด้านงานบำรุงรักษาในองค์กร จำนวน 500 ราย โดยใช้วิธีการสุ่มตัวอย่างแบบหลายขั้นตอน (Multi-stage sampling) หาคุณภาพเครื่องมือวิจัยด้วยการวิเคราะห์ค่าความเชื่อมั่นได้เท่ากับ 0.98 สถิติที่ใช้ในการวิเคราะห์ข้อมูล ได้แก่ การแจกแจงความถี่ ค่าร้อยละ ค่าเฉลี่ย ค่าเบี่ยงเบนมาตรฐาน และวิเคราะห์สมการโครงสร้างด้วยโปรแกรม AMOS (Analysis of Moment Structure)

ผลการวิจัยพบว่า แนวทางการจัดการงานบำรุงรักษาในภาคธุรกิจอุตสาหกรรมให้มีประสิทธิภาพที่มีค่าเฉลี่ยสูงที่สุด ได้แก่ ด้านการจัดการความรู้ รองลงมาได้แก่ ด้านนวัตกรรมเทคโนโลยี ด้านการวางแผน และด้านกระบวนการทำงาน ตามลำดับ ผลการทดสอบสมมติฐาน พบว่า องค์ประกอบด้านการจัดการความรู้ส่งอิทธิพลทางตรงต่อองค์ประกอบด้านกระบวนการทำงาน ด้านการวางแผน และด้านนวัตกรรมเทคโนโลยี ส่วนองค์ประกอบด้านกระบวนการทำงาน ส่งอิทธิพลทางตรงต่อองค์ประกอบด้านการวางแผน และด้านนวัตกรรมเทคโนโลยี

ผลการวิเคราะห์ตัวแบบจำลองสมการโครงสร้างที่ได้พัฒนาขึ้น พบว่า ผ่านตามเกณฑ์การประเมิน มีความสอดคล้องกลมกลืนกับข้อมูลเชิงประจักษ์ โดยมีค่าระดับความน่าจะเป็นของไคสแควร์เท่ากับ 0.33 ค่าไคสแควร์สัมพัทธ์เท่ากับ 1.04 ค่าดัชนีวัดระดับความสอดคล้องเท่ากับ 0.97 และค่าดัชนีรากของค่าเฉลี่ยกำลังสองของการประมาณค่าความคลาดเคลื่อนเท่ากับ 0.01
คำสำคัญ: แนวทางการจัดการงานบำรุงรักษา, ภาคธุรกิจอุตสาหกรรม

ABSTRACT

The objectives of this research were to explore the general operational characteristics of industrial sector on the managing maintenance guidelines, to design the guidelines for the effective managing maintenance in the industrial sector, and to develop the effective structural equation model of managing maintenance guidelines for the industrial sector. The researcher used the mixed-methodology research method. Regarding the qualitative research, the in-depth interview and the focus-group discussion, selected of purposive sampling was conducted, and it contained the questionnaire that had reliability value (0.98) to survey the data from 500 executives in charge of the organization's maintenance, selected by the multi-stage sampling method. The statistics used in analyzing the quantitative data were frequency, percentage, mean, standard deviation, and analyzed the structural equation model with AMOS program.

The research results show that the effective guideline for managing maintenance in the industrial sector that is in the highest level is Knowledge Management, followed by Technological Innovation, Planning, and Working Procedure respectively. The hypothesis analysis result shows that the component of Knowledge Management had a direct influence on the component of Working Procedure, Planning and Technological Innovation, while the component of Working Procedure had a direct influence on the component of Planning and Technological Innovation. The analysis result of the developed structural equation model shows the assessment criteria that is relevant to the empirical data (Chi-square=0.33, CMIN/DF=1.04, GFI=0.97, RMSEA=0.01).
Keywords : Guidelines for managing maintenance, Industrial business

INTRODUCTION

Nowadays, Thailand imports the machine with the purposes of production in order to respond to domestic demand and to export to foreign countries. The production of the products by themselves has a lower cost than importing the products but some industries cannot increase their production volume because of the obstacle in production factors and factory location. This causes the loss of opportunity in increasing the production capacity. It is an important problem that the executives try to find the solutions, which might take long time or have to spend high cost for problem solving because this obstacle occurs from external factors which are hard to

control (Office of Industrial Economics, 2019a, pp. 13-17). Looking into the internal business, one problem that executives can improve or solve quickly and needs merely small budget or may not require a budget at all but the return to the business is worthwhile, resulting in a reduction in operating costs as well, is the reduction of maintenance cost in the industrial sector; including that this can improve the efficiency of maintenance activities.

Regarding the study about the maintenance cost of machine and equipment in the industrial sector, it is found that the trend in the value of maintenance cost is higher, which may affect the cost of production, domestic sales, exports and the country's overall economy (see Figure 1).

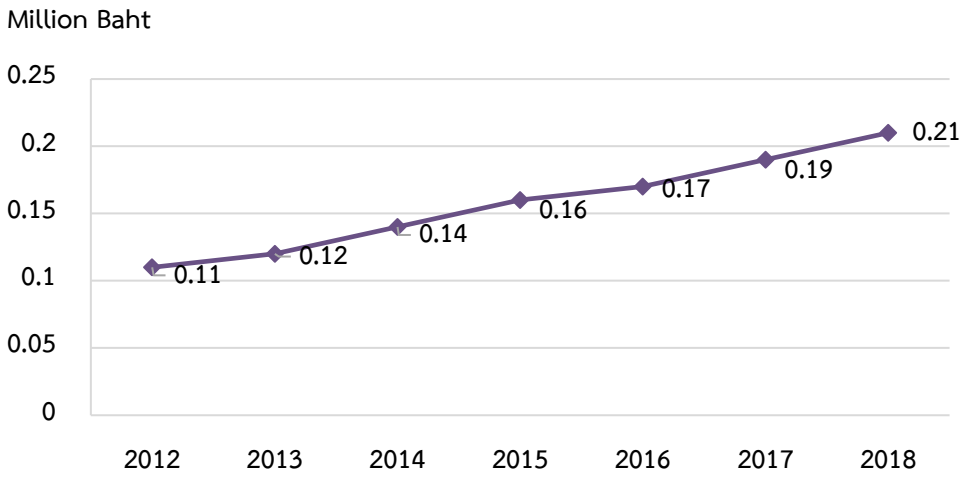

Figure 1 The maintenance cost of machine and equipment in the industrial sector during the year 2012-2018.

Source : Office of Industrial Economics, 2019b, p. 30-32.

From Figure 1, The value of maintenance of machine and equipment in the industrial sector during the year 2012-2018 was 0.11 million Baht, 0.12 million Baht, 0.14 million Baht, 0.16 million Baht, 0.17 million Baht, 0.19 million Baht and 0.21 million Baht respectively. It means that the continuously-higher maintenance cost is caused by the use of machine and equipment at its full capacity in order to focus on the highest productivity for the organization to have revenue from product sales. Therefore, the costs that are wasted on maintenance that require additional investment in machine maintenance have an impact on production costs, which may cause the product price to rise. The executives or those who are directly responsible must consider dimensions on the reliability and integrity of machine, the mean time to failure, the mean time to repair, the root cause analysis, the training for employees to have expertise according to the academic principles in order to increase the safety, to reduce the maintenance cost, to reduce the accident rate from work and to deliver the work efficiently.

Accordingly, the researcher is interested in studying about the maintenance work management in the industrial sector in order to retrieve the research results to use as guidelines for managing maintenance in the industrial sector so that the machine and equipment can be used without damage before a reasonable time, reduce the maintenance costs, including that the organization can use machine and equipment in producing products efficiently; and the organization can continuously generate profits.

RESEARCH OBJECTIVES

1. To study the general operational characteristics of industrial sector on the guidelines for managing maintenance.
2. To study the guidelines for managing maintenance in the industrial sector to be effective.
3. To develop the structural equation model of guidelines for managing maintenance in the industrial sector to be effective.

BENEFIT OF RESEARCH

The industrial sector

The industrial sector can apply this approach to corporate strategic plans in order to support the growth and performance to create a competitive advantage for the business with stability; including enhancing the country's competitiveness.

The public sector and relevant agencies

The government can use this research result to create guidelines for managing maintenance of machine and equipment to be efficient in the public sector and the private public agencies set up under special law, which is a direction to increase competitiveness of the country sustainably.

The education

Educational institutions that provide tertiary education can apply the knowledge gained from this research in teaching by adding content to the relevant courses or as a case study on issues in business administration or organizational management.

Theoretical and literature review

The researcher studied the concepts and theories from documents and related researches as guidelines for conducting the research, which can be summarized as follows;

Maintenance means the attempt to maintain the condition of various machine and equipment to be ready for use at all times (Hodkiewicz & Ho, 2016, p. 146-163), the entire activity or work performed on machine and equipment to maintain or prevent damage by being in a condition that is ready to be used at all times, as well as helping to prolong the service life (Kiefer, Schilde, & Doerner, 2018, pp. 1158-1170). There are 6 characteristics of maintenance work which are to make the machine able to be used effectively, to make it to have highest

work performance, reliability and safety, to reduce the environmental pollution, and to economize the energy. In addition, there are 4 types of maintenance work which are the breakdown maintenance, the planned/ preventive maintenance, the predictive maintenance and the proactive maintenance (Hodkiewicz & Ho, 2016, pp. 146-163).

Regarding the literature review about guidelines of maintenance work in the industrial sector, it is found that the entrepreneur prioritized the maintenance work for the production of products to sell to the consumers, thus they applied the technology in the machine maintenance procedure (Mehmiti, Mehmiti, & Sejdiu, 2018, pp. 800-802; Macchi et al., 2014, pp. 147-152; Straub, 2011, pp. 683-708). In order to operate business in the international market and to increase the work performance of machine, the successful entrepreneur will manage the machine maintenance so that it can work at its full capacity by using the data from modern technological innovation in the maintenance work, including scheduling the training for maintenance employees to have expertise about machine by focusing on the preventive maintenance (Mehmiti, Mehmiti, & Sejdiu, 2018, pp. 800-802; Portioli-Staudacher & Tantardini, 2012, pp. 3257-3273; Veldman, Wortmann, & Klingenberg, 2011, pp. 183-198; Gentzler & Patel, 2014, pp. 4-15; Jyoti, Gupta, & Kotwal, 2011, pp. 315-330). In the sector of industrial production, the machine maintenance system is used in prolonging the service time of machine by applying the technology or innovation in the form of preventative maintenance (Hongjiu & Jiaxuan, 2018, pp. 165-174). Firstly, the maintenance work should begin with the assessment of machine performance, then the determination of machine quality and the reliability in the production, which can reduce the cost of machine maintenance by 26.02% (He, Gu, Chen, & Han, 2017, pp. 5841-5862). Moreover, the industrial sector places importance on the machine maintenance to reduce the production costs the most by allowing maintenance engineers to continuously learn how to manage and plan the machine maintenance so that it can work at its full capacity (Pongpech, Murthy, & Boondiskulchock, 2006, pp. 52-67).

Research hypotheses

H1: The component of Knowledge Management has a direct influence on the component of Working Procedure.

H2: The component of Knowledge Management has a direct influence on the component of Planning.

H3: The component of Knowledge Management has a direct influence on the component of Technological Innovation.

H4: The component of Working Procedure has a direct influence on the component of Planning.

H5: The component of Working Procedure has a direct influence on the component of Technological Innovation.

H6: The overall importance levels of guidelines for managing maintenance in the industrial sector to be effective, classified by business sizes, are different.

RESEARCH METHODOLOGY

This is the inductive research. The researcher applied the mixed-methodology research method which consists of 3 parts; beginning with the qualitative research by conducting the in-depth interview, then the quantitative research by collecting the data from the survey, followed by the qualitative research by conducting the focus-group discussion.

Regarding the population and sample in this research, the researcher conducted the in-depth interview with 9 experts by using the purposive sampling for the initial qualitative research. The populations for the quantitative research were the executives in maintenance management of both large, and small and medium industrial businesses which received ISO 9000 quality system. To determine the sample size, the researcher used the research criteria in the category of structural analysis or structural equation model, which specifies the size of sample group at a very good level of 500 samples (Comrey & Lee, 2010, pp. 1-442). The researcher used the multi-stage sampling method (Babbie, 2010, pp. 218-222), consisting of the cluster sampling, which are categorized into 2 types of industrial business which are large industrial business and small and medium industrial business; then used the probability sampling by drawing lots. Lastly, the researcher conducted the focus-group discussion with 7 senior experts by using the purposive sampling in order to confirm the model.

Regarding the research tools, beginning with the qualitative research, the researcher used the structured-interview form for the in-depth interview. Then, for the quantitative research, the researcher used the questionnaire for the quantitative data collection. The researcher found the quality of research tool by examining the Index of Item-Objective Congruence (IOC) and conducted the try-out with 30 people in the population group that is similar to the population that the researcher wants to study (Engel & Schutt, 2005, p. 242). The obtained scores were used to find the discrimination value. The Corrected Item-Total Correlation was 0.31-0.85. The analysis of reliability was 0.98. For the qualitative research to confirm the model, the researcher used the audio record form for the focus-group discussion.

Regarding the statistics used in analyzing the data, the researcher used the content analysis for the qualitative data. Then, the statistics used in quantitative data analysis were frequency, percentage, mean, standard deviation, chi-square probability (CMIN–p), relative chi-square (CMIN/DF), goodness of fit (GFI) and root mean square error of approximation (RMSEA) with the SPSS Program (Statistical Packages for the Social Science) and AMOS Program (Analysis of Moment Structure). Regarding the development of models to be consistent with empirical data, the researcher relies on the criteria according to Arbuckle (2016, pp. 53-604) that Chi-square probability level should be more than 0.05, the relative chi-square should be less than 2, the goodness of fit index (GFI) should be more than 0.90, and the root mean square error of approximation (RMSEA) should be less than 0.08.

RESEARCH RESULTS

The general operational characteristics of industrial sector on the guidelines for managing maintenance

With regard to the analysis of guidelines for managing maintenance in the industrial sector to be effective by conducting the in-depth interview with experts, the qualitative research results show that there were 4 components of guidelines for managing maintenance in the industrial sector to be effective, which were the component of planning, the component of working procedure, the component of knowledge management and the component of technological innovation.

The guidelines for managing maintenance in the industrial sector to be effective

Table 1 Mean and standard deviation of importance level of guidelines for managing maintenance in the industrial sector to be effective in total

Guidelines for managing maintenance in the industrial sector to be effective	$\overline{X}$	S.D.	Importance level
in total	3.92	0.93	High
1. Planning	3.92	0.94	High
2. Working Procedure	3.92	0.94	High
3. Knowledge Management	3.93	0.92	High
4. Technological Innovation	3.92	0.92	High

From Table 1, with regard to the analysis of guidelines for managing maintenance in the industrial sector to be effective, the results show that the importance level in total was at high level with the mean score of 3.92 (S.D.=0.93). In particular, Knowledge Management had the highest mean score of 3.93 (S.D.=0.92), followed by Technological Innovation with the mean score of 3.92 (S.D.=0.92), Planning with the mean score of 3.92 (S.D.=0.94) and Working Procedure with the mean score of 3.92 (S.D.=0.94) respectively.

The structural equation model of guidelines for managing maintenance in the industrial sector to be effective

With regard to the analysis of structural equation model of guidelines for managing maintenance in the industrial sector to be effective in the mode of unstandardized estimate and the mode of standardized estimate before the modification, the results are demonstrated in Figure 3 and 4.

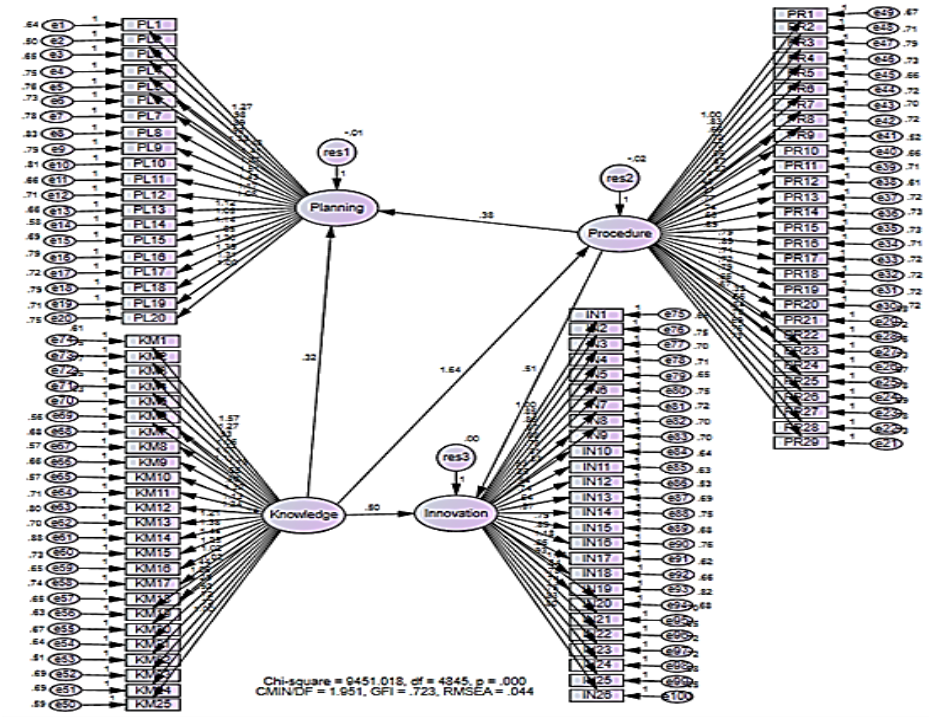

Figure 3 The model of guidelines for managing maintenance in the industrial sector to be effective in the mode of unstandardized estimate before the modification

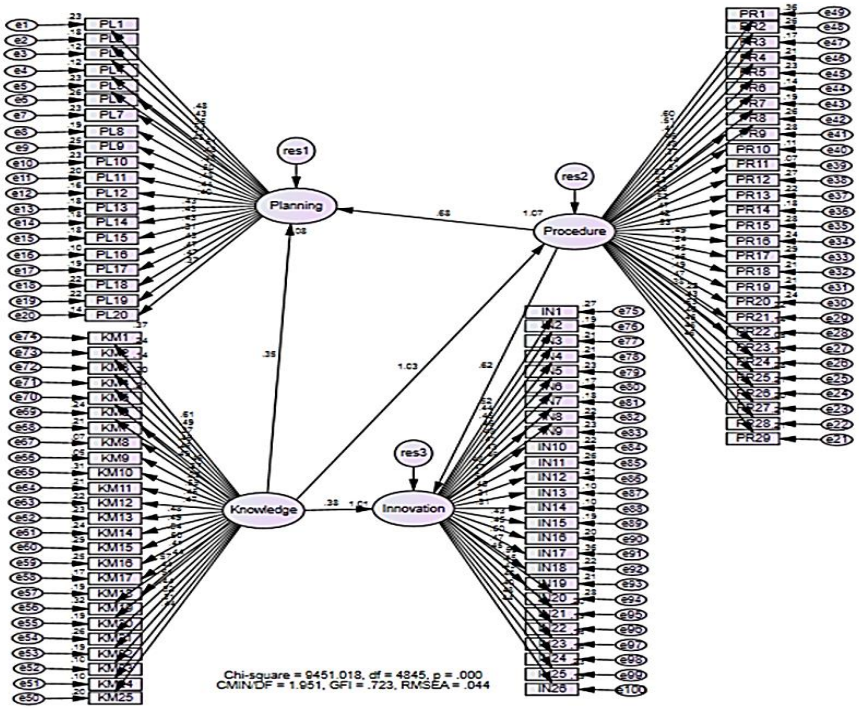

Figure 4 The model of guidelines for managing maintenance in the industrial sector to be effective in the mode of standardized estimate before the modification

With regard to the analysis of structural equation model of guidelines for managing maintenance in the industrial sector to be effective after the modification, the results are demonstrated in Figure 5 and 6.

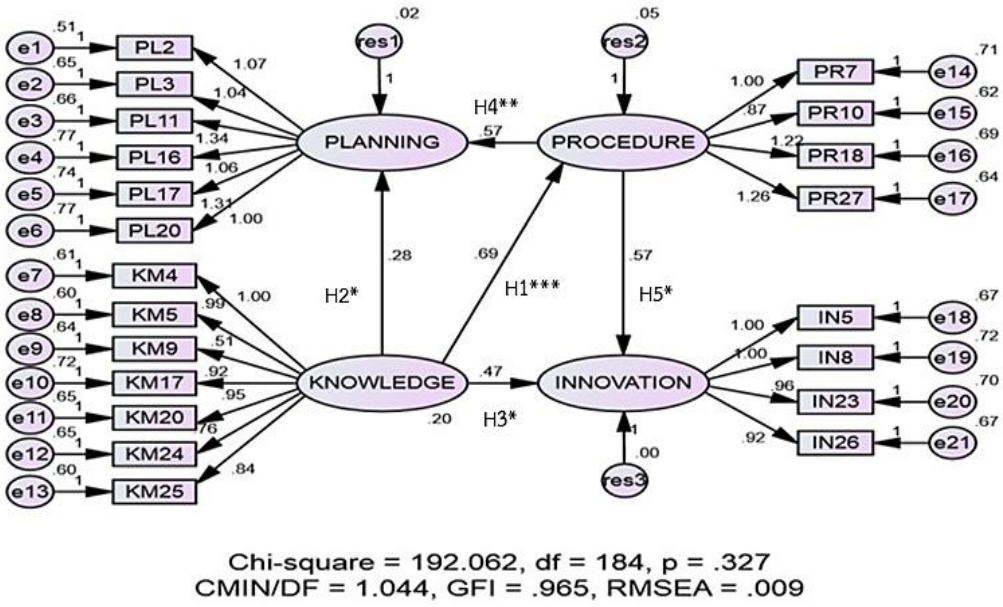

Figure 5 The model of guidelines for managing maintenance in the industrial sector to be effective in the mode of unstandardized estimate after the modification

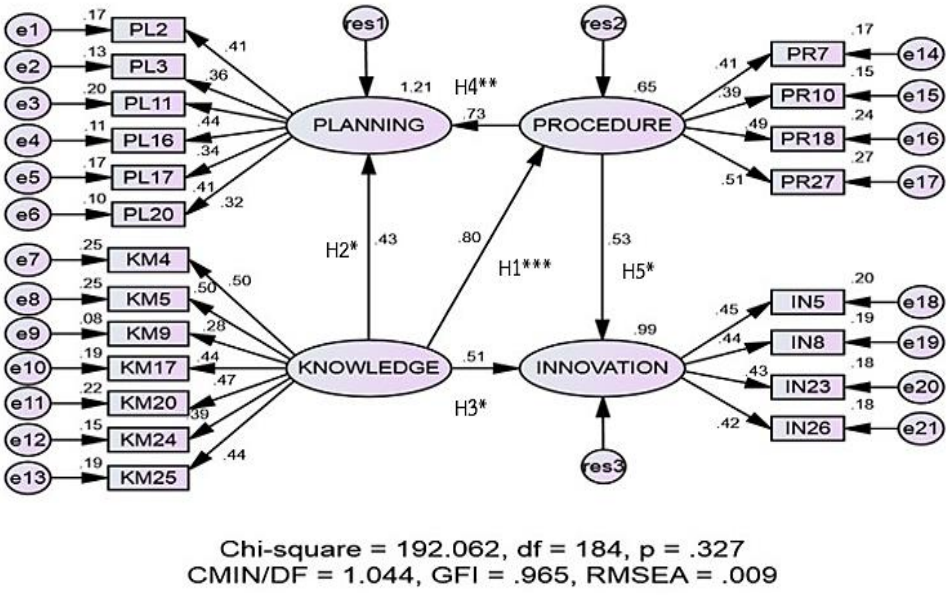

Figure 6 The model of guidelines for managing maintenance in the industrial sector to be effective in the mode of standardized estimate after the modification

With regard to the consistency assessment of the structural equation model of guidelines for managing maintenance in the industrial sector to be effective before and after the modification, the results are demonstrated in Table 2.

Table 2 The statistics used to assess consistency of the structural equation model, comparing before and after the modification

Statistics	Criteria	Before the modification	After the modification
Chi-Square	No statistical significance (P>0.05)	0.00	0.33
CMIN/DF	Less than 3	1.95	1.04
GFI	More than 0.90	0.72	0.97
RMSEA	Less than 0.08	0.04	0.01

The Figure 5 and 6, and Table 2 demonstrate the statistics used to assess consistency of the structural equation model of guidelines for managing maintenance in the industrial sector to be effective before the modification, the results show that RMSEA was 0.04 and CMIN/DF was 1.95; which passed the consistency assessment criteria with the empirical data of the model. However, the Chi-Square Probability Level was 0.00 and GFI was 0.72; which still did not pass the consistency assessment criteria with the empirical data respectively.

Therefore, the researcher conducted the model modification by considering the modification indices according to Arbuckle (2016, pp. 53-604). The results show that the Chi-Square Probability Level was 0.33 (more than 0.05); which means this model did not have the statistical significance. The CMIN/DF was 1.04 (less than 2); the GFI was 0.97 (more than 0.90); and the RMSEA was 0.01 (less than 0.08). It can be concluded that these 4 statistics values passed the assessment criteria; therefore, the structural equation model of guidelines for managing maintenance in the industrial sector to be effective after the modification was relevant to the empirical data.

The hypotheses analysis results

With regard to hypotheses for analyzing the causal influence between latent variables in the structural equation model of guidelines for managing maintenance in the industrial sector to be effective, the results are as follows;

With regard to the hypothesis 1, the result shows that the component of Knowledge Management had a direct influence on the component of Working Procedure with the statistical significance at 0.01 (Factor Loading=0.80), which is relevant to the set hypothesis.

With regard to the hypothesis 2, the result shows that the component of Knowledge Management had a direct influence on the component of Planning with the statistical significance at 0.05 (Factor Loading=0.43), which is relevant to the set hypothesis.

With regard to the hypothesis 3, the result shows that the component of Knowledge Management had a direct influence on the component of Technological Innovation with the statistical significance at 0.05 (Factor Loading=0.51), which is relevant to the set hypothesis.

With regard to the hypothesis 4, the result shows that the component of Working Procedure had a direct influence on the component of Planning with the statistical significance at 0.01 (Factor Loading=0.73), which is relevant to the set hypothesis.

With regard to the hypothesis 5, the result shows that the component of Working Procedure had a direct influence on the component of Technological Innovation with the statistical significance at 0.05 (Factor Loading=0.53), which is relevant to the set hypothesis.

With regard to the hypothesis 6, the result shows that the large industrial business and the small and medium industrial business gave importance to guidelines for managing maintenance in the industrial sector to be effective in different way with the statistical significance at 0.05.

DISCUSSION

With regard to the research results, it shows the importance level of guidelines for managing maintenance in the industrial sector to be effective; in particular, the component of Knowledge Management had the highest mean score, which had a direct influence on the component of Working Procedure. This is relevant to the study of Kiefer, Shilde and Doerner (2018, pp. 1158-1170), and Al nasseri and Aulin (2016, p. 1). The component of Knowledge Management also had a direct influence on the component of Technological Innovation, which is relevant to the study of Azar and Ciabuschi (2017, pp. 324-336). Including that the component of Knowledge Management also had a direct influence on the component of Planning, which is relevant to the study of Samaranayake and Kiridena (2012, pp. 432-453). This means to work efficiently must arise from the study of knowledge before working in that career; it also needs good skills and capability in that career or the specialized training for working in the business organization.

In addition, the component of Working Procedure had a direct influence on Planning, which is relevant to the study of Niu et al. (2018, pp. 1-23), and Ruiqiu and Huimin (2018, pp. 217-225). The component of Working Procedure also had a direct influence on Technological Innovation, which is relevant to the study of Mehmiti, Mehmiti and Sejdiu (2018, pp. 800-802), Macchi et al. (2014, pp. 147-152), Portioli-Staudacher and Tantardini (2012, pp. 3257-3273), Veldman, Wortmann, and Klingenber (2011, pp. 183-198), Jyoti, Gupta, and Kotwar (2011, pp. 315-330), and Straub (2011, pp. 683-708). This means the efficient working procedure affects the planning because knowing well about working procedure leads to the good planning and the good setting of work priority. Then, it can be employed by applying the technological innovation as an assistant in recording the parameter values from work.

RECOMMENDATIONS

1. The executives of maintenance work are required to declare their explicit vision and set it to be the organization goals so that the relevant people can focus on the same direction. They must dedicate their creative power to create the differentiation from the competitors and to think out of the box for the survival of organization among the changing situation.

2. The management of maintenance work prioritizes the knowledge and knowledge management to reuse for the highest benefit to the organization. This can solve the problems on changing organizational structure or the in-out of employee. Good executives should reduce the reliance on the individual talents of the employee, but focus on training the employees to have knowledge and skills. The most important thing is the systematic knowledge management.

3. The maintenance work in the industrial sector required a large number of employees; and the production still cannot work fully automatically. Therefore, the organization begins to have a problem on shortage of skilled labor so that it must import the labor from neighbor countries. The problem is that it is hard to develop the labor standard and to communicate with them; thereby, the entrepreneur must adjust themselves and give importance on technology to replace the labor.

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