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THE EMPIRICAL STUDY ON MEDIATING ROLE OF AMT ON THE TQM AND AUTONOMOUS MAINTENANCE IMPLEMENTATION IN WORLD CLASS MANUFACTURING

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ABSTRACT

Manufacturing companies nowadays are facing serious challenges to compete in the intensified global markets. Increasing customers' expectations in term of quality, cost, delivery, and volume flexibility added more challenges. To be competitive and survive in the heat of market competition, many IC manufacturing companies are striving to be recognized as a world class manufacturer that is offering the best in class products quality, services, operation management, maintenance management system and organizational culture. To achieve such level of an excellent organizational performance, many manufacturing companies sort out to explore new practices in running the manufacturing processes. The traditional ways of manufacturing are no longer capable to meet ever increasing challenges and to satisfy the customers' needs. Many IC manufacturing companies aggressively adopted Total Quality Management (TQM) methodology in their manufacturing operation as a tool to achieve an effective and efficient manufacturing system, a good maintenance management system, an effective process control and develop a good working culture within the organization.

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Adoption of an effective TQM implementation is strategically important in achieving world class manufacturing, especially in manufacturing companies. The advanced manufacturing technology (AMT) is evolved at greater extent nowadays in the most of manufacturing companies. AMT represents a variety of modern computerized based system devoted to improve the manufacturing operations and hence enhance the competitiveness of the firms. The integration of AMT into the TQM and autonomous maintenance implementation will provide a double barrels strategy for the greater benefits to the companies. The study which was based on the data collected from IC manufacturing companies in Malaysia aims to investigate the impact of the AMT integration into TQM dimension to the plant performance.

Keywords: TQM, Automation, World Class Manufacturing, Management

INTRODUCTION

When facing highly competitive and intensified global marketplaces, manufacturing companies are seeking ways to improve their competitiveness and achieve the world class manufacturing (WCM) standard. There are many literatures written to define the WMC; but there were not commonality in the standard definition. Hayes and Wheelwright (1984), in their classic book "Restoring Our Competitive Edge: Competing through Manufacturing", defined that world class manufacturing is organization that composed of six dimensions: 1) high workforce skills and capabilities, 2) high management technical competence, 3) ability to compete through quality, 4) strong workforce participation in improvement practices, 5) strong rebuilding manufacturing engineering capabilities, and 6) strong drive in incremental improvement approaches. Giffi, Roth and Seal (1990) defined the WCM standard as those companies that exercising the key principles in the following areas: 1) quality and customer, 2) management approach, 3) manufacturing strategy, 4) manufacturing capabilities, 5) performance measurement, 5) organization, 6) human assets and 7) technology. Giffi, Roth and Seal (1990) reinforced that the dimensions of the WMC have a strong linkage to each other, where the quality and customer are two main focal of attention, all other dimension are playing the vital role to interact with the quality dimension. According to Yamashina (2000) there are two basic characteristics of the WCM

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1. to be outstanding in the applied, production engineering, improvement capability, and detail shop floor know-how involving good maintenance; and
2. to integrate as dimensions as a system.

Oliver, Delbridge, Jone and Lowe (1994) in his study from nine Japanese and nine UK automotive parts companies concluded that to qualify as world class, a plant had to demonstrate outstanding performance on measures of both productivity and quality. Total Quality Management (TQM) emerged in 1988 as a key competitive strategy and approach for all business organizations in the global marketplace. TQM methodology is widely written in many researches and literature as the operation management paradigms that integrate all the functions within the manufacturing firm to achieve the maximum operational performance dimensions, thus enables the manufacturing firm to be defined as the WCM. In fact, TQM is a way to continuously improve performance at every level of operation, in every functional area of an organization, using all available human and capital resources (Cho, 1994). It is not a program but rather an ongoing, continuous process that requires radical changes in the way the organization is designed and managed (Lee, 1993). According to Chang (2005), TQM is a system that continuously improves customer requirements by utilizing the commitment of all employees to produce products at a lower cost. Gomez-Gras and Verdu-Jover (2005), stated that companies that implement TQM are more flexible and willing to adjust to requirements of the environment. These flexibility aspects are important for the companies to adapt themselves with the customers' ever increasing expectation and to continue building the confidents in the customers. The significant of adoption of an effective TQM shall be recognized by the management of the companies to propel them in the severe competitive global market.

LITERATURE REVIEW

TQM is not only seen as do the right thing at the first time, but it is a holistic approach of looking the manufacturing processes and controls in the different perspectives. TQM covers the broad approaches on all the operational dimensions that enable the companies to achieve the world class manufacturing practices, good quality products and services and the same time develop the good organizational culture. The increasing complexity, scope and organizational role of advanced

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manufacturing technologies and integration of many advanced manufacturing technologies in the current process and operational controls underpins the effective implementation of the TQM practices. Advanced manufacturing technology is a set of tools that automate and integrate steps in product design, manufacturing, and planning and control (Ettlie & Reifeis, 1987).

AMT is recognized as an important element in building a competitive manufacturing system that delivers the product variety that customers demand (Boyer, Ward & Leong, 1996; Gerwin & Kolodny, 1992; Lei, Hitt & Goldhar, 1996; Meredith, 1987; Saraph & Sebastian, 1992; Small & Chen, 1997). AMT involves new manufacturing techniques and machines combined with information technology, microelectronics and new organizational practices in the manufacturing process (Teng & Seetharaman, 2003).

Many new advanced manufacturing technologies tools are introduced in the operational management to improve the efficiency of the operation. The use of electronic statistical process control (*e*SPC) provide an online equipment and processes control that enable for engineers to monitor the process behaviors real time. The use of *e*SPC enables the determination of whether a process is in "control" or not. Any change of the trend of eSPC shall be able to viewed real time and actions can be taken immediately to stop the process as well as to rectify the issue.

Computerized Maintenance Management System (CMMS) is another new advanced maintenance technology adopted into the current maintenance practices. CMMS enables the maintenance engineers or personals to have a data collection system real-time, such as data related to frequency and duration of maintenance breakdowns as well as spare parts costs (Walib, 1998). The stored information is very important for the maintenance engineers to analyze the behavior and history of the equipment and include the frequent breakdown parts as the periodical check items. Ability to identify the parts before the breakdown is an important element of predictive maintenance. The study will probe more into the insight of the employment of the advanced manufacturing technology into the TQM and autonomous maintenance practices and aims to suggest the empirical evidence on the mediating effects of AMT on the WCM's key performances.

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PROBLEM STATEMENT

Many researches and literature were written to link the TQM practices to the companies' operational performance. While many researchers found that an effective TQM practices has benefited the companies, but few researches also suggested the results were vague. The top management involvement in policy building and cultivating the TQM culture is the main pinnacle of the success in TQM implementation. In order to successfully gain the benefit from TQM, the participation from all level of employees is critically required. While many literatures were written that evidenced the positive outcomes of the TQM implementation on the companies key performances, many management of the companies still have a vague ideas on which dimension of the TQM shall be embarked to enhance the performance of the companies. With the introduction of the AMT in the manufacturing system, the TQM implementation is becoming more complex and many companies are deferring the adoption of advance of manufacturing technology into their manufacturing system due to cost and complexity of the system. AMT provides the foundation to strengthen the manufacturing management and reduce the reliance to the human factors. The AMT can contribute expressively for the manufacturing function goals attainment, simultaneously considering the competitive objectives (cost, quality, time, flexibility and innovativeness) and the manufacturing system decision areas (capacity, facilities, manufacturing process technology, vertical integration, organization, quality policy, human resources, production control, new products introduction and performance measurement and reward (Hayes & Wheelwright, 1984). For the companies to achieve the WCM standard it is an important justification to integrate the AMT into the implementation of TQM and autonomous maintenance practices in the companies.

RESEARCH QUESTIONS

The development of research questions is the very crucial part to tailor the research to identify the nature of research problem and highlight issues upon which the study should be focused on. It is also important to note that the research questions will guide the researcher to achieve the original research objectives. Even though TQM and AMT are becoming important parts of manufacturing practices, the effects of employment of both strategies to the manufacturing companies'

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operational performances are still largely unproven. This study seeks to enhance the understanding the effect of TQM implementation on the companies' operational performance and the effect of TQM with the moderating factor on the companies' operational performance:

RQ1: Is there any relationship between TQM implementation to the manufacturing performance?

RQ2: Is there any relationship between autonomous implementation to the manufacturing performance

THEORETICAL FRAMEWORK

Based on the literature review outcomes, the theoretical framework for the study is developed. The study aims to investigate the TQM factors; production enhancement and process control and Autonomous Maintenance implementation to the company's operational performance with the moderating effect of AMT.

The theoretical framework model is shown in Figure 1

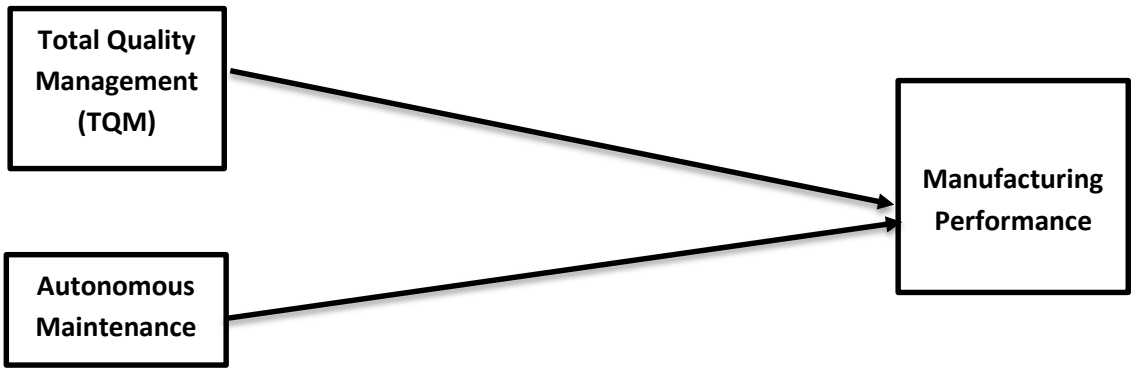

Figure 1. The Theoretical Framework

HYPOTHESIS DEVELOPMENT

Many researches are conducted to investigate the relationship of TQM soft-factor to the performance of the firm. Samson and Terziovski (1999) pointed out that the

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TQM factors of leadership, people management and customer focus were positively associated with organisational performance. Thus the following hypothesis is proposed:

Hypothesis 1: The adoption of TQM methodology is positively associated with companies' manufacturing performance.

In the study by Park and Han (2001), it was evidenced that TPM initiatives can be effectively integrated with other manufacturing management programs to optimize improved performance, and ultimately competitiveness. TPM is a world-class approach, which involves everyone in the organization, working to increase equipment effectiveness. TPM implementation in an organization can ensure higher productivity, better quality, fewer breakdowns, lower costs, reliable deliveries, motivating working environments, enhanced safety and improved morale of the employees (Tripathi, 2005) thus, ultimately enhanced productivity and profitability of the organizations. Thus the following hypothesis is proposed:

Hypothesis 2: The implementation of Autonomous Maintenance is positively associated with the companies' manufacturing performance.

Several benefits of AMTs are highlighted in the literature, and flexibility is one of the most frequently mentioned, but overall competitiveness and profitability are other broader benefits. Jonnson (2000) found that the companies which invested in the AMT can improve their manufacturing performances, the following hypothesis is proposed:

METHODOLOGY

This chapter outlines the main elements of methodology that has been employed to analyze the interaction between three factors of TQM; process control, maintenance system and top management involvement with the WCM key performance. The study also aims to test the moderating effect of AMT on the TQM implementation and impact to the WCM performance.

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Survey Design

This study used a quantitative, cross-sectional research design. The data have been collected through a combination approach of email and personal handover of the questionnaires survey from IC manufacturing companies in the central part of Malaysia. The simple random sampling method was used to collect the data for the study. The target group was identified, which composed of employees who are from executive level and higher.

SAMPLE

Table 1. Background of the companies and number of data collected

Company	Origin	Product	Location	Total No of Employee	No of Questionnaires sent	No of Questionnaires Returned	Respond Rate (%)
A	Japan	Semiconductor	Selangor	2650	80	68	85
B	US	Semiconductor	Selangor	5300	50	33	66
C	US	Semiconductor	N.Sembilan	2700	50	31	62
			Total		180	132	73

The target population for the study comprised all the IC manufacturing across Malaysia. However, for the purpose of the study, the data were collected from three IC manufacturing companies in the central region of Malaysia. The study followed simple random sampling. The background of the companies and number of data collected are tabulated in the Table 1.

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RESULT

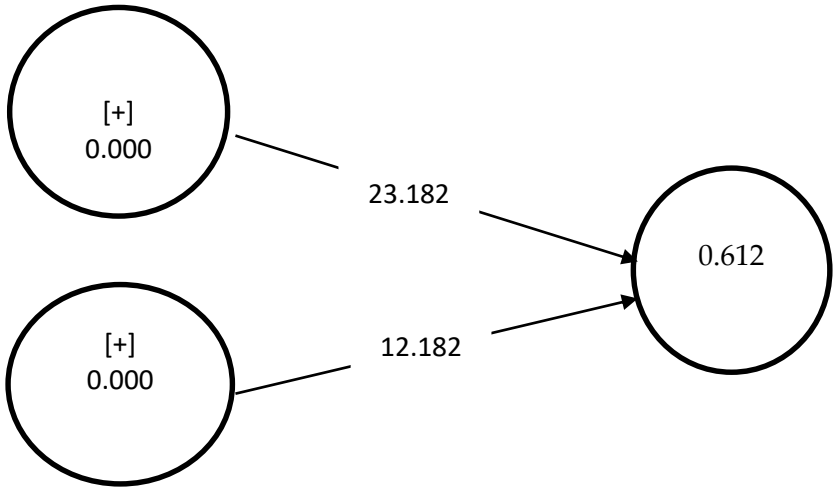

Figure 1. Structural Model

FINDINGS

The research is to investigate the relationship between TQM, autonomous maintenance implementation and AMT to the manufacturing performance. The study also investigate the moderating factor of AMT on the TQM and Autonomous Maintenance implementation and the effects on the manufacturing performance. From the data collected form three IC manufacturing companies in the central region of Malaysia, the Partial Least Square Structural Equation Modelling analysis is used to examine the causal model of research and understand the relationship between the latent variable.

1. From the PLS-SEM result, it is indicated that there is a positive relationship between the TQM implementation and the companies' manufacturing performance. The hypothesized path relationship indicates value of 0.612, hence it is indicated that there is a very highly positive relationship between latent variable TQM and latent variable M.PERFORMANCE. This means that TQM high moderately explain 61.2 percent variance in M.PERFORMANCE. So, the finding validate Hypothesis 1: The adoption

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of TQM methodology is positively associated with companies' manufacturing performance

2. From PLS_SEM result, it is also that there is a positive relationship between the AUTOMAINT adoption and the companies' manufacturing performance. The hypothesized path relationship indicates value of 0.126, hence it is indicated that there is a very low positive relationship between latent variable AUTOMAINT and latent variable MPERFORMANCE. This means that latent AUTOMAINT is very moderately low explain1.26 percent variance in MPERFORMANCE. So, the finding even though very low, still validates Hypothesis 2: The implementation of Autonomous Maintenance is positively associated with the companies' manufacturing performance.

THEORETICAL IMPLICATIONS

In the Demming's theory of improvement, he further emphasized the management of the companies should move away from the traditional way of quality inspection, defect detection, and move toward defect prevention techniques. The management should not stop from continually searching for the method to improve the process through statistical methods and team problem-solving techniques. All levels of employees and managements should be equipped with the relevant knowledge that making full use of the new methods and advance manufacturing tools. Various techniques of operational improvement shall be deeply considered by management of the companies. Brainstorming, parts analysis, flow charts, control charts, etc are the common tools that can be used by management and employees. This will enhance performance and create a positive attitude among workers. Crosby's (1979) quality improvement program is primarily based on a team concept. The team shall be formed as a synergy team that responsible to establish the improvement programs and procedures as well as execute the quality improvement programs. It is very important to expose all levels of employees to the procedure prior to implementation of the program that may cover both manufacturing and non-manufacturing aspects. Both theories of improvement emphasize the involvement of all level of employees, with top management of the companies shall be at the driver seat. Top management of the companies must buy in the benefit of the TQM practices in their manufacturing process and ultimately translate into the positive results of the companies' performance.

RESEARCH LIMITATION AND FUTURE RESEARCH

The data for the study were collected from small population of the IC manufacturing companies in Malaysia. Thus, the result of the study cannot be generalized to all the factory. Thus to explore more on the effect of TQM, Autonomous implementation and AMT deployment, more data sampling shall be collected. Furthermore, the data collected covers the central region of Malaysia, thus to generalize the outcome to all the manufacturing in Malaysia is inappropriate.

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