A STUDY OF RELATIONSHIP BETWEEN TOTAL PRODUCTIVE MAINTENANCE (TPM) AND MANUFACTURING PERFORMANCE

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A STUDY OF RELATIONSHIP BETWEEN TOTAL PRODUCTIVE MAINTENANCE (TPM) AND MANUFACTURING PERFORMANCE

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ABSTRACT

Most organizations production is based on machine – human system. The dependable of production system on machine has increased drastically with the increase of automation. The purpose of this study is to examine the relationship between Total Productive Maintenance (TPM) practices which are top management leadership, information system focus, employee involvement, and autonomous and planned maintenance with manufacturing performance. A total of 100 questionnaires were circulated to various manufacturing industries in Northern regions of Malaysia such as Kedah, Penang, and Perak. However, only 95 questionnaires were returned and usable for analysis. The correlation and multiple regression analysis were performed to test the hypotheses of the study. The findings indicated of the four (4) components of TPM, only employee involvement was not significantly related to manufacturing performance. This was aligned with the results shown in multiple regression analysis. In addition, the effectiveness of production is relying on skills level, management, and maintenance of equipment efficiently. The implications were discussed and recommendations for the future research were also addressed.

ABSTRAK

Kebanyakan organisasi penggeluaran adalah berasaskan sistem mesin-manusia. Pengantungan sistem produksi keatas mesin meningkat secara mendadak dengan peningkatan automasi. Tujuan kajian ini adalah untuk melihat hubungan antara amalan penyelenggaraan produktif menyeluruh iaitu kepimpinan pengurusan, fokus sistem maklumat, penglibatan pekerja, dan penyelenggaraan berautonomi dan penyelenggaraan terancang dengan prestasi perkilangan. Sejumlah 100 soalan kajian selidik diedarkan kepada pelbagai industri perkilangan di kawasan-kawasan utara Malaysia seperti Kedah, Pulau Pinang, dan Perak. Namun, hanya 95 soalan kajian selidik dipulangkan dan boleh digunakan untuk melaksanakan analisis kajian. Analisis Korelasi dan Regresi berganda dilakukan untuk menguji semua hipotesis kajian. Penemuan menunjukkan daripada empat (4) komponen TPM, hanya penglibatan pekerja tidak signifikasi dengan prestasi perkilangan. Hal ini selaras dengan keputusan yang diperolehi dalam analisis regresi berganda. Selain itu, keberkesanan pengeluaran bergantung kepada tahap kemahiran, pengurusan, dan penyelenggaraan peralatan secara cekap. Perbincangan tentang implikasi dan saranan untuk kajian yang akan datang juga diberikan.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Cost and quality are two important elements to consider in strategic decisions in business and manufacturing sector. Even in different industry, organizations are focusing in achieving the cost effectiveness and continuous improvement in the production processes. The current business environment and rapid changes in technology have put severe pressured on manufacturing sectors (Halim and Ramayah, 2010). Besides, the manufacturing sectors have to maintain its relationship with other parties such as customers, suppliers, and, governments as these parties are significant for the future development of manufacturing sectors. It seems that the path for manufacturing sectors able to compete and success in the industry was very challenging nowadays.

Therefore, in today's dynamic environment, a strategic decision in operation management and a reliable productive system must be seen as a critical factor for competitiveness; thus maintenance has become a strategic issue for manufacturers (Brah and Chong, 2004). Traditionally, maintenance has been described as a support function, non-productive and not a core function thus has little value to the business (Bamber *et al*., 1999). The role of maintenance is to support the production department to achieve the desired quantity and quality of products produced through ensuring the availability of equipment (Halim and Ramayah, 2010). Total productive maintenance (TPM) represents a potential source of improvement, an essential strategic tool for an organization and a possible next step for extending the benefits of total quality management (TQM) concept (Brah and Chong, 2004). The scope of TPM extends far beyond manufacturing to areas such as research and development, and logistics.

1.1 Total Productive Maintenance (TPM)

Basically, Total Productive Maintenance (TPM) is the Japanese approach to maximizing the effectiveness of the facilities that used within businesses. It not only addresses maintenance but all aspects of the operation and installation of those facilities. It involves the whole organization and when implemented effectively benefits all sections of the business through improved efficiency and better overall performance (Brah and Chong, 2004). In addition, according to Davis (1995), there are three components of TPM:

1. *Total approach*: An all-embracing philosophy which deals with all aspects of the facilities employed within all areas of an operating company and the people who operate, set up, and maintain them.

2. *Productive action*: A very pro-active approach of the condition and operation of facilities, aimed at constantly improving productivity and overall business performance.

3. *Maintenance*: A very practical methodology for maintaining and improving the effectiveness of facilities and the overall integrity of production operations.

Furthermore, Schonberger (1987) as well as Cheng and Podolski (1996) also highlight TPM as an important move for companies seeking world class manufacturing status. TPM can be considered as a comprehensive maintenance strategy. TPM focuses on a total system of maintenance prevention, preventive maintenance, and maintainability improvement (Nakajima, 1989). Moreover, manufacturing performance can be achieved in many ways and one them is through the implementation of Total Productive Maintenance (TPM). There are many widely accepted manufacturing performance indicators such as quality, cost, delivery, and flexibility (McKone, *et al*., 2001).

In addition, Meyer (2004) found that TPM managed to reduce lost capacity by 90%, exceeded 90% of overall equipment effectiveness (OEE), improved the delivery of painted products to assembly areas and reduced the costs significantly. In addition, the role of top management commitment in supporting TPM implementation in manufacturing companies is very important (Ramayah, *et al*., 2002). Top management leadership enables change management application towards TPM implementation and total employee involvement is essential for the success of process.

1.2 An Overview of the Manufacturing Industry in Malaysia

The manufacturing industry in Malaysia became a significant contributor to the country's economy in the beginning of 1960s. Manufacturing can be described as the transformation of raw materials into finished good for sale, or intermediate processes involving the production or finishing of semi-manufactures. The country had been a major producer of raw materials, namely, tin and rubber. The manufacturing sector is now a dynamic and flourishing component of the national economy, accounting for about one third of the gross domestic product (GDP). The current GDP for the year 2010 is shown in Table 1.1.

Table 1.1: Gross Domestic Product by Kind of Economy Activity at Constant 2000 Prices (RM million)

UPDATED AS AT 25 OCTOBER 2010	2010 [3]		2011 [4]	
Pertanian[1] *Agriculture[1]*	41,367	*3.4*	43,238	*4.5*
Perlombongan dan kuari/*Mining and quarrying*	40,654	*1.0*	41,835	*2.9*
Pembuatan/*Manufacturing*	153,750	*10.8*	164,107	*6.7*
Pembinaan/*Construction*	18,173	*4.9*	18,975	*4.4*
Perkhidmatan/*Services*	319,646	*6.5*	336,609	*5.3*
Utiliti/*Utilities*	16,810	8.5	17,750	5.6
Perdagangan borong dan runcit/*Wholesale and retail trade*	74,669	7.4	78,835	5.6
Penginapan dan restoran/*Accomodation and restaurant*	13,621	4.7	14,336	5.2
Pengangkutan dan penyimpanan/*Transport and storage*	21,144	7.0	22,454	6.2
Komunikasi/*Communication*	23,198	7.3	25,262	8.9
Kewangan dan insurans/*Finance and insurance*	65,057	6.3	68,732	5.6
Harta tanah dan perkhidmatan perniagaan *Real estate and business services*	29,911	5.6	31,390	4.9
Perkhidmatan lain[2] / Other services[2]	32,909	4.2	34,702	5.4
Perkhidmatan Kerajaan/*Government Services*	42,327	6.7	43,148	1.9
(-) FISIM yang tidak diagihkan/*Undistributed FISIM*	23,144	*5.8*	24,036	*3.9*
(+) Cukai import/*Import duties*	7,003	*8.7*	7,110	*1.5*
KDNK pada harga pembeli/*GDP at purchaser's prices*	**557,449**	***7.0***	**587,839**	***5.0 ~ 6.0***

[1] Termasuk ternakan dan hortikultur / *Includes livestock and horticulture.*

[2] Perkhidmatan kemasyarakatan, sosial dan persendirian, perkhidmatan swasta tanpa keuntungan kepada isi rumah dan perkhidmatan rumah tangga bagi isi rumah. *Community, social and personal services, private non-profit services to households and domestic services of households.*

[3] Anggaran/*Estimate*

[4] Unjuran/*Forecast*

Source: Ministry of Finance, Malaysia

Statistically, it was reported that the manufacturing sector contributed 31.4% to the GDP, 80.5% to total export and 28.7% to total employment in 2005 (EPU, 2006). Additionally, many manufacturing companies in Malaysia are exporting their products to international markets. For instance, the manufacturing sector had recorded an increased in sales value of 10.9% or RM44.6 billion as against to RM40.2 billion reported for the same month of 2010 (Monthly Manufacturing Statistics, 2011). The manufacturing industries include the following industries: food manufacturing, beverages and tobacco products, paper products, industrial chemicals, plastic products, petroleum products, rubber products, non-metallic mineral products, basic metal industry, fabricated metal products, and transport equipment.

Most of the manufacturing industries are resource-based industries. While timber, textile, leather, machinery, electrical, and electronic products are export oriented industries. The electrical, electronics, and machinery-products industries experienced rapid growth and expansion during the 1970s. Malaysia progressed from assembling electrical goods and machinery to manufacturing a wide range of these products by the 1980s. The electronics industry is the largest in the region, and Malaysia is the leading exporter of semiconductor components to the United States.. Moreover, multinational companies like Intel, AMD, Sony, Sharp, Motorola, and others are well-established with huge amounts of capital investments. Additionally, the electrical and electronic products were the main contributor for Malaysian major exports and were valued at more than RM266 billion in 2007 (Department of Statistics, 2008).

In addition, the manufacturing industry in Malaysia comes under the purview of the Ministry of International Trade and Industry (MITI). Specifically, MITI oversee the promotion and development of the manufacturing sector. In order to promote manufactured exports the government has been established a number of free trade zones, which have provided duty-free access to imported raw materials and semi-finished parts, numerous investment, and export incentives.

1.3 Problem Statement

The global manufacturing industry today is facing many business challenges in the current global financial crisis. Due to this unforeseen circumstance, most manufactures today are going through high demands to ensure cost-effective production without jeopardizing innovation and quality. Organizations are therefore always looking forward to instil efficiencies to sustain large-scale growth and are on constant look out for advanced techniques in improving production techniques. In order to operate efficiently and effectively, manufacturing sectors need to ensure no disruption due to equipment breakdown, stoppages, and failure (Halim and Ramayah, 2010). In fact, reliable equipment is regarded as the main contributor to the performance and profitability of manufacturing systems (Kutucuoglu, *et al*., 2001). Now, the manufacturing sectors in Malaysia have successfully developed and attracted a large number of foreign capital investments to the country.

Of course the high pressured certainly affected the manufacturing industries to keeping up with fast moving technologies advances and in the same time to ensure excellent performance. More sophisticated and advanced machines were utilized and became costly to manufacturers. According to Nakajima, (1989), there are six big losses that can stop equipment from being operated to its full potential, those incurred by breakdowns, set-up and adjustments, idling and minor stoppages, speed reduction, quality defects, and reworks and start-up losses. Hence, the adoption of Total Productive Maintenance (TPM) as one of operation strategy in the manufacturing industries was important to overcome the production losses due to equipment inefficiency.

Introducing TPM in Malaysian manufacturing is still considered a major challenge due to several non-conducive environments in the adoption and implementation process. With the varieties of types of production processes applied in the production floor, the challenge will be greater. Total participation from all employees, especially top management and operators is a key to TPM success. Additionally, the usage of information system to update the data and autonomous and planned maintenance activities are also vital in TPM. Nevertheless, according to McKone, *et al*., (2001), TPM can be thought of as integral to a World Class Manufacturing Strategy along with Just-In-Time (JIT), Total Quality Management (TQM), and Employee Involvement (EI).

Besides, the studies found that TPM will not only be able to enhance maintenance practices but also can lead to improvements in quality, cost, delivery, and flexibility. Therefore, TPM practices are the strategic decision that eliminate any potential of equipment deterioration, failures, breakdowns, and stoppages and also improve manufacturing performance.

1.4 Research Questions

This research is conducted to find the relationship between TPM practices; top management leadership, information system focus, employee involvement, and autonomous and planned maintenance and dependent variable which is manufacturing performance. Based on the facts and issues from the problem statement, this study has structured several research questions:

1. Whether there is a relationship between top management leadership and manufacturing performance?
2. Whether there is a relationship between information system focus and manufacturing performance?
3. Whether there is a relationship between employee involvement and manufacturing performance?
4. Whether there is a relationship between autonomous and planned maintenance and manufacturing performance?
5. Which of the TPM practices are critical predictors of manufacturing performance?

1.5 Research Objectives

The objectives of this research are as the following:

1. To examine the relationship between TPM practices namely top management leadership, information system focus, employee involvement, autonomous and planned maintenance, and manufacturing performance.
2. To find out the critical predictor of manufacturing performance.

1.6 Significance of Study

Increased globalisation is forcing manufacturing companies to implement world class manufacturing techniques through new technology, more production system and production strategies.

On the basis of this research, it should be useful to:

- Top management who address the impact of TPM on manufacturing performance in term of cost, quality, delivery, and flexibility;
- Managers who to allocate limited resources to those areas, which have the most significant contribution to manufacturing performance; and
- Team leaders and team members who should continuously focus on improving their processes.

1.7 Definition of Terms

For the purpose of the study, the following meanings are associated with concepts in the title, the problem statement, and the study as a whole. These concepts have specific definition that need to be understood to develop comprehension of this study.

1.7.1 Total Productive Maintenance (TPM)

Total productive maintenance (TPM) is a resource-based maintenance management system. It focuses on improving equipment effectiveness, productivity, workplace safety and environment issues, and eliminating production losses (Halim and Ramayah, 2010).

TPM also encourages radical changes such as:

- Flatter organizational structures, i.e. fewer managers and empowered teams;
- Multi-skilled workforce; and
- Rigorous re-appraisals of the way things are done, often with the goal of simplification.

1.7.2 TPM practices

There are many definitions of TPM practices as highlighted by various authors (Bamber, *et al*., 1999; Cua, *et al*., 2001; Nakajima, 1989). However, the TPM practices for this study were highlighted in the study by Brah and Chong (2004). The four practices selected were top management leadership, information system focus, employee involvement, and autonomous and planned maintenance.

1.7.2.1 Top Management Leadership

Leadership is the ability to inspire people to make a total, willing, and voluntary commitment to accomplishing or exceeding organizational goals.

1.7.2.2 Information System Focus

Information systems are combination of people, organizations and utilizing technologies to gather, process, store, use and distribute information. Castro, *et al*., (2002) stated that the information system itself is conceived as a collection of (software) modules, entities (e.g., objects, agents), data structures and interfaces.

1.7.2.3 Employee Involvement

Employee involvement is any activity by which employees participate in work-related decisions and improvement activities. Its objective is to tap creative energies of all employees and improve their motivation.

1.7.2.4 Autonomous and Planned Maintenance

Autonomous maintenance is the best practice of operators taking ownership of their equipment and sharing the responsibility for its maintenance with the maintenance department (Nakajima, 1989). This process of transition frees an element of the maintenance role each time these skills are passed from technician and includes the transfer of routines that hold low levels of value-add when this type of work is passed on to operators who benefit from improved ownership of the production process when they are empowered through greater control. While planned maintenance is typically involves the work conducted by highly skilled maintenance technicians.

1.7.3 Manufacturing Performance

The most common dimensions in manufacturing performance are quality, cost, delivery, and flexibility. Therefore, these dimensions will be used in this study.

1.8 Organization of the Study

This paper is organized into five chapters. *Chapter One* - Introduction deals with the view of total productive maintenance (TPM), an overview of manufacturing industries in Malaysia, the problem statement, the objectives, the significance of study, definition of terms, and the organization of the paper.

Chapter Two - Literature Review consists of the theoretical studies of TPM, TPM practices: top management leadership, information system focus, employee involvement, and autonomous maintenance and planned maintenance as well as the manufacturing performance. The hypotheses and theoretical framework are also included in this chapter.

Chapter Three - Research Methodology will describe the variables and measurement, sample, research instrument used, scale of measurement, data collection method and statistical testing and analysis.

Chapter Four - Data Analysis and Findings will describe the data analysis and results of the study.

Chapter Five - Discussion, Conclusion, and Recommendation presents the discussion of the results. It also highlights the implications of the results, limitation of the study and recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter examines the concept of Total Productive Maintenance (TPM) and it impacts on manufacturing performance. TPM will be measure by top management leadership, information system focus, employee involvement, and autonomous and planned maintenance. According to Nakajima (1989), the word “total” in “total productive maintenance” has three meanings that describe the principal features of TPM:

- *Total effectiveness* indicates TPM’s pursuit of economic efficiency or profitability which includes productivity, cost, quality, delivery, safety, environment, health, and morale.
- *Total maintenance system* includes maintenance prevention and maintainability improvement as well as preventive maintenance: It refers to “maintenance-free” through the incorporation of reliability, maintainability and supportability characteristics into the equipment design.
- *Total participation of all employees* includes autonomous maintenance by operators through small group activities: The small group activities promote planned maintenance through “motivation management”.

2.1 Origin and Development of TPM

The concept of Total Productive Maintenance (TPM) was introduced by Nakajima in 1971. Seiichi Nakajima was a vice-chairman of the Japanese Institute of Plant Engineers (JIPE) and the predecessor of the Japan Institute of Plant Maintenance (JIPM). Basically, TPM is a productive maintenance carried out by all employees through small group activities (Fu, 2006). In fact, the TPM actually was integrated from the American-style of productive maintenance. But, the important of this concept was emphasised on total employee involvement and cooperation among various departments in maintenance activities. The innovation approach in TPM is that operators perform basic maintenance on their equipment. In other word, they maintain their machines in good condition and develop the ability to detect potential problems before they generate breakdowns.

Historically, TPM concepts was firstly introduced in Japan and then employed outside Japan. Basically, there have three eras of maintenance in Japan. According to Halim and Ramayah, (2010) the first era known as the preventive maintenance era (1950s), focused on establishing maintenance functions. The second era (1960s) where maintenance prevention, reliability, maintainability engineering took place. While in third era (1970s), total productive maintenance put the emphasis on total employee involvement and top management support.

Overall, Nakajima (1988) has summarized the definition of TPM into five major elements:

1. Overall equipment effectiveness maximization;
2. A through system of preventive maintenance for the equipment's whole life span;
3. Implementation by various departments (engineering, production, maintenance, etc.);
4. Total employee involvement from top management to the workers on the floor; and
5. Motivation management through small group activities and teamwork.

2.2 World Class Manufacturing and TPM

Manufacturing organizations are vehicles for the creation of goods. In current situation, to compete in the global environment, a manufacturing firm must be a world-class organization. Therefore, it is essential that the firm develop an effective manufacturing strategy. The competitive position enjoyed by Japan and some newly industrialized countries, such as Korea, largely depends on their ability to implement effective production technologies. Furthermore, according to Tarek, (2000), the competitive advantage achievement of any country is based on its ability to attract investments and to effectively manage its technological resources.

For instance, a small country like Japan with few natural resources, yet it is one of the world's industrial leaders. Through good strategic planning, the application of innovative production technologies, and excels in the area of quality, Japan's economy now occupies a leading position in the world. Nevertheless, during the last decade, many manufacturing companies have made extensive use of benchmarking activities to determine "best in class" performance for management practices (Todd, 1995). These management practices are termed world-class manufacturing concepts:

- Total Quality Management (TQM);
- Total Productive Maintenance (TPM);
- Just-in-Time Production (JIT);
- Total Employee Involvement (TEI), and
- Continuous Quality Improvement (CQI).

These concepts cover all the components of an effective manufacturing management system. The following brief descriptions are some of the world-class manufacturing concepts that will not be covered in detail in this research paper.

- Total Quality Management (TQM) is a business-wide philosophy which is all about changing attitudes, working practices, values and the overall method of operation of the company. Its overall aim is to improve continuously the operating performance of the business, thus providing better customer service and increased profitability (Davis, 1995).

- Just-In-Time is a manufacturing program with the primary goal of continuously reducing and ultimately eliminating all forms of waste. In simple term, it means producing only what is needed, when needed, and in quantity required. The philosophy behind it was no goods produced without demand.

- Continuous Quality Improvement (CQI) requires that all the world-class manufacturing concepts be continuously improved over their entire life cycle. The main aim of CQI is long-term, incremental improvements that provide evolutionary performance gains.

2.3 Maintenance Concepts

A maintenance concept is defined as the set of various maintenance interventions (preventive, corrective, reliability-centred, condition-based, etc). An explanation of some maintenance concepts is as follows (Wireman, 1991):

2.3.1 Preventive Maintenance (PM)

In this type of maintenance, items are replaced or restored to their optimal working condition before a failure is allowed to occur. This may be based on scheduled, time-based or condition-based PM. The schedule is drawn up on the supplier's recommendation, which usually only considers limited knowledge of the actual conditions. Therefore, it is better to draw from experience.

2.3.2 Reliability-Centred Maintenance (RCM)

RCM is a process used to decide what must be done to ensure that any physical system or process continues to accomplish whatever its users want it to do. What is expected is defined in terms of primary performance parameters, such as output, speed, range, and capacity. Sometimes, the RCM process defines minimum standards, which the users can tolerate in terms of risk (relating to safety and adverse environmental-impact), quality (in terms of precision, accuracy, consistency, and stability), control, comfort, economy, and customer service.

RCM operates through the use of analysis techniques such as:

- Failure modes effect analysis (FMEA);
- Cause and effect analysis; and
- Risk analysis

2.3.3 Condition-Based Maintenance (CBM)

Condition-based maintenance or also called predictive maintenance, forecasts failures through analysis of the condition of the equipment. A number of monitoring techniques are used such as vibration monitoring, thermography, oil analysis, and ferrography. Each of these methods is designed to detect a specific category of faults.

For example vibration monitoring can detect wear, imbalance misaligned components, loosened assemblies or turbulence in a plant with rotational or reciprocating parts. The design may be modified to achieve improved reliability, enhanced maintainability, minimum maintenance resource requirements and so even eliminate the need for routine maintenance. Predictive maintenance is not always appropriate but where it is, it permits the shutdown of machinery before any damage occurs.

2.4 Measurement of TPM Effectiveness

TPM has three objectives which are to achieve zero defects, zero breakdowns, and zero accidents in all functional areas of the organization. The major difference between TPM and other concepts is that the operators are also involved in the maintenance process. TPM effectiveness is measured for two reasons: 1) to help establish priorities for improvement projects and 2) to accurately and fairly reflect their results. When breakdowns and defects are eliminated, equipment operation rates improve, costs are reduced, inventory can be minimized, and as a consequence, labour productivity increases.

2.4.1 Maximizing Equipment Effectiveness

All factory are aim to increase productivity by minimizing input and maximizing output. Output refers not only to increased productivity but also to better quality, lower costs, timely delivery, improved industrial safety and hygiene, higher morale, and a more favourable working environment (Nakajima, 1989). Furthermore, Nakajima, mentions that TPM maximizes equipment effectiveness through two types of activity:

- *Quantitative:* increasing the equipment's total availability and improving its productivity within a given period of operating time;
- *Qualitative*: reducing the number of defective products, stabilizing, and improving quality.

From a generic perspective, TPM can be defined in terms of overall equipment effectiveness (OEE) (Dal, *et al*., 2000). OEE provides an effective way of measuring and analysing the efficiency of a single machine/cell or an integrated manufacturing system. It also used as a driver for improving performance of the business by concentrating on quality, productivity, and machine utilization issues. Besides, it is aimed at reducing non-value adding activities, often inherent manufacturing processes.

2.4.2 Six Big Losses

Chronic and random disturbances in the manufacturing process result in different kinds of waste or losses. These can be defined as activities which absorb resources and create no value. The objective of overall equipment effectiveness (OEE) is to identify these losses. Equipment effectiveness is maximized through company wide efforts to eliminate the following "six big losses" that reduce equipment effectiveness.

Nakajima (1989) classifies these six big losses as shown in the table below.

Table 2.1: The Six Big Losses

Loss Categories	**Six Big Losses**
Downtime (Lost availability)	- Equipment failure - Setup and adjustment (e.g. exchange of die in injection moulding machines, etc.)
Speed losses (Lost performance)	- Idling and minor stoppages (abnormal operation of sensors, etc.) - Reduced speed operation (discrepancies between designed and actual speed of equipment)
Defect losses (Lost quality)	- Scrap and rework - Start-up losses (reduced yield between machine start-up and stable production)

Source: Nakajima, (1989)

2.5 TPM Practices

Many literatures such as (Nakajima, 1988, 1989; Brah and Chong, 2004; McKone, *et al*., 2001; Takahashi and Osada, 1990; Tsuchiya, 1992) proposed many critical success factors of TPM. The comparison leads to the identification of autonomous maintenance and planned maintenance, equipment technology emphasis, committed leadership, strategic planning, cross-functional training and employee involvement as the most commonly cited practices of TPM.

2.5.1 Top Management Leadership

The role of top management in an organization is very crucial for the successfully of TPM implementation. It was noted in many literatures of its influences over successful TPM implementation (Tsang and Chan, 2000). Henry Mintzberg's in his research identifies three major categories of roles that managers must be prepared to enact. Those are interpersonal roles, informational roles, and decisional roles. Each of those roles derives from the manager's position of formal authority in the organization and involves a number of distinct action responsibilities. For example, managers have to motivate subordinates and integrate their needs with those of the organization. However, in some views believed that both strong leadership and strong management as necessary for optimum organizational effectiveness.

Broadly, leadership is defines as the ability to influence a group toward the achievement of goals. The source of this influence may be formal, such as that provided by the possession of managerial rank in an organization. Even thou, the management not directly involved in operation and maintenance activities, but they are responsible in directing, promoting and providing a favourable work environment. Nakajima, (1988) said that "TPM cannot be implemented if top management fails to provide the psychological and physical environment that promotes true participative management". The psychological environment requires 1) an escape from authoritarian management system and 2) changes in company structure to promote participative management.

It was a management commitment to employees, which provided the foundation for mutual trust, concern, and fairness. On the other hand, the physical environment is when management improving the factory condition and environment such as provide a specific place for maintenance team (e.g. handling meeting). An enthusiastic top management would build a lounge in the factory for use as meeting room. In addition, TPM requires a drastic change in the traditional mindset of work culture and maintenance approaches. It is a long journey that demands commitment and investment before its show the result in at least five years. Therefore, active support from top management is vital to overcome resistance from the operators and as well as the maintenance personnel, especially during the transition period (Fredendall, *et al*., 1997).

Eliminating such resistance requires preliminary education and training at every level; managers, group leaders, engineers, and employees on the shop floor. Therefore, management leadership plays a critical role in convincing employees of the importance of TPM.

2.5.2 Information System Focus

The emerging of new global economy and communication technology is the major driven of businesses to growth. Large corporations and small and medium enterprises (SMEs) are taking the opportunity to expand their business using information technology (IT). IT gives tremendous impact to the business world and change the way of managing business operations. In addition, the impact of information technology (IT) use on performance and other organization outcomes is an important topic to both practitioners and academics. During the 1970s and 1980s, manufacturers began adopting IT to automate plant operations. Companies that fail to cope with the changes in latest technology are most likely to leave behind in the competitive market.

According to Hill (2009) information technology is concerned with improvements in a variety of human and organizational problem-solving endeavours through the design, development, and use of technologically based systems and processes that enhance the efficiency and effectiveness of information in a variety of strategic, tactical, and operational situations. While information systems are the combination of people, organizations, and system by utilizing technologies to gather, process, store, use, and distribute information. In TPM, information system focus handles the issue of the use of information in the company to analyze performance of employees, machines, and management in the TPM plan. Suzuki (1992) stated that a good information system benefits TPM implementation and it is supported by McKone, *et al*., (1999) and Brah, *et a*l., (2002).

Furthermore, managing a manufacturing operation includes a wide range of activities ranging from production planning and control, material sourcing to production scheduling, logistics, and distribution network optimization, evidenced with the necessary information flows within and between departments and firm, which are supported by relevant information systems. Most manufacturing firms implement various information system practices to improve operational performance. Traditionally, the statistical process control (SPC) is used to monitor the stability of a process and to detect the non-stable factors (out-of-control activities). If assignable causes such as unskilled workers and maintenance problems are present, then a change to the mean or variance of the process is indicated. Besides, SPC has proven to be effective for monitoring the stability of a process.

2.5.3 Employee Involvement

Many companies have come to recognize that employees can contribute significantly to the organization when they are allowed to participate in decisions that impact their area of responsibility (McKone, *et al*., 1999). Employee involvement is evident in initiatives, such as quality improvement teams and employee suggestion programs that support both JIT and TQM programme. Employee involvement is also critical to successful implementation of TPM. As mention earlier by Nakajima, (1989), total productive maintenance comprises three principles feature which are total effectiveness, total maintenance system, and total participation of all employees. These three are the foundation of TPM programme.

Despite of top management leadership is essential for TPM success, it is not enough without the involvement of employees. According to Tsang and Chan, (2000), TPM embraces empowerment to production operators establishing a sense of ownership in their daily operating equipment. The operators, who are most familiar with the daily operation of the equipment, and the maintenance personnel, who are most familiar with the technical specifications and long run performance of the equipment are the greatest sources of information for companies that want to improve their equipment performance.

Moreover, Tajiri and Gotoh, (1992) claims "the TPM programme promotes operator involvement by preparing operators to become active partners with maintenance and engineering personnel in improving the overall performance and reliability of the equipment" (p.20, 53). Both operating and maintenance technicians understand the equipment and can receive both short and long term benefits from reliable equipment. Therefore, the basic principle of TPM is to let a sense of responsible among operators towards their own machine equipment by cleaning and maintaining it.

Most importantly, it is based on the beliefs that shop floor operators have the most hands-on experience with the machines they operate daily (One, *et al*., 2005). Involvement from all employees allows companies to make better use of its available resources.

2.5.4 Autonomous and Planned Maintenance

TPM provides a comprehensive company-wide approach to maintenance management, which can be divided into long-term and short-term elements. An autonomous and planned maintenance are classified as a short-term approach. In fact, an autonomous maintenance programme is for the production department while a planned maintenance programme for the maintenance department.

According to McKone, *et al*., (1999), there are seven elements of TPM: four elements of autonomous maintenance - *housekeeping* on the production line, *cross-training* of operators to perform maintenance tasks, *teams* of production and maintenance personnel, and *operator involvement* in the maintenance delivery system; and three elements of planned maintenance - *disciplined planning* of maintenance tasks, *information tracking* of equipment and process condition and plans, and *schedule compliance* to the maintenance plan. Typically, the usual pattern applied in factory was the thinking "I operate – you fix" where the separation of job, responsibility, and also mentality take places.

However, Nakajima, (1989) said that an autonomous maintenance creates a system of regular preventive maintenance cycles by the team to support the conversion process by cleaning, lubricating, and inspecting the assets under the control of the team in a pre-defined and timely manner. In other words, "I'm responsible for my own equipment". All employees must agree that operators are responsible for the maintenance of their own equipment. The benefits of this activity include the transfer of vital skills from maintenance technicians to the teams, the creation of discipline, and control in the organization and maturation of the team-development process (Nakajima, 1989).

In other words, through autonomous maintenance, operators learn to carry out important daily tasks that maintenance technicians rarely have time to perform. Nevertheless, this cooperative effort allows maintenance personnel to focus their energies on the tasks that demand their technical expertise more.

Oppositely, planned maintenance basically involves the work conducted by highly skilled maintenance technicians. As more tasks are transferred to operators through autonomous maintenance, the maintenance department is able to develop a disciplined planning process for maintenance tasks, such as equipment repair/replacement, and on determining countermeasures for equipment design weakness (Nakajima, 1988; Suzuki, 1992).

2.6 Manufacturing Performance

There are many different ways of measuring manufacturing performance. The traditional measures of manufacturing performance focused on three issues (Rich, 1999):

1. ***Asset utilization*** which was targeted at 100 per cent or the highest possible level to ensure that the production time was maximized and that a stream of products could be placed in the distribution channel to the customer.
2. ***Labour utilization*** was also set 100 per cent or the maximum to ensure that the legions of production personnel were occupied making products for the amount of time they spent in the factory.
3. ***Low material costs and usage*.** This meant that the costs of materials were kept low by maximizing the use of all materials within the adaptation process and through buying from the lowest piece-part-price supplier.

These traditional measures of manufacturing performance are opposed to the objectives of TPM. It allows for a culture to be developed which limited and detached from the commercial requirements of the business (Rich, 1997). Currently, according to many literatures, the most predominant approach used for this study is cost, quality, delivery, and flexibility.

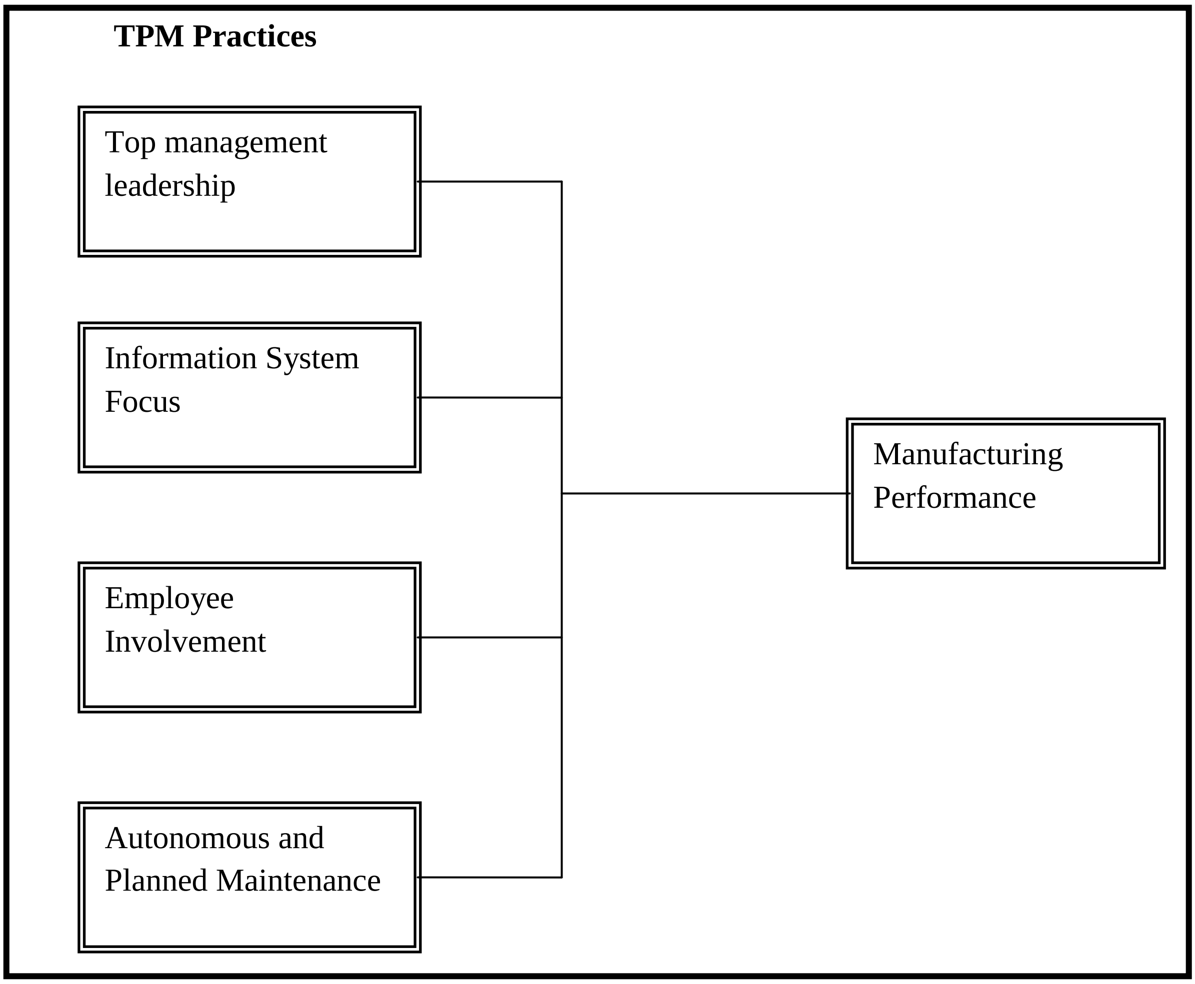
The further elaboration as follows:

- ***Cost:*** This is the economic cost associated with inventories as well manufacturing cost measured as a percentage of sales. A high inventory turnover ratio indicates a low cost position;
- ***On-time delivery and speed of delivery performance*** are measures which are indicative of a plant's ability to deliver quickly and as promised;
- ***Quality***: In this instance, conformance to quality is considered; and
- ***Flexibility***: This reflects an organization's capability to make changes.

The use of these measurements can be traced back to Schroeder, (1993) and Ward, *et al*., (1995). These authors support TPM's positive influence and its ability to enhance the technology base of the organization which leads to improved manufacturing performance. Additionally, in some studies, these dimensions have been expanded to include several additional measures.

2.7 Theoretical Framework

Figure 2.1: Research Framework



The framework showed in Figure 2.1 has been developed based on literature review and research problems. This model focuses on the relationship and influence of TPM practices on manufacturing performance. In this study, there are two variables, which are independent variables (IV) and dependent variables (DV). The IV includes top management leadership, information system focus, employee involvement, and autonomous and planned maintenance while the DV of this study is manufacturing performance.

2.8 Hypothesis Development

Based on the research objectives and research model, four hypotheses have been structured. The hypotheses that will be tested in this study are as below:

Hypothesis 1

Ho1: There is no significant relationship between top management leadership and manufacturing performance.

Ha1: There is a significant positive relationship between top management leadership and manufacturing performance.

Hypothesis 2

Ho2: There is no significant relationship between the information system focus and manufacturing performance.

Ha2: There is a significant positive relationship between information system focus and manufacturing performance.

Hypothesis 3

Ho3: There is no significant relationship between employee involvement and manufacturing performance.

Ha3: There is a significant positive relationship between employee involvement and manufacturing performance.

Hypothesis 4

Ho4: There is no significant relationship between autonomous and planned maintenance and manufacturing performance.

Ha4: There is a significant positive relationship between autonomous and planned maintenance and manufacturing performance.

2.9 Summary

This chapter explains the conceptual part of the study. It described the details about Total Productive Maintenance (TPM) and its practices: top management leadership, information system focus, employee involvement, and autonomous and planned maintenance. Through the literature review, TPM has been identified as a strong contributor to the strength of the organization and has the ability to improve manufacturing performance. In addition, it also precisely indicated the measurement for the TPM practices and manufacturing performance. The following chapter will discuss on the research methodology of this study in details.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

In this section are discussed the research design, data collection method, development of questionnaires, sampling design and technique. It also includes the measurement that used for the data collected. The purpose of this chapter is to explain the research design and methodology that has been followed to reach the conclusion of the research topic.

3.1 Research Design

Research design can be defined as the overall plan for relating the conceptual research problem to relevant and practicable empirical research (Ghauri and Gronhaug, 2002). The research is based on a descriptive study. The key characteristics of descriptive research are structure, precise rules, and procedures. It is normally used to describe the characteristics of certain groups, population, or phenomenon. For example, a profile study of people that goes to Bank Islam. The assumption in this type of research is that the relevant secondary data is not available and the researcher plans to collect data by a survey using questionnaires, personal interviews or observations.

There are two sources of data available for this research; primary data and secondary data.

The primary source means the data that is collected for a specific purpose from original source. Dunsmuir and Williams, (1992) categorized the questionnaires, interviews, and observations as the most common primary research sources. For this study, the questionnaires survey was selected as it was an inexpensive way to gather data from a potentially large number of respondents (Zikmund, 2000) and also it is the common and popular method to collect data. On the other hand, secondary data are statistics not gathered for the immediate study at hand but for some other purpose. There are several sources of secondary or external data, including books, the media, census data, and so on (Cavana, *et al*., 2000). Most of the data collected in this research are from several electronic databases such as Emerald Fulltext, ScienceDirect, Proquest, and also from academic journals like Journal of Operations Management, International Journal of Production Research and so on.

Quantitative data collection and analysis method was used for the study. Quantitative research is research involving the use of structured questions where the response options have been predetermined and a large number of respondents are involved. The measurement will be objective, controllable, and statistically valid. Moreover, this study is investigated correlations between TPM practices (independent variables) and manufacturing performance (dependent variables). The cross-sectional design is used for this research because the time constraint and less cost. It is a structured observation on a sample for a single period only. Furthermore, this cross-sectional study tested all hypotheses that related to the research questions.

3.2 The Sampling

Sampling is the process of selecting a sample from a population using scientific procedure (Cavana, *et al*., 2000). According to Sekaran, (2003), population can be referred to the entire group of people, events, or things of interest that can be a focus for the researcher to investigate. Based on the objectives of the study, the population of this study was drawn from database of the manufacturing companies registered under the Federation of Malaysian Manufacturers' (FMM) Directory. The sampling frame of this study was the manufacturing companies from various industries situated in Northern regions of Malaysia. 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 TPM practices and manufacturing performance.

Determining the size of the sample is a complex issue. Generally, the bigger the sample size the more accurate will be the result of the research in terms of the increased level of confidence. But a bigger sample size consumes a higher cost for the research. Krejcie and Morgan (1970) have come out with a table (refer Table 3.1) for determining sample size and it is applicable to any population of a defined (finite) size. The symbol **N** represents the total population and **n** is the sample size. As referred to the FMM directory, it is estimated 120 companies with TPM implementation and the sample size needed is 92.

Table 3.1: Table for Determining Sample Size from a Given Population

N-n	N-n	N-n	N-n	N-n
10 - 10	100 – 80	280 - 162	800 - 260	2800 - 338
15 - 14	110 – 86	290 - 165	850 - 265	3000 – 341
20 - 19	120 – 92	300 - 169	900 - 269	3500 – 346
25 - 24	130 – 97	320 - 175	950 - 274	4000 – 351
30 - 28	140 – 103	340 - 181	1000 - 278	4500 – 354
35 - 32	150 – 108	360 - 186	1100 - 285	5000 – 357
40 - 36	160 – 113	380 - 191	1200 - 291	6000 – 361
45 - 40	170 – 118	400 - 196	1300 - 297	7000 – 364
50 - 44	180 – 123	420 - 201	1400 - 302	8000 – 367
55 - 48	190 – 127	440 - 205	1500 - 306	9000 – 368
60 - 52	200 – 132	460 - 210	1600 - 310	10000 – 370
65 - 56	210 – 136	480 - 241	1700 - 313	15000 – 375
70 - 59	220 – 140	500 - 217	1800 - 317	20000 – 377
75 - 63	230 – 144	550 - 226	1900 - 320	30000 – 379
80 - 66	240 – 148	600 - 234	2000 - 322	40000 – 380
85 - 70	250 – 152	650 - 242	2200 - 327	50000 – 381
90 - 73	260 – 155	700 - 248	2400 - 331	75000 – 382
95 - 76	270 – 159	750 - 254	2600 - 335	100000 – 384

Note: Required sample size, given a finite population, where N=population size and n=sample size.

Adopted from Krejcie, R.V. & Morgan, D.W. (1970). Determining sample size for research activities. Educational & Psychological Measurement, 30, 607-610.

3.3 Data Collection Method

Previously, in the research design clearly clarified that this research was a quantitative in nature and the best method to collect data was through a survey. A survey has many advantages such as easy to get feedback from respondents in a short time because the suitable answers were provided. Meanwhile, it also reduces the tendency of bias as the researcher doest not participate directly to the respondents' answers. Indeed, the structure and simple questionnaires were design to answer the research questions and achieve its objectives. With an attachment of recognition letter from university, the selected respondents have been distributed the structured questionnaire to be answer through e-mails and by hands to 100 companies located in Northern regions of Malaysia (e.g. Kedah, Penang, and Perak).

Nonetheless, most of the distribution was done through e-mails as the factor of location and cost were taken into consideration. Additionally, a period of two weeks was given to each company for completing the questionnaires. It is noted that ample time was needed by the companies in order to complete the questionnaires. After one week, the companies are reminded again about the surveys. All the e-mails were sent to the people related to operation, maintenance, production, quality, and to whom that experience directly on the TPM practices within the companies.

3.4 The Development of Questionnaires

The questionnaires design is simple, easy to understand and not required much time of the participants to answer it. The development of the survey questionnaires was guided by the supervisor. The questionnaire consists of six sections, each collecting a specific type of information. These six sections were divided into three major parts as follows:

3.4.1 PART 1: Demographic profile

This part represents by Section A. There are 7 questions in this section. Section A gathers information on the demographic profile of the respondents (e.g. types of company, years of operation, ISO certification, number of employees, annual sales turnover, the category of industry involved, and the position of participant). There is one dichotomous question in this section which is whether the company has ISO certification. The answer is only two alternatives listed: Yes or No. Whereas, the rest of questions were the multichotomous questions which have more than two alternative answers. The respondent is asked to choose the alternative that most closely corresponds to his position on the subject. Usually, the respondent would be instructed to check the box or boxes that apply.

3.4.2 PART 2: Independent Variables

In part 2, there are four sections which are Section B, C, D and E that represents the four TPM practices (independent variables). It comprises 23 questions. These factors help to assess the relationship between TPM practices and manufacturing performance. Section B has 5 questions that focused on first variable which is top management leadership. The objectives of the questions are to know the involvement of higher management people on the implementation of TPM in their plants and how these people support are influenced the performance of plants. Section C would be the second variable; information system focus. It has 5 questions describing the use of information system that helps in collecting the data on productivity improvement.

Next, Section D with a total of 5 questions covers the third variable which is employee involvement. In TPM, the employee involvement is the fundamental factor in achieving the goals of the programme. Without the participation of employees, the TPM programme is useless. Nevertheless, the last section E, indicates of 8 questions on autonomous and planned maintenance. This variable is the TPM most basic practices. The first four questions in this section represent a planned maintenance while the others four are about an autonomous maintenance.

In addition, most of the scales in these sections were standardized to five-point Likert scales. Likert scales are used to get people's attitudes by asking them the extent of their agreement or disagreement with a series of statements about an issue:

1 = Strongly Disagree

2 = Disagree

3 = Neither Disagree nor Agree

4 = Agree

5 = Strongly Agree

3.4.3 PART 3: Dependent Variable

Section F measures the performance of the respondent's company. There are 20 questions in this section. The manufacturing performance is categorized into four elements which are cost, quality, delivery, and flexibility with in each element comprises 5 questions. However, for section F the five-point Likert scales used was:

1 = No Improvement

2 = Little Improvement

3 = Neither Both

4 = Big Improvement

5 = Very Big Improvement.

The summary of questionnaires development is as shown in Table 3.2

Table 3.2: Summary of Questionnaire

VARIABLE	NO. OF QUESTIONS	ITEMS
PART 1		
Section A		
Demographic Profile		
Types of company	1	7 Questions
Years of operation	2	
ISO certification	3	
Number of employees	4	
Annual sales turnover	5	
Category of industry involved	6	
The job position	7	
PART 2		
Section B		
Top management leadership	8 - 12	5 Questions
Section C		
Information system focus	13 - 17	5 Questions
Section D		
Employee involvement	18 - 22	5 Questions
Section E		
Autonomous and planned maintenance	23 - 30	8 Questions
PART 3		
Section F		
Manufacturing performance	31 - 50	20 Questions

3.5 Validation of Instrument

Although the questionnaires used were adapted from other sources and had been tested, since some of the questionnaires had been modified, a pilot study was conducted in order to determine the validity and reliability of the instruments. The reliability of the instrument was tested using Cronbach's Alpha. According to Sekaran (2003) Cronbach's Alpha is a reliability coefficient that reflects how well the responses of related items in a set are positively correlated to one another. The closer Cronbach's Alpha is to 1, the higher the internal consistency reliability. More specifically, George and Mallery, (2003) provides the following rule of thumb:

> "_>.9 = Excellent, _>.8 = Good, _>.7 = Acceptable, _>.6 = Questionable, _>.5 = Poor, and _<.5 = Unacceptable" (p.231).

A pilot test was carried out with a random sample of 30 respondents. The data from the pilot study showed that the instrument was reliable with Cronbach's Alpha value as referred to the Table 3.3.

Table 3.3: Reliability Statistic for the Pilot Test

Variables	Number of Item	Cronbach's Alpha
Top Management Leadership	5	0.832
Information System Focus	5	0.749
Employee Involvement	5	0.716
Autonomous and Planned Maintenance	8	0.814
Manufacturing Performance	20	0.963

3.6 Data Analysis Method

All the data collection for this study will be processed through the usage of Statistical Package for the Social Sciences (SPSS) version 15.0. Some of the data analysis method that can be used to test the data such as frequencies distribution, t-test, one-way analysis of variance (ANOVA), correlation, and multiple regression analysis. Furthermore, the two statistical techniques were used:-

3.6.1 Descriptive Statistic

Descriptive statistic can be used to describe the sample pattern. The frequencies, percentage, mean and standard deviations provide descriptive information of a set of data. Frequencies in which the number of times various subcategories of a phenomenon occur and percentages of the profile of respondent were computed and reported. Descriptive analysis will be based on various demographic factors of respondents such as type of company, number of employees, type of industry, and others. Mean is calculated to measure the importance of each of them respectively.

3.6.2 Correlation Coefficients Analysis

Correlation coefficients analysis is utilized to examine the data and test the hypothesis. The scale is used to describe the intensity of relationships between the dependent and the independent variables of the study. The correlation coefficient's value indicates the strength of the relationship which can be from -1 to +1. The sign (- or +) indicates the direction of the relationship.

3.7 Summary

In this chapter, the research design, the sampling, and data collection was explained in details. In fact, the pilot test conducted showed that the data provided were reliable and valid to be used as instrument for the study. It also stated some of the analysis techniques that will be used in analyzing the data. The empirical study and the finding will be presented in the next chapter.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.0 Introduction

The aim of this chapter is to present the data analysis and findings of the relationship of Total Productive Maintenance (TPM) practices and manufacturing performance. The analysis tools from SPSS software were used to analyze the data collection. Some of the tools commonly used to analyze the research data are reliability analysis, correlations, regression analysis, t-test, ANOVA and descriptive statistics such as frequencies, means and standard deviation.

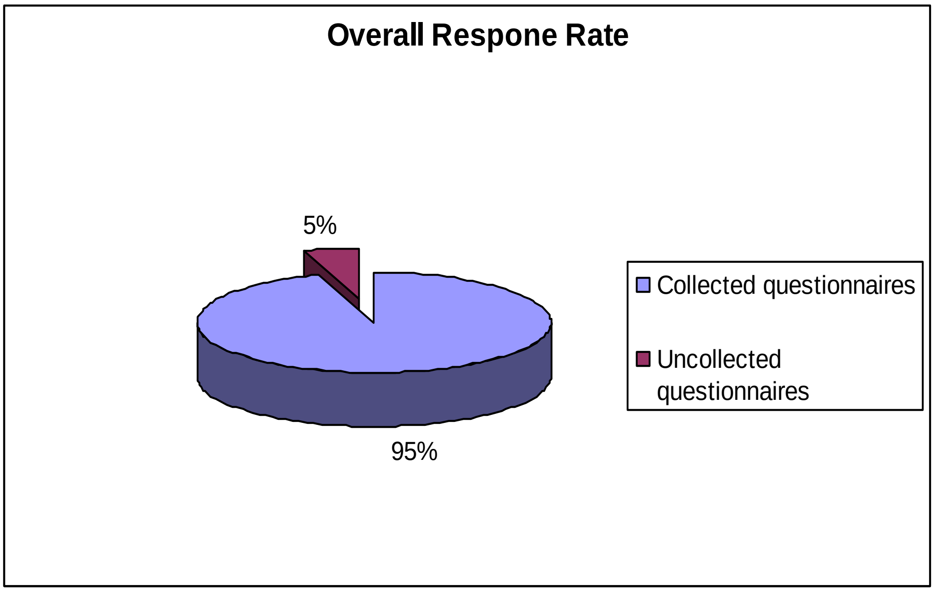
4.1 Respond Rate

The totals of 100 questionnaires are distributed to 100 manufacturing companies in Northern region of Malaysia (e.g. Kedah, Perak, and Penang). The companies are from various industries such as electrical/electronic, food products, machinery, transport, textile, plastic and others. The main focus in the selection of companies is based on the ISO certification gains by companies. It is assumed that those ISO companies are implementing the programmes that improves the quality, production, and performance such as Total Quality Management (TQM), Just-in-time (JIT), and Total Productive Maintenance (TPM).

In addition, the questionnaires are not equally distributed according to the industries. It had been circulated randomly. From 100, only 95 questionnaires had been answered and returned. All 95 questionnaires are accepted to be analyzed without rejection. The summarization of the details is as in table 4.1.

Table 4.1: Overall Response Rate

	Total	**%**
Questionnaire circulated	100	100
Collected questionnaires	95	95
Uncollected questionnaires	5	5
Usable questionnaires	95	95
Rejected questionnaires	-	-



Source: Table 4.1-Converted to Pie Chart

4.2 Reliability Analysis

Reliability analysis is "the degree to which measures are free from random error and therefore yield consistent results" (Zikmud, 2000). Table 4.2 was shown the reliability analysis done for all 95 questionnaires collected for the study.

Table 4.2: Reliability Analysis

Variables	Number of Item	Cronbach's Alpha
Top Management Leadership	5	0.867
Information System Focus	5	0.709
Employee Involvement	5	0.751
Autonomous and Planned Maintenance	8	0.798
Manufacturing Performance	20	0.940

There are five variables have been tested for its reliability. Among other independent variables, top management leadership obtain the highest cronbach alpha value which is 0.867 and followed by autonomous and planned maintenance, 0.798. Whereas, the other two independent variables; employee involvement and information system focus acquire 0.751 and 0.709 respectively. It is observed from the result that all the cronbach alpha values are approaching the higher internal consistency reliability with manufacturing performance was the highest. Basically, it indicates how well the responses from the questionnaires are positively correlated with each other.

4.3 Descriptive Analysis

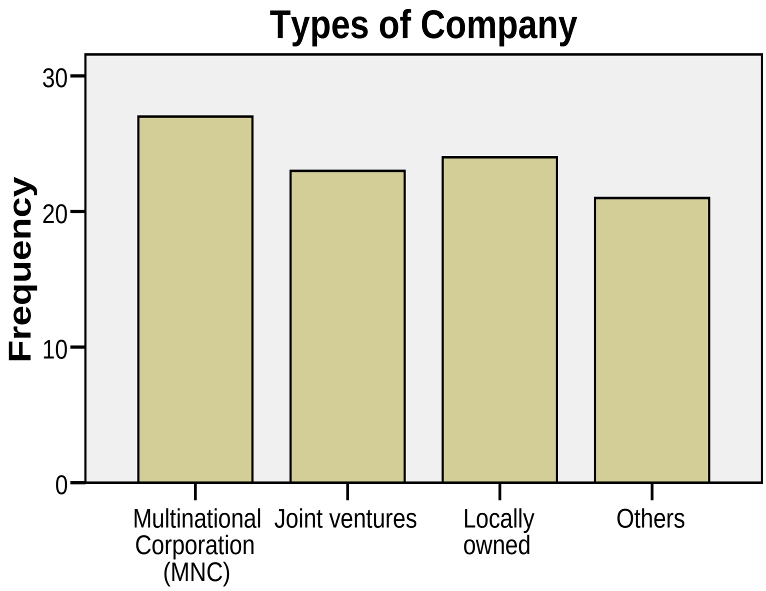
Descriptive analysis is used to show the frequency, mean, median, standard deviation, and etc. of the data sample. The researcher interest is to know the frequencies, to show the comparison between different groups or categories of respondents, and the extent of variability in the set of study. Furthermore, it is commonly used to analyze the demographic data of the research. The demographic profile for this study consists of types of company, years of operation, ISO certification, number of employees, annual sales turnover, the industry types, and the position of the respondents.

4.3.1 Types of Company

Table 4.3 below shows the types of company where the questionnaires are distributed. There is not much difference in term of the frequency. Mostly, the respondents selected are multinational corporation (MNC) with (27 companies or 28.4%) of total distribution. It followed by the locally owned company (25%), joint ventures (24.2%), and others (22.1%). The data is also converted to bar chart below for better observation.

Table 4.3: Types of company

	Frequency	Per cent
Multinational Corporation (MNC)	27	28.4
Joint ventures	23	24.2
Locally owned	24	25.3
Others	21	22.1
Total	95	100.0



Source: Table 4.3 – Converted to Bar Chart

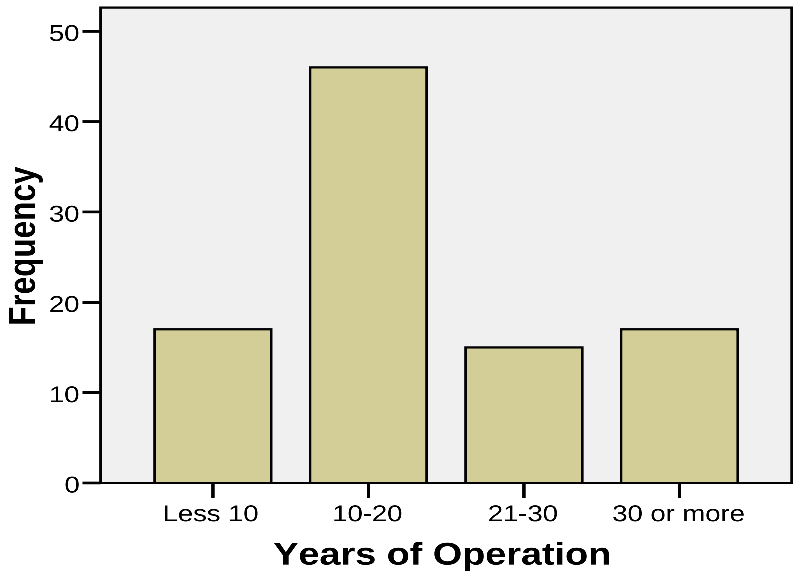
4.3.2 Years of Operation

Based on the data collection in Table 4.4, 46 of manufacturing companies are operated within a range of 10 to 20 years. It is accumulated of 48.4% overall. Additionally, (17 companies or 17.9%) are still new or fresh start-up in the industry with operation year less than 10. Besides, the same result was also shared for the establish companies in the industry with 30 or more years of operation. The rest of companies are operated for about 21 to 30 years.

Table 4.4: Years of Operation

	Frequency	Per cent
Less 10	17	17.9
10-20	46	48.4
21-30	15	15.8
30 or more	17	17.9

Total	95	100.0



Source: Table 4.4 – Converted to Bar Chart

4.3.3 ISO Certified Company

Overall, majority of the companies have the ISO certification while only (11 companies or 11.6%) without ISO certification. The result is shown as the following:

Table 4.5: ISO Certification

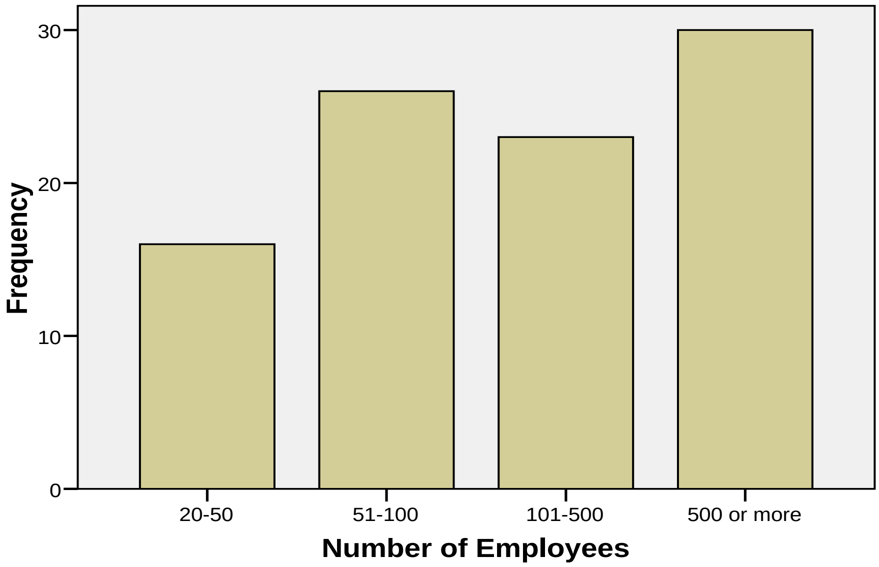
	Frequency	Per cent
Yes	84	88.4
No	11	11.6
Total	95	100.0

4.3.4 Number of Employees

In the Table 4.6 indicates the number of employees in a company. The result shows that (31.6% or 30 of companies) have a total of 500 or more employees. While (26 companies or 27.4%) are hired around 51 to 100 employees as compared to another 23 companies which have more than 100 but not less than 500 people. In fact, there is a small portion of companies with a small number of employees between 20 and 50 people.

Table 4.6: Number of Employees

	Frequency	Per cent
20-50	16	16.8
51-100	26	27.4
101-500	23	24.2
500 or more	30	31.6
Total	95	100.0



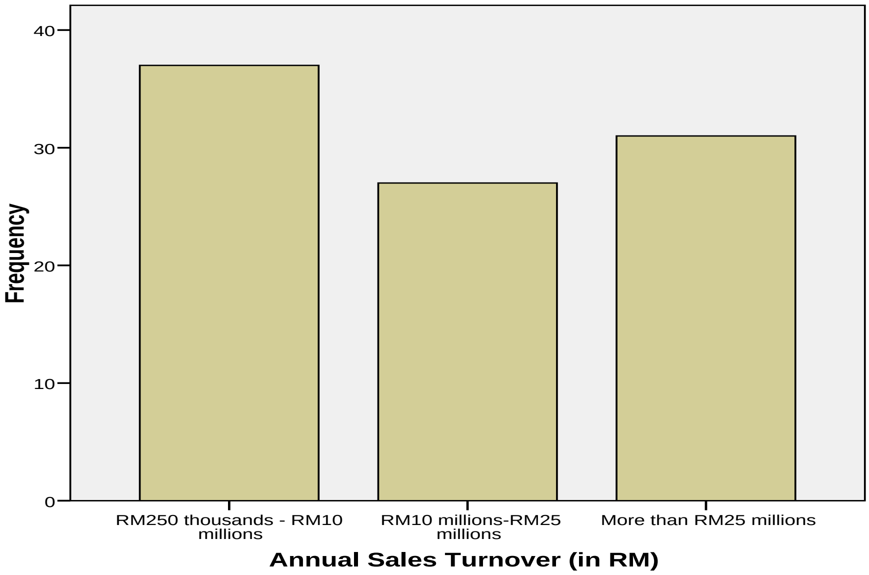
Source: Table 4.6 – Converted to Bar Chart

4.3.5 Annual Sales Turnover

From the information gathers on the gains the companies made yearly, most companies sales are around RM250 thousands to RM10 millions. It is about 38.9% or 37 out of 95 companies. Moreover, 27 companies or 28.4% gains profit more than RM10 million and not less RM25 millions. Instead of that 31 more companies have more than RM25 millions sales turnover annually.

Table 4.7: Annual Sales Turnover (in RM)

	Frequency	Per cent
RM250 thousands - RM10 millions	37	38.9
RM10 millions-RM25 millions	27	28.4
More than RM25 millions	31	32.6
Total	95	100.0



Source: Table 4.7-Converted to Bar Chart

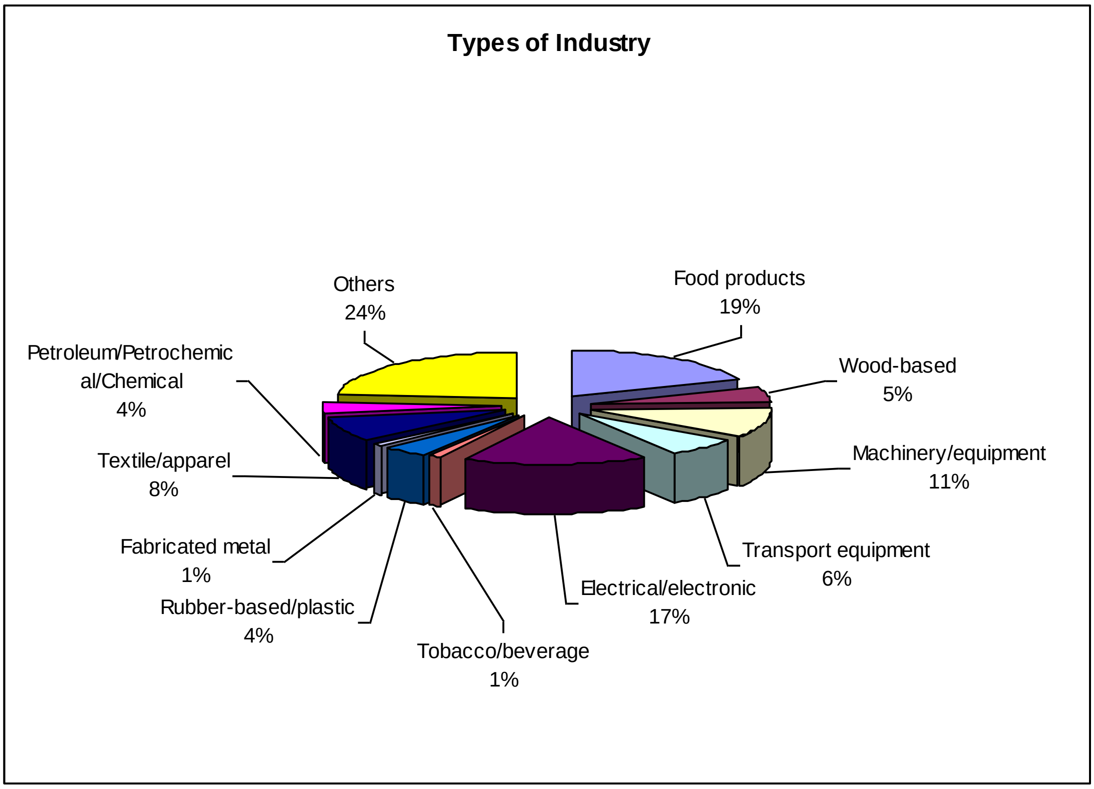
4.3.6 Types of Industry

According the questionnaires, there are 13 industries listed. Based on the Table 4.8 below, the highest score is the respondents from other industries which consume 23.2% or 22 companies. Another 3 industries with higher frequency are food products (18 companies or 18.9%), electrical/electronic (16 companies or 16.8%), and machinery/equipment (10 companies or 10.5%). In addition, there are 8 respondents from textile/apparel industry and 6 respondents from transport equipment industry. The rest are scores below 5 respondents.

Table 4.8: Types of industry

	Frequency	Per cent
Food products	18	18.9
Wood-based	5	5.3
Machinery/equipment	10	10.5
Transport equipment	6	6.3
Electrical/electronic	16	16.8
Tobacco/beverage	1	1.1
Rubber-based/plastic	4	4.2
Fabricated metal	1	1.1
Textile/apparel	8	8.4
Petroleum/Petrochemical/Chemical	4	4.2

Others	22	23.2
Total	95	100.0



Source: Table 4.8-Converted to Pie Chart

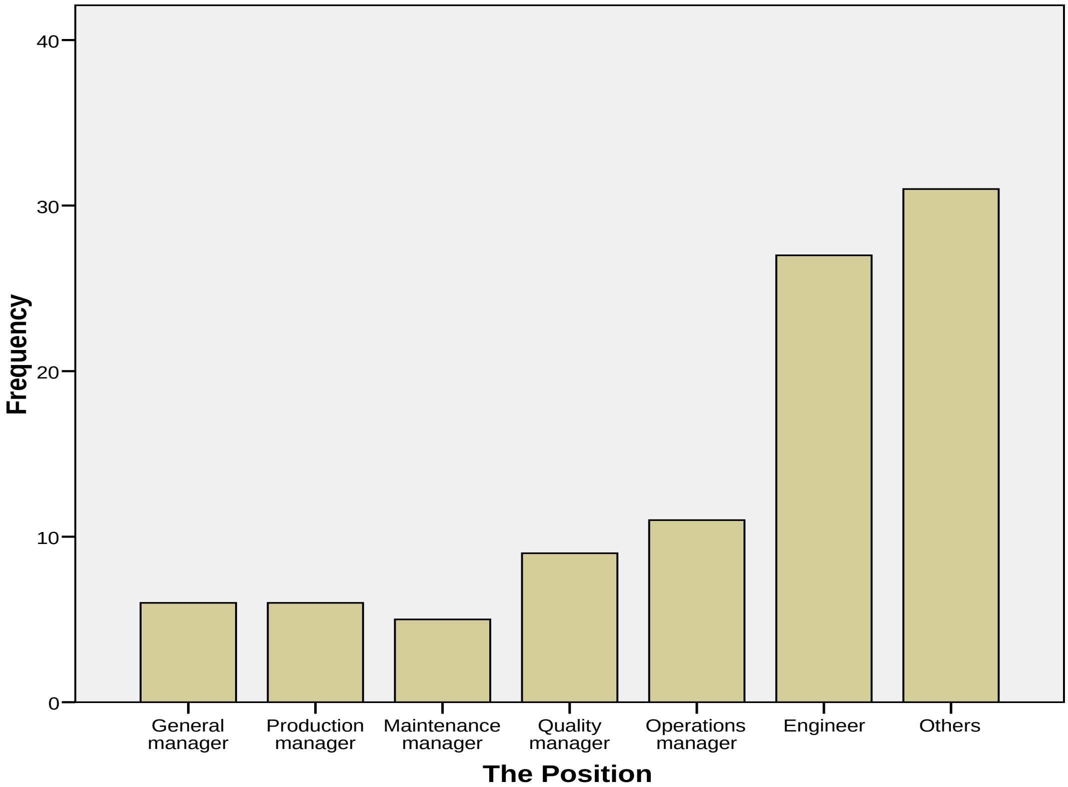
4.3.7 The Position

This is the last question in demographic profile of the questionnaire. It is to indicate the position of the respondents in the companies. The Table 4.9 accumulates the results from the surveys. 31 or 32.6% of respondents answered the surveys are working in other than listed position. Majority of candidates are an engineer with 28.4% and operations manager with 11.6%. It is followed by quality manager (9.5%

or 9 respondents), general manager (6.3% or 6 respondents), production manager (6.3 or 6 respondents), and maintenance manager (5.3% or 5 respondents).

Table 4.9: The position

	Frequency	Per cent
General manager	6	6.3
Production manager	6	6.3
Maintenance manager	5	5.3
Quality manager	9	9.5
Operations manager	11	11.6
Engineer	27	28.4
Others	31	32.6
Total	95	100.0



Source: Table 4.9 – Converted to Bar Chart

4.4 The Analysis of Mean Scores

This analysis is to determine the variables that most influence in the manufacturing performance. The highest means score according to Table 4.10 is autonomous and planned maintenance with 30.93. This shows that among the four variables, respondents recognized autonomous and planned maintenance as the most important indicators that influence the relationship between TPM practices and manufacturing performance. Information system focus as the second higher means scores with 21.36 and followed by top management leadership with 20.76. The lowest means scores of 17.44 goes to employee involvement.

Table 4.10: Means and Standard Deviations Scores

Variables	Means	Std. Deviation
Top Management Leadership	20.76	2.96
Information System Focus	21.36	1.85
Employee Involvement	17.44	3.63
Autonomous and Planned Maintenance	30.93	4.73

4.5 Analysis of Variance (ANOVA)

Table 4.11: One-Way ANOVA for Types of Company, Years of Operation, and Types of Industry with Manufacturing Performance.

	F	Sig.
Types of Company	3.428	0.020
Years of Operation	5.455	0.002
Types of Industry	2.573	0.009

The One-way ANOVA used to compare the mean of one or more groups based on one independent variable (or factor). Refer to the Table 4.11, the F value for types of company is 3.428 and it significance value is 0.020, $p<0.05$. Thus, it is say there is a significant difference between types of company on manufacturing performance. Next, the F value for years of operation is 5.455 and type of industry is 2.573. Both groups have significance value less than 0.01 which are 0.002 for years of operation and 0.009 for types of industry. Therefore, as the types of company, there was a significant difference between those two groups and manufacturing performance.

4.6 Hypotheses Testing

Hypothesis is statements that researcher sets out to **accept** or **reject** based on the data collected. The hypothesis normally flow from the study's objectives so their acceptance or rejection enables these objectives to be met. The NULL hypothesis (Ho) is important in such a way that its rejection leads to the acceptance of the alternative hypothesis. The correlation and regression analysis are used as method in testing the hypotheses. The restatement of the hypotheses is as follows:

Hypothesis 1

Ho1: There is no significant relationship between top management leadership and manufacturing performance.

Ha1: There is a significant positive relationship between top management leadership and manufacturing performance.

Hypothesis 2

Ho2: There is no significant relationship between the information system focus and manufacturing performance.

Ha2: There is a significant positive relationship between information system focus and manufacturing performance.

Hypothesis 3

Ho3: There is no significant relationship between employee involvement and manufacturing performance.

Ha3: There is a significant positive relationship between employee involvement and manufacturing performance.

Hypothesis 4

Ho4: There is no significant relationship between autonomous and planned maintenance and manufacturing performance.

Ha4: There is a significant positive relationship between autonomous and planned maintenance and manufacturing performance.

4.7 Correlation Analysis

Correlation analysis describes the strength of the relationship between variables. A coefficient of determination (r^2) is computed, it indicates the portion of changes in the dependent variable is associated with changes in the independent variable.

Table 4.12: Correlation of top management leadership and manufacturing performance

		Top mgt leadership	Manufacturing performance
Top mgt leadership	Pearson Correlation	1	.334(**)
	Sig. (2-tailed)		.001
	N	95	95
Manufacturing performance	Pearson Correlation	.334(**)	1
	Sig. (2-tailed)	.001	
	N	95	95

** Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 4.12, the correlation coefficient was statistically significant with weak correlation (r=0.334, p<0.01) between top management leadership and manufacturing performance. The significant value is 0.001 which is less than level of significance (α) = 0.01. Hence, we **accept** hypothesis Ha1 and reject Ho1.

Ha1: There is a significant positive relationship between top management leadership and manufacturing performance.

Table 4.13: Correlation of information system focus and manufacturing performance

		Info system focus	Manufacturing performance
Info system focus	Pearson Correlation	1	.216(*)
	Sig. (2-tailed)		.036
	N	95	95
Manufacturing performance	Pearson Correlation	.216(*)	1
	Sig. (2-tailed)	.036	
	N	95	95

*Correlation is significant at the 0.05 level (2-tailed).

There is a significant relationship between the information system focus and manufacturing performance. The Table 4.13 shows that the correlation is significant as p<0.05 which is 0.036. In addition, the information system focus and manufacturing performance are related with a weak positive relationship (r=0.216). Nevertheless, the result indicates that the hypothesis Ha2 is **accepted** and rejected Ho2.

Ha2: There is a significant positive relationship between information system focus and manufacturing performance.

Table 4.14: Correlation of employee involvement and manufacturing performance

		Employee Involvement	Manufacturing performance
Employee Involvement	Pearson Correlation	1	.168
	Sig. (2-tailed)		.104
	N	95	95
Manufacturing performance	Pearson Correlation	.168	1
	Sig. (2-tailed)	.104	
	N	95	95

Clearly, there is a small correlation between employee involvement and manufacturing performance as r=0.168 which approaching to 0. Besides, the p-value is 0.104 and it is consistent with the correlation. In other words, this is nowhere near either alpha (0.05 or 0.01). As the result in Table 4.14 above, the two variables have a weak positive correlation but not statistically significant as the p-value exceeds alpha (α). Thus, we fail to reject the null and conclude that the Ha3 is **not accepted.**

Ho3: There is no significant relationship between employee involvement and manufacturing performance.

Table 4.15: Correlation of autonomous and planned maintenance and manufacturing performance

		Auto n plan maintenance	Manufacturing performance
Auto n plan maintenance	Pearson Correlation	1	.311(**)
	Sig. (2-tailed)		.002
	N	95	95
Manufacturing performance	Pearson Correlation	.311(**)	1
	Sig. (2-tailed)	.002	
	N	95	95

**Correlation is significant at the 0.01 level (2-tailed).

Table 4.15 indicates the relationship between autonomous and planned maintenance and manufacturing performance. It shows the positive significant relationship as p-value is 0.002 less than the significant level $p<0.01$. In fact, there is a weak correlation ($r=0.311$) between the two variables. Therefore, we **accept** the Ha4 hypothesis and reject Ho4.

Ha4: There is a significant positive relationship between autonomous and planned maintenance and manufacturing performance.

4.8 Multiple Regression Analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.462(a)	.214	.179	13.82573

a) Predictors: (Constant), Auto n plan maintenance, Top mgt leadership, Employee Involvement, Info system focus

ANOVA (b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4672.209	4	1168.052	6.111	.000(a)
	Residual	17203.580	90	191.151		
	Total	21875.789	94			

a) Predictors: (Constant), Auto n plan maintenance, Top mgt leadership, Employee Involvement, Info system focus
b) Dependent Variable: Manufacturing performance

Coefficients (a)

Model		Unstandardized Coefficients		Standardized Coefficients	t
		B	Std. Error	Beta	B
1	(Constant)	-9.166	19.265		-.476
	Top mgt leadership	1.577	.487	.306	3.239
	Info system focus	.664	.826	.081	.803
	Employee Involvement	.506	.401	.120	1.261
	Auto n plan maintenance	.764	.325	.237	2.351

a) Dependent Variable: Manufacturing performance

In the model summary, the four TPM practices; top management leadership, information system focus, employee involvement, and autonomous and planned maintenance were used predictor. The value of the multiple correlation coefficient between the predictors and the outcome is R=0.462. The R^2 value is 0.214, which means that the four TPM practices account for 21.4% of variation in manufacturing performance.

The next is ANOVA table that tests whether the model is significantly better at predicting the outcome than using the mean. The result shows that the F value of 6.111 is statistically significant at the 0.000 level. It reflects that 21.4% of the variance (R^2) in manufacturing performance has been significantly illustrates by the four variables.

In multiple regressions, the model takes the form of an equation that contains a coefficient (*b*) for each predictor. The *b* values tell about the relationship between manufacturing performance and each predictor. For these data, all predictors have positive *b* values indicating positive relationships. So, as top management leadership increases, manufacturing performance increases and so on. Nonetheless, the standardized beta value for top management leadership is 0.306, information system focus is 0.081, employee involvement is 0.120, and autonomous and planned maintenance is 0.237. Thus, this indicates that top management leadership has slightly more impact in the model.

4.9 Summary

After a detail analysis conducted in this chapter by using various SPSS statistical analysis tools such as reliability analysis, descriptive analysis, ANOVA, correlations, and multiple regressions some findings are concluded. In the final chapter, the researcher will present the summary of the research findings and conclusions which is based on the empirical survey. Limitations and recommendations will also be presented in the next chapter.

CHAPTER 5

DISCUSSION, RECOMMENDATION AND CONCLUSION

5.0 Introduction

This final chapter provides a brief summary of the results of the research conducted on the relationship between TPM practices and manufacturing performance. The implication as well as limitation of the research will also be highlighted. For future research, the suggestions will be included and also conclusion of the study.

5.1 Summary of Research

Generally, the aim of this study is to investigate the relationship between the Total Productive Maintenance practices and the performance of the manufacturing companies. The four practices have been selected for the study purpose was top management leadership, information system focus, employee involvement, and autonomous and planned maintenance. In the global context, the industries in various sectors are tremendously developing and competing in achieving the World Class Manufacturing. A lot of management concepts or programme is developed in order to help improving the productivity, quality, and performance of the companies such as Total Quality Management (TQM), Just-In-Time (JIT), Continuous Quality Improvement (CQI), and Total Productive Maintenance (TPM).

Maintenance is one of an important element in manufacturing operations. It has developed from Preventive Maintenance to Total Productive Maintenance. The objectives in every maintenance field are to minimize the machine break downs, avoid deterioration, failures, and stoppages. The study has distributed 100 questionnaires to companies from difference industries. Only 95% was managed to be collected. A part of the respondents, 88.4% or 88 companies have ISO certification. A correlation analysis is conducted in order to test the hypotheses of the study. The result shows that all the hypotheses are accepted except one. The analysis found out that employee involvement was not significantly related with the manufacturing performance because its p value was neither less than 0.01 nor 0.05.

The finding is somewhat contradicts with previous studies that people involvement is significantly positive related and essential in plant performance (Powell, 1995; Brah and Chong, 2004). A possible reason for the contradiction is that some of the plant is still managed conservatively. Though the companies had been operated more than 30 years, remnants of the traditional management style still exist. Nevertheless, the other variables which are top management leadership, information system focus, and autonomous and planned maintenance are positively correlated with r=0.334, r=0.216, and r=0.311 respectively. This is consistent with the results of studies by (Brah and Chong, 2004; Halim and Ramayah, 2010; Mckone, *et al*., 1999).

Furthermore, the outcome from the regression analysis indicates the top management leadership as the indicator that most influence and give impact on manufacturing performance. Its beta score is 0.306. In most of studies, the support from management in implementing TPM programme is seen as vital towards it success. In fact, senior management plays an important role in assisting employees in the transition process. Training and education are provided sufficiently through proper and well-structured programme to help employees understand the needs and significance of the new programme. Nonetheless, an autonomous and planned maintenance is the second independent variable that has high beta score which is 0.237.

Typically, autonomous and planned maintenance are the basic or common practices in Total Productive Maintenance. The main idea in TPM is direct involvement of operators in maintenance process. McKone *et al*., (2001) summarized that the practices in TPM improve the plant performance through break down the traditional barriers between maintenance and production, foster improvement by looking at multiple perspectives for equipment operation and maintenance, increase technical skills of operators, include maintenance in daily tasks as well as long-term maintenance plans, and allow for information sharing among different department.

Moreover, the influence of the other factors such as information system focus and employee involvement on plant performance is significant only in their relationships with manufacturing performance individually but not collectively as indicated in the regression result. However, it cannot be claimed them as irrelevant to management as the regression analysis determines relative strengths and significance among the variables with plant performance.

Table 5.1: A Summary of Result of Hypotheses Testing

Hypotheses	**Outcome**

Ha1	There is a significant positive relationship between top management leadership and manufacturing performance	Supported
Ha2	There is a significant positive relationship between information system focus and manufacturing performance.	Supported
Ha3	There is a significant positive relationship between employee involvement and manufacturing performance.	Not Supported
Ha4	There is a significant positive relationship between autonomous and planned maintenance and manufacturing performance.	Supported

5.2 Implication of Research

TPM is well-recognized of it efficiency and effectiveness in maintenance management. The results of total productive maintenance implementation are shown reduction in variability, increased in productivity, reduction in maintenance costs, and reduced inventory. Not only that, there are more promising advantages in TPM programme. Some of the implication of this research is best suit to manufacturing companies especially those companies that not yet implement total productive maintenance. In order to claim world class manufacturing (WCM) status and compete globally and locally, this research helps exposed the companies about TPM programme and its benefits toward productivity and plant performance.

In addition, top management level in the companies should benefit from this study. The top management can structure a proper and strategic planning of the direction of companies to achieve its TPM goals that aligned with business objectives. Moreover, as much as the impact of TPM on the cost, quality, delivery, and flexibility of the productivity output, the management might think to put some investment for this programme such as enhancing the personnel skills, provide suitable working environment, training, and compensation to employees. This is to built positive relationship and good environment between the top management and shop floor workers.

Last but not least, the implication of this research is also applicable to plant managers. As the people that handle the plant operations daily, this study showed a better method in maintenance management. The plant managers can decide whether to allocate more resources to the maintenance function based on the findings.

5.3 Limitation of Research

Overall, this research is based on a quantitative approach only. The data is collected through the distribution of questionnaires to respective companies. Moreover, the scope of the study has to be generalized. For example, the questions selected are common or basic TPM practices. Therefore, some information gained from the data collection is limited to discover and analyze its actual practices. Besides, the focus of the research is the respondents of the manufacturing companies in Northern regions only which are Kedah, Penang, and Perak.

5.4 Recommendations

In future, there are some opportunities the researchers should look at. One of it is the use of the combination of quantitative and qualitative research designs when conducting a further research on total productive maintenance. When we relate total productive maintenance practices with the manufacturing performance, the best approach for researchers to gain better results on their studies is by using both quantitative and qualitative research methods. The questionnaires usually used general questions that commonly understood or practiced by most companies. The advantages of quantitative method are it simple, less cost, suitable for large population, and avoid bias. However, the data collected will only summarized the overall practices and performances of companies not the actual or exact thing happen.

Thus, it is recommended for researchers to conduct interviews with some companies. Different companies have different ways in practicing TPM programme. Direct interactions with the respondents will help researchers understand more about how TPM practices have influence plant performance. Furthermore, the selection of industries involve could be narrow down to three or four categories only. So that, the researchers can sees the trends and implications of TPM practices between those categories. Additionally, rather than focused Northern regions only, the scope of the research should cover all regions in Malaysia. As listed in Federation of Manufacturing Malaysia (FMM) directory, there are approximately 3000 manufacturing companies all over Malaysia.

5.5 Conclusion

Generally, this research is basically focused on maintenance management in manufacturing companies. Maintenance is the technical part in every operations process and if not properly managed will cause losses to the companies and organizations. However, high return on investment could be gained if best maintenance practices are selected. Therefore, a better maintenance approach which is Total Productive Maintenance (TPM) has been introduced by Seiichi Nakajima. Typically, this concept was adapted from American approach and has been modified to suit with Japan’s culture.

From the observation of this research, it is concluded that total productive maintenance (TPM) practices basically have influence the productivity and performance of manufacturing companies. The improvement can be seen in term of cost, quality, delivery, and flexibility that have show better results after implementing TPM programmes in plant operations. For example, there are less defects during process, reduction in late delivery, increase product quality, decrease in cost of manpower, and etc.

Even thou, some of manufacturing companies just have little improvement in their operations process, but it indicates that TPM has positive impact towards the development of the companies in the future. Moreover, total participation of employees in the TPM programme is significant as an autonomous maintenance urges its operators to do basic maintenance on its machine and daily routine such as cleaning, lubricating, and inspecting in order to avoid break downs and so on.

Through the study, the finding shows that the employee involvement has no significant relationship with the manufacturing performance. It is contradict with the objectives in TPM that requires the total commitment and participation from employees. Some of the reason may be the traditional management still has a little impact on the situation in the plant operations. Therefore, the manufacturing companies have to create and impose new culture and environment that encourage empowerment among employees.

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APPENDIX A

QUESTIONNAIRES

Total Productive Maintenance and Manufacturing Performance

This questionnaire is conducted in partial requirement for my master project paper. I am doing a research about the influence of TPM practices on manufacturing performance. Please spend a couple of minutes to do the survey. All personal information will be kept confidential. Thank you.

Section 1 :

Demographic Profile

Please indicate the followings by tick the appropriate answers

1. Types of company:

- ☐ Multinational Corporation (MNC)
- ☐ Locally owned
- ☐ Joint ventures
- ☐ Others

2. Years of operation:

☐ Less 10 ☐ 10- 20 ☐ 21 - 30 ☐ 30 or more

3. ISO certified company

☐ Yes ☐ No

4. Number of employees in this company:

☐ 20 - 50 ☐ 51 - 100 ☐ 101 - 500 ☐ 500 or more

5. Annual sales turnover (in RM)

- ☐ RM250 thousands - RM10 millions
- ☐ RM10 millions - RM25 millions
- ☐ More than RM25 millions

6. This company is best categorized as in the following industry (please tick one):

- ☐ Food products
- ☐ Electrical/electronic
- ☐ Furniture/fixtures
- ☐ Tobacco/beverage
- ☐ Other non-metallic mineral
- ☐ Rubber-based/plastic
- ☐ Basic metal product
- ☐ Fabricated metal
- ☐ Wood-based
- ☐ Textile/apparel
- ☐ Machinery/equipment
- ☐ Petroleum/Petrochemical/Chemical
- ☐ Transport equipment
- ☐ Others

7. Please state your position in this company:

- ☐ General Manager
- ☐ Quality Manager
- ☐ Production Manager
- ☐ Operations Manager
- ☐ Engineering Manager
- ☐ Engineer
- ☐ Maintenance Manager
- ☐ Others

Section 2 :

Top Management Leadership

Please indicate the degree of your agreement with each statement by tick your answer using the scale below:

1. Strongly Disagree 2. Disagree 3. Neither Disagree nor Agree 4. Agree 5. Strongly Agree

		1	2	3	4	5
8.	Senior managers are involved in improving the performance of the maintenance programme	☐	☐	☐	☐	☐
9.	Senior managers define and identify preventive maintenance measures clearly	☐	☐	☐	☐	☐
10.	Our top management actively encourages a TPM culture	☐	☐	☐	☐	☐
11.	Our top management strongly encourages employee involvement in the production process	☐	☐	☐	☐	☐
12.	Plant management creates and communicates a vision focused on quality improvements	☐	☐	☐	☐	☐

Section 3:

Information System Focus

Please indicate the degree of your agreement with each statement by tick your answer using the scale below:

1. Strongly Disagree 2. Disagree 3. Neither Disagree nor Agree 4. Agree 5. Strongly Agree

		1	2	3	4	5
13.	Our company uses statistical process control to record company performance	☐	☐	☐	☐	☐
14.	Employees have easy access to information on productivity	☐	☐	☐	☐	☐
15.	Information on quality performance is readily available to employees	☐	☐	☐	☐	☐
16.	Decision to change or improve maintenance process is based on objective figures	☐	☐	☐	☐	☐
17.	Company tries to implement the latest maintenance techniques	☐	☐	☐	☐	☐

Section 4

Employee Involvement

Please indicate the degree of your agreement with each statement by tick your answer using the scale below:

1. Strongly Disagree 2. Disagree 3. Neither Disagree nor Agree 4. Agree 5. Strongly Agree

		1	2	3	4	5
18.	Employees are encouraged to try to solve their problems as much as possible	☐	☐	☐	☐	☐
19.	Problem solving teams have helped improve manufacturing processes at this plant	☐	☐	☐	☐	☐
20.	Any decision I make has to have my boss approval	☐	☐	☐	☐	☐
21.	Even small matters have to be referred to someone higher up for a final answer	☐	☐	☐	☐	☐
22.	There can be little action taken here until a supervisor approves a decision	☐	☐	☐	☐	☐

Section 5:

Autonomous and Planned Maintenance

Please indicate the degree of your agreement with each statement by tick your answer using the scale below:

1. Strongly Disagree 2. Disagree 3. Neither Disagree nor Agree 4. Agree 5. Strongly Agree

		1	2	3	4	5
23.	We dedicated a portion of every day solely to maintenance	☐	☐	☐	☐	☐
24.	We emphasize good maintenance as a strategy for achieving quality and schedule compliance	☐	☐	☐	☐	☐
25.	We have a separate shift, or part of a shift, reserved each day for maintenance activities	☐	☐	☐	☐	☐
26.	Our maintenance department focuses on assisting machine operators perform their own preventive maintenance	☐	☐	☐	☐	☐
27.	Operators understand the cause and effect of equipment deterioration	☐	☐	☐	☐	☐
28.	Basic cleaning and lubrication of equipment is done by operators	☐	☐	☐	☐	☐
29.	Operators inspect and monitor the performance of their own equipment	☐	☐	☐	☐	☐
30.	Operators are able to detect and treat abnormal operating conditions of their equipment	☐	☐	☐	☐	☐

Section 6:

Manufacturing Performance

Please indicate the changes in performance after the implementation of TPM by tick the appropriate answers:

1. No Improvement 2. Little Improvement 3. Neither Both 4. Big Improvement 5. Very Big Improvement

Cost		1	2	3	4	5
31.	Reduction in cost of production	☐	☐	☐	☐	☐
32.	Reduction in cost of manpower	☐	☐	☐	☐	☐
33.	Reduction in overhead costs	☐	☐	☐	☐	☐
34.	Sales have increased	☐	☐	☐	☐	☐
35.	Higher return on investment	☐	☐	☐	☐	☐
Quality		1	2	3	4	5
36.	Reduction in defects during process	☐	☐	☐	☐	☐
37.	Increase in product quality	☐	☐	☐	☐	☐
38.	Reduction in claims from customer	☐	☐	☐	☐	☐
39.	Reduction in rework losses	☐	☐	☐	☐	☐
40.	Reduction in minor stoppages	☐	☐	☐	☐	☐

Delivery		1	2	3	4	5
41.	Reduction in late delivery	☐	☐	☐	☐	☐
42.	Improvement in inventory turnover	☐	☐	☐	☐	☐
43.	Improvement in meeting delivery schedule in time	☐	☐	☐	☐	☐
44.	Increase in delivery reliability	☐	☐	☐	☐	☐

45.	Increase in delivery speed	☐ ☐ ☐ ☐ ☐
Flexibility		1 2 3 4 5
46.	Increase in equipment flexibility	☐ ☐ ☐ ☐ ☐
47.	Increase in variety of tasks/jobs performed by a worker	☐ ☐ ☐ ☐ ☐
48.	Reduction in new product development cycle	☐ ☐ ☐ ☐ ☐
49.	Reduction in manufacturing lead time	☐ ☐ ☐ ☐ ☐
50.	Reduction in set-up time (e.g. Single Minute	
	Exchange of Die)	☐ ☐ ☐ ☐ ☐

THANK YOU FOR YOUR SUPPORT

APPENDIX B

RESULTS FROM SPSS TEST

FREQUENCIES

Types of company

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Multinational Corporation (MNC)	27	28.4	28.4	28.4
	Joint ventures	23	24.2	24.2	52.6
	Locally owned	24	25.3	25.3	77.9
	Others	21	22.1	22.1	100.0
	Total	95	100.0	100.0	

Years of operation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less 10	17	17.9	17.9	17.9
	10-20	46	48.4	48.4	66.3
	21-30	15	15.8	15.8	82.1
	30 or more	17	17.9	17.9	100.0
	Total	95	100.0	100.0	

ISO certified company

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	84	88.4	88.4	88.4
	No	11	11.6	11.6	100.0
	Total	95	100.0	100.0	

Number of employees

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-50	16	16.8	16.8	16.8
	51-100	26	27.4	27.4	44.2
	101-500	23	24.2	24.2	68.4
	500 or more	30	31.6	31.6	100.0
	Total	95	100.0	100.0	

Annual sales turnover

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	RM250 thousands - RM10 millions	37	38.9	38.9	38.9
	RM10 millions-RM25 millions	27	28.4	28.4	67.4
	More than RM25 millions	31	32.6	32.6	100.0
	Total	95	100.0	100.0	

Types of industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Food products	18	18.9	18.9	18.9
	Wood-based	5	5.3	5.3	24.2
	Machinery/equipment	10	10.5	10.5	34.7
	Transport equipment	6	6.3	6.3	41.1
	Electrical/electronic	16	16.8	16.8	57.9
	Tobacco/beverage	1	1.1	1.1	58.9
	Rubber-based/plastic	4	4.2	4.2	63.2
	Fabricated metal	1	1.1	1.1	64.2
	Textile/apparel	8	8.4	8.4	72.6
	Petroleum/Petrochemical/Chemical	4	4.2	4.2	76.8
	Others	22	23.2	23.2	100.0
	Total	95	100.0	100.0	

The position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	General manager	6	6.3	6.3	6.3
	Production manager	6	6.3	6.3	12.6
	Maintenance manager	5	5.3	5.3	17.9
	Quality manager	9	9.5	9.5	27.4
	Operations manager	11	11.6	11.6	38.9
	Engineer	27	28.4	28.4	67.4
	Others	31	32.6	32.6	100.0
	Total	95	100.0	100.0	

RELIABILITY

Top Management Leadership

Case Processing Summary

		N	%
Cases	Valid	95	100.0
	Excluded[a]	0	.0
	Total	95	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.867	.868	5

Item Statistics

	Mean	Std. Deviation	N
B1	4.21	.667	95
B2	4.01	.805	95
B3	4.20	.709	95
B4	4.16	.776	95
B5	4.18	.699	95

Inter-Item Correlation Matrix

	B1	B2	B3	B4	B5
B1	1.000	.669	.563	.511	.534
B2	.669	1.000	.537	.542	.488
B3	.563	.537	1.000	.774	.485
B4	.511	.542	.774	1.000	.575
B5	.534	.488	.485	.575	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.152	4.011	4.211	.200	1.050	.007	5
Item Variances	.537	.445	.649	.204	1.459	.007	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
B1	16.55	6.038	.695	.538	.838
B2	16.75	5.553	.674	.508	.844
B3	16.56	5.781	.727	.639	.829
B4	16.60	5.477	.738	.659	.826
B5	16.58	6.119	.622	.414	.854

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
20.76	8.760	2.960	5

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		164.686	94	1.752		
Within People	Between Items	2.518	4	.629	2.693	.031
	Residual	87.882	376	.234		
	Total	90.400	380	.238		
Total		255.086	474	.538		

Grand Mean = 4.15

Information System Focus

Case Processing Summary

		N	%
Cases	Valid	95	100.0
	Excluded[a]	0	.0
	Total	95	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.709	.701	5

Item Statistics

	Mean	Std. Deviation	N
C1	4.32	.490	95
C2	4.20	.594	95
C3	4.26	.622	95
C4	4.31	.507	95
C5	4.27	.493	95

Inter-Item Correlation Matrix

	C1	C2	C3	C4	C5
C1	1.000	.256	.178	.208	.299
C2	.256	1.000	.604	.360	.283
C3	.178	.604	1.000	.552	.283
C4	.208	.360	.552	1.000	.173
C5	.299	.283	.283	.173	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.272	4.200	4.316	.116	1.028	.002	5
Item Variances	.296	.240	.387	.148	1.617	.005	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
C1	17.04	2.679	.315	.136	.716
C2	17.16	2.092	.569	.394	.615
C3	17.09	1.959	.618	.503	.589
C4	17.05	2.412	.479	.317	.657
C5	17.08	2.610	.358	.153	.701

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
21.36	3.424	1.850	5

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		64.366	94	.685		
Within People	Between Items	.787	4	.197	.989	.413
	Residual	74.813	376	.199		
	Total	75.600	380	.199		
Total		139.966	474	.295		

Grand Mean = 4.27

Employee Involvement

Case Processing Summary

		N	%
Cases	Valid	95	100.0
	Excluded[a]	0	.0
	Total	95	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.751	.694	5

Item Statistics

	Mean	Std. Deviation	N
D1	4.33	.643	95
D2	4.36	.667	95
D3	3.16	1.188	95
D4	2.76	1.269	95
D5	2.84	1.170	95

Inter-Item Correlation Matrix

	D1	D2	D3	D4	D5
D1	1.000	.568	.029	-.019	-.030
D2	.568	1.000	.089	.028	-.050
D3	.029	.089	1.000	.844	.784
D4	-.019	.028	.844	1.000	.877
D5	-.030	-.050	.784	.877	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.488	2.758	4.358	1.600	1.580	.630	5
Item Variances	1.050	.414	1.611	1.197	3.894	.329	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
D1	13.12	12.274	.101	.328	.808
D2	13.08	12.099	.129	.353	.804
D3	14.28	6.823	.791	.727	.583
D4	14.68	6.367	.806	.834	.572
D5	14.60	7.115	.747	.784	.606

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
17.44	13.143	3.625	5

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		247.086	94	2.629		
Within People	Between Items	239.276	4	59.819	91.310	.000
	Residual	246.324	376	.655		
	Total	485.600	380	1.278		
Total		732.686	474	1.546		

Grand Mean = 3.49

Autonomous and Planned Maintenance

Case Processing Summary

		N	%
Cases	Valid	95	100.0
	Excluded[a]	0	.0
	Total	95	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.798	.799	8

Item Statistics

	Mean	Std. Deviation	N
E1	3.82	.911	95
E2	4.05	.790	95
E3	3.74	.959	95
E4	3.83	.895	95
E5	3.80	.963	95
E6	4.02	.758	95
E7	3.85	.967	95
E8	3.81	1.065	95

Inter-Item Correlation Matrix

	E1	E2	E3	E4	E5	E6	E7	E8
E1	1.000	.530	.323	.367	.092	.175	.211	.173
E2	.530	1.000	.440	.208	.293	.194	.080	.138
E3	.323	.440	1.000	.320	.196	.242	-.065	.013
E4	.367	.208	.320	1.000	.503	.492	.450	.357
E5	.092	.293	.196	.503	1.000	.516	.573	.647
E6	.175	.194	.242	.492	.516	1.000	.541	.427
E7	.211	.080	-.065	.450	.573	.541	1.000	.861
E8	.173	.138	.013	.357	.647	.427	.861	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.866	3.737	4.053	.316	1.085	.012	8
Item Variances	.843	.574	1.134	.560	1.975	.033	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
E1	27.11	18.478	.388	.438	.793
E2	26.87	18.963	.401	.442	.790
E3	27.19	19.028	.287	.350	.809
E4	27.09	17.108	.599	.475	.761
E5	27.13	16.431	.639	.604	.754
E6	26.91	18.044	.579	.451	.768
E7	27.07	16.622	.607	.817	.759
E8	27.12	16.146	.592	.799	.761

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
30.93	22.346	4.727	8

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		262.561	94	2.793		
Within People	Between Items	8.205	7	1.172	2.076	.044
	Residual	371.545	658	.565		
	Total	379.750	665	.571		
Total		642.311	759	.846		

Grand Mean = 3.87

Manufacturing Performance

Case Processing Summary

		N	%
Cases	Valid	95	100.0
	Excluded[a]	0	.0
	Total	95	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.940	.940	20

Item Statistics

	Mean	Std. Deviation	N
F1a	3.67	1.026	95
F1b	3.56	1.127	95
F1c	3.54	1.099	95
F1d	3.34	1.182	95
F1e	3.32	1.074	95
F2a	3.63	1.167	95
F2b	3.71	1.138	95
F2c	3.55	1.137	95
F2d	3.65	1.050	95
F2e	3.77	1.076	95
F3a	3.38	1.150	95
F3b	3.40	1.143	95
F3c	3.51	1.147	95
F3d	3.60	1.086	95
F3e	3.60	1.066	95
F4a	3.48	1.157	95
F4b	3.47	1.090	95
F4c	3.34	1.088	95
F4d	3.42	1.126	95
F4e	3.28	1.173	95

Inter-Item Correlation Matrix

	F1a	F1b	F1c	F1d	F1e	F2a	F2b	F2c	F2d	F2e	F3a	F3b	F3c	F3d	F3e	F4a	F4b	F4c	F4d	F4e
F1a	1.000	.840	.808	.610	.606	.316	.327	.292	.388	.287	.458	.394	.331	.359	.405	.188	.206	.281	.286	.326
F1b	.840	1.000	.846	.712	.731	.328	.304	.349	.453	.336	.451	.395	.421	.410	.427	.337	.276	.314	.391	.354
F1c	.808	.846	1.000	.777	.765	.330	.298	.324	.440	.331	.468	.411	.390	.369	.530	.396	.354	.390	.408	.425
F1d	.610	.712	.777	1.000	.862	.261	.249	.281	.396	.397	.265	.254	.320	.280	.454	.331	.354	.391	.484	.475
F1e	.606	.731	.765	.862	1.000	.348	.294	.336	.476	.386	.333	.346	.387	.328	.409	.406	.416	.454	.557	.578
F2a	.316	.328	.330	.261	.348	1.000	.822	.618	.606	.583	.454	.439	.466	.495	.385	.370	.222	.015	.152	.202
F2b	.327	.304	.298	.249	.294	.822	1.000	.767	.706	.673	.419	.361	.376	.472	.419	.344	.234	.115	.198	.231
F2c	.292	.349	.324	.281	.336	.618	.767	1.000	.803	.774	.507	.435	.414	.481	.446	.346	.286	.193	.292	.273
F2d	.388	.453	.440	.396	.476	.606	.706	.803	1.000	.851	.648	.552	.457	.437	.407	.333	.276	.271	.296	.340
F2e	.287	.336	.331	.397	.386	.583	.673	.774	.851	1.000	.561	.508	.449	.466	.391	.305	.303	.240	.292	.314
F3a	.458	.451	.468	.265	.333	.454	.419	.507	.648	.561	1.000	.863	.676	.566	.515	.364	.246	.297	.253	.298
F3b	.394	.395	.411	.254	.346	.439	.361	.435	.552	.508	.863	1.000	.818	.670	.569	.407	.282	.318	.298	.351
F3c	.331	.421	.390	.320	.387	.466	.376	.414	.457	.449	.676	.818	1.000	.839	.689	.495	.342	.246	.311	.311
F3d	.359	.410	.369	.280	.328	.495	.472	.481	.437	.466	.566	.670	.839	1.000	.807	.469	.333	.295	.339	.324
F3e	.405	.427	.530	.454	.409	.385	.419	.446	.407	.391	.515	.569	.689	.807	1.000	.539	.476	.484	.470	.483
F4a	.188	.337	.396	.331	.406	.370	.344	.346	.333	.305	.364	.407	.495	.469	.539	1.000	.803	.655	.700	.650
F4b	.206	.276	.354	.354	.416	.222	.234	.286	.276	.303	.246	.282	.342	.333	.476	.803	1.000	.761	.746	.692
F4c	.281	.314	.390	.391	.454	.015	.115	.193	.271	.240	.297	.318	.246	.295	.484	.655	.761	1.000	.786	.808
F4d	.286	.391	.408	.484	.557	.152	.198	.292	.296	.292	.253	.298	.311	.339	.470	.700	.746	.786	1.000	.867
F4e	.326	.354	.425	.475	.578	.202	.231	.273	.340	.314	.298	.351	.311	.324	.483	.650	.692	.808	.867	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.511	3.284	3.768	.484	1.147	.020	20
Item Variances	1.245	1.052	1.396	.344	1.327	.010	20

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
F1a	66.54	213.975	.590	.820	.938
F1b	66.65	209.761	.664	.852	.937
F1c	66.67	209.350	.697	.864	.936
F1d	66.87	210.048	.621	.853	.937
F1e	66.89	209.904	.696	.861	.936
F2a	66.58	212.119	.566	.779	.938
F2b	66.51	212.146	.582	.826	.938
F2c	66.66	210.651	.629	.772	.937
F2d	66.56	210.143	.706	.854	.936
F2e	66.44	211.228	.650	.824	.937
F3a	66.83	209.312	.664	.817	.937
F3b	66.81	209.347	.667	.867	.937
F3c	66.71	209.082	.673	.872	.936
F3d	66.61	210.325	.674	.864	.936
F3e	66.61	209.389	.720	.827	.936
F4a	66.73	209.626	.650	.793	.937
F4b	66.74	212.962	.584	.789	.938
F4c	66.87	213.750	.559	.820	.938
F4d	66.79	211.040	.624	.832	.937
F4e	66.93	209.729	.636	.836	.937

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
70.21	232.721	15.255	20

ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		1093.789	94	11.636		
Within People	Between Items	35.653	19	1.876	2.687	.000
	Residual	1247.347	1786	.698		
	Total	1283.000	1805	.711		
Total		2376.789	1899	1.252		

Grand Mean = 3.51

ANOVA ANALYSIS

One-Way Analysis for Types of Company

Descriptives

Manufacturingperformance

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Multinational Corporation (MNC)	27	77.6667	11.85165	2.28085	72.9783	82.3550	56.00	100.00
Joint ventures	23	68.7826	10.22455	2.13197	64.3612	73.2040	45.00	82.00
Locally owned	24	67.3750	15.55583	3.17532	60.8064	73.9436	25.00	97.00
Others	21	65.4286	20.17070	4.40161	56.2470	74.6102	21.00	88.00
Total	95	70.2105	15.25520	1.56515	67.1029	73.3182	21.00	100.00

ANOVA

Manufacturingperformance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2221.109	3	740.370	3.428	.020
Within Groups	19654.681	91	215.986		
Total	21875.789	94			

One-Way Analysis for Years of Operation

Descriptives

Manufacturingperformance

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Less 10	17	66.9412	10.79624	2.61847	61.3903	72.4921	40.00	80.00
10-20	46	66.3261	16.80748	2.47813	61.3349	71.3173	21.00	100.00
21-30	15	72.4000	11.17267	2.88477	66.2128	78.5872	51.00	88.00
30 or more	17	82.0588	11.77110	2.85491	76.0067	88.1110	56.00	98.00
Total	95	70.2105	15.25520	1.56515	67.1029	73.3182	21.00	100.00

ANOVA

Manufacturingperformance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3334.198	3	1111.399	5.455	.002
Within Groups	18541.591	91	203.754		
Total	21875.789	94			

One-Way Analysis for Types of Industry

Descriptives

Manufacturingperformance

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Food products	18	63.7222	20.44449	4.81881	53.5554	73.8890	21.00	97.00
Wood-based	5	49.6000	16.36460	7.31847	29.2807	69.9193	25.00	71.00
Machinery/equipment	10	72.6000	12.50955	3.95587	63.6512	81.5488	56.00	96.00
Transport equipment	6	68.8333	12.62405	5.15375	55.5852	82.0815	45.00	79.00
Electrical/electronic	16	75.5000	9.41630	2.35407	70.4824	80.5176	57.00	92.00
Tobacco/beverage	1	40.0000	.	.	.	.	40.00	40.00
Rubber-based/plastic	4	73.0000	8.40635	4.20317	59.6236	86.3764	62.00	82.00
Fabricated metal	1	76.0000	.	.	.	.	76.00	76.00
Textile/apparel	8	75.7500	14.54795	5.14348	63.5876	87.9124	57.00	98.00
Petroleum/ Petrochemical/Chemical	4	80.2500	14.19800	7.09900	57.6578	102.8422	67.00	100.00
Others	22	72.4091	11.41285	2.43323	67.3489	77.4693	37.00	88.00
Total	95	70.2105	15.25520	1.56515	67.1029	73.3182	21.00	100.00

ANOVA

Manufacturingperformance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5130.177	10	513.018	2.573	.009
Within Groups	16745.613	84	199.353		
Total	21875.789	94			

CORRELATION ANALYSIS

Top Management Leadership

Correlation of top management leadership and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Topmgtleadership	20.7579	2.95971	95
Manufacturingperformance	70.2105	15.25520	95

Correlations

		Topmgtleadership	Manufacturing performance
Topmgtleadership	Pearson Correlation	1	.334**
	Sig. (2-tailed)		.001
	N	95	95
Manufacturingperformance	Pearson Correlation	.334**	1
	Sig. (2-tailed)	.001	
	N	95	95

**. Correlation is significant at the 0.01 level (2-tailed).

Information System Focus

Correlation of information system focus and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Infosystemfocus	21.3579	1.85034	95
Manufacturingperformance	70.2105	15.25520	95

Correlations

		Infosystemfocus	Manufacturing performance
Infosystemfocus	Pearson Correlation	1	.216*
	Sig. (2-tailed)		.036
	N	95	95
Manufacturingperformance	Pearson Correlation	.216*	1
	Sig. (2-tailed)	.036	
	N	95	95

*. Correlation is significant at the 0.05 level (2-tailed).

Employee Involvement

Correlation of employee involvement and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
EmployeeInvolvement	17.4421	3.62531	95
Manufacturingperformance	70.2105	15.25520	95

Correlations

		Employee Involvement	Manufacturing performance
EmployeeInvolvement	Pearson Correlation	1	.168
	Sig. (2-tailed)		.104
	N	95	95
Manufacturingperformance	Pearson Correlation	.168	1
	Sig. (2-tailed)	.104	
	N	95	95

Autonomous and Planned Maintenance

Correlation of autonomous and planned maintenance and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Autonplanmaintenance	30.9263	4.72711	95
Manufacturingperformance	70.2105	15.25520	95

Correlations

		Autonplanmaintenance	Manufacturing performance
Autonplanmaintenance	Pearson Correlation	1	.311**
	Sig. (2-tailed)		.002
	N	95	95
Manufacturingperformance	Pearson Correlation	.311**	1
	Sig. (2-tailed)	.002	
	N	95	95

**. Correlation is significant at the 0.01 level (2-tailed).

TPM Practices

Correlation of TPM practices and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Topmgtleadership	20.7579	2.95971	95
Infosystemfocus	21.3579	1.85034	95
EmployeeInvolvement	17.4421	3.62531	95
Autonplanmaintenance	30.9263	4.72711	95
Manufacturingperformance	70.2105	15.25520	95

Correlations

		Topmgtleadership	Infosystemfocus	Employee Involvement	Autonplanmaintenance	Manufacturing performance
Topmgtleadership	Pearson Correlation	1	.134	-.016	.082	.334**
	Sig. (2-tailed)		.194	.880	.432	.001
	N	95	95	95	95	95
Infosystemfocus	Pearson Correlation	.134	1	.111	.340**	.216*
	Sig. (2-tailed)	.194		.284	.001	.036
	N	95	95	95	95	95
EmployeeInvolvement	Pearson Correlation	-.016	.111	1	.184	.168
	Sig. (2-tailed)	.880	.284		.074	.104
	N	95	95	95	95	95
Autonplanmaintenance	Pearson Correlation	.082	.340**	.184	1	.311**
	Sig. (2-tailed)	.432	.001	.074		.002
	N	95	95	95	95	95
Manufacturingperformance	Pearson Correlation	.334**	.216*	.168	.311**	1
	Sig. (2-tailed)	.001	.036	.104	.002	
	N	95	95	95	95	95

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

REGRESSION

Top management leadership and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Manufacturingperformance	70.2105	15.25520	95
Topmgtleadership	20.7579	2.95971	95

Correlations

		Manufacturing performance	Topmgtle adership
Pearson Correlation	Manufacturingperformance	1.000	.334
	Topmgtleadership	.334	1.000
Sig. (1-tailed)	Manufacturingperformance	.	.000
	Topmgtleadership	.000	.
N	Manufacturingperformance	95	95
	Topmgtleadership	95	95

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Topmgtleadership[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Manufacturingperformance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.334[a]	.112	.102	14.45460

a. Predictors: (Constant), Topmgtleadership

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2444.785	1	2444.785	11.701	.001[a]
	Residual	19431.005	93	208.936		
	Total	21875.789	94			

a. Predictors: (Constant), Topmgtleadership

b. Dependent Variable: Manufacturingperformance

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	34.443	10.561		3.261	.002
	Topmgtleadership	1.723	.504	.334	3.421	.001

a. Dependent Variable: Manufacturingperformance

Information system focus and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Manufacturingpe rformance	70.2105	15.25520	95
Infosystemfocus	21.3579	1.85034	95

Correlations

		Manufacturing performance	Infosystemfocus
Pearson Correlation	Manufacturingpe rformance	1.000	.216
	Infosystemfocus	.216	1.000
Sig. (1-tailed)	Manufacturingpe rformance	.	.018
	Infosystemfocus	.018	.
N	Manufacturingpe rformance	95	95
	Infosystemfocus	95	95

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Infosystem focus[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Manufacturingperformance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.216[a]	.046	.036	14.97658

a. Predictors: (Constant), Infosystemfocus

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1016.070	1	1016.070	4.530	.036[a]
	Residual	20859.720	93	224.298		
	Total	21875.789	94			

a. Predictors: (Constant), Infosystemfocus

b. Dependent Variable: Manufacturingperformance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	32.261	17.896		1.803	.075
	Infosystemfocus	1.777	.835	.216	2.128	.036

a. Dependent Variable: Manufacturingperformance

Employee involvement and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Manufacturingperformance	70.2105	15.25520	95
EmployeeInvolvement	17.4421	3.62531	95

Correlations

		Manufacturing performance	Employee Involvement
Pearson Correlation	Manufacturingperformance	1.000	.168
	EmployeeInvolvement	.168	1.000
Sig. (1-tailed)	Manufacturingperformance	.	.052
	EmployeeInvolvement	.052	.
N	Manufacturingperformance	95	95
	EmployeeInvolvement	95	95

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Employee Involvement[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Manufacturingperformance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.168[a]	.028	.018	15.11912

a. Predictors: (Constant), EmployeeInvolvement

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	617.116	1	617.116	2.700	.104[a]
	Residual	21258.673	93	228.588		
	Total	21875.789	94			

a. Predictors: (Constant), EmployeeInvolvement

b. Dependent Variable: Manufacturingperformance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	57.883	7.661		7.555	.000
	EmployeeInvolvement	.707	.430	.168	1.643	.104

a. Dependent Variable: Manufacturingperformance

Autonomous and planned maintenance and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Manufacturingperformance	70.2105	15.25520	95
Autonplanmaintenance	30.9263	4.72711	95

Correlations

		Manufacturing performance	Autonplanmaintenance
Pearson Correlation	Manufacturingperformance	1.000	.311
	Autonplanmaintenance	.311	1.000
Sig. (1-tailed)	Manufacturingperformance	.	.001
	Autonplanmaintenance	.001	.
N	Manufacturingperformance	95	95
	Autonplanmaintenance	95	95

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Autonplan maintenance[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Manufacturingperformance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.311[a]	.097	.087	14.57472

a. Predictors: (Constant), Autonplanmaintenance

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2120.511	1	2120.511	9.983	.002[a]
	Residual	19755.279	93	212.422		
	Total	21875.789	94			

a. Predictors: (Constant), Autonplanmaintenance

b. Dependent Variable: Manufacturingperformance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	39.137	9.948		3.934	.000
	Autonplanmaintenance	1.005	.318	.311	3.160	.002

a. Dependent Variable: Manufacturingperformance

TPM practices and manufacturing performance

Descriptive Statistics

	Mean	Std. Deviation	N
Manufacturingperformance	70.2105	15.25520	95
Topmgtleadership	20.7579	2.95971	95
Infosystemfocus	21.3579	1.85034	95
EmployeeInvolvement	17.4421	3.62531	95
Autonplanmaintenance	30.9263	4.72711	95

Correlations

		Manufacturing performance	Topmgtleadership	Infosystemfocus	Employee Involvement	Autonplanmaintenance
Pearson Correlation	Manufacturingperformance	1.000	.334	.216	.168	.311
	Topmgtleadership	.334	1.000	.134	-.016	.082
	Infosystemfocus	.216	.134	1.000	.111	.340
	EmployeeInvolvement	.168	-.016	.111	1.000	.184
	Autonplanmaintenance	.311	.082	.340	.184	1.000
Sig. (1-tailed)	Manufacturingperformance	.	.000	.018	.052	.001
	Topmgtleadership	.000	.	.097	.440	.216
	Infosystemfocus	.018	.097	.	.142	.000
	EmployeeInvolvement	.052	.440	.142	.	.037
	Autonplanmaintenance	.001	.216	.000	.037	.
N	Manufacturingperformance	95	95	95	95	95
	Topmgtleadership	95	95	95	95	95
	Infosystemfocus	95	95	95	95	95
	EmployeeInvolvement	95	95	95	95	95
	Autonplanmaintenance	95	95	95	95	95

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Autonplanmaintenance, Topmgtleadership, EmployeeInvolvement, Infosystemfocus[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Manufacturingperformance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.462[a]	.214	.179	13.82573

a. Predictors: (Constant), Autonplanmaintenance, Topmgtleadership, EmployeeInvolvement, Infosystemfocus

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4672.209	4	1168.052	6.111	.000[a]
	Residual	17203.580	90	191.151		
	Total	21875.789	94			

a. Predictors: (Constant), Autonplanmaintenance, Topmgtleadership, EmployeeInvolvement, Infosystemfocus

b. Dependent Variable: Manufacturingperformance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-9.166	19.265		-.476	.635
	Topmgtleadership	1.577	.487	.306	3.239	.002
	Infosystemfocus	.664	.826	.081	.803	.424
	EmployeeInvolvement	.506	.401	.120	1.261	.211
	Autonplanmaintenance	.764	.325	.237	2.351	.021

a. Dependent Variable: Manufacturingperformance

DESCRIPTIVE STATISTICS

Top Management Leadership

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
B1	95	2	5	4.21	.667
B2	95	2	5	4.01	.805
B3	95	2	5	4.20	.709
B4	95	2	5	4.16	.776
B5	95	2	5	4.18	.699
Valid N (listwise)	95				

Information System Focus

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
C1	95	3	5	4.32	.490
C2	95	2	5	4.20	.594
C3	95	2	5	4.26	.622
C4	95	3	5	4.31	.507
C5	95	3	5	4.27	.493
Valid N (listwise)	95				

Employee Involvement

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
D1	95	2	5	4.33	.643
D2	95	2	5	4.36	.667
D3	95	1	5	3.16	1.188
D4	95	1	5	2.76	1.269
D5	95	1	5	2.84	1.170
Valid N (listwise)	95				

Autonomous and Planned Maintenance

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
E1	95	2	5	3.82	.911
E2	95	2	5	4.05	.790
E3	95	1	5	3.74	.959
E4	95	2	5	3.83	.895
E5	95	2	5	3.80	.963
E6	95	2	5	4.02	.758
E7	95	1	5	3.85	.967
E8	95	1	5	3.81	1.065
Valid N (listwise)	95				

Manufacturing Performance

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
F1a	95	2	5	3.67	1.026
F1b	95	1	5	3.56	1.127
F1c	95	1	5	3.54	1.099
F1d	95	1	5	3.34	1.182
F1e	95	1	5	3.32	1.074
F2a	95	1	5	3.63	1.167
F2b	95	1	5	3.71	1.138
F2c	95	1	5	3.55	1.137
F2d	95	1	5	3.65	1.050
F2e	95	1	5	3.77	1.076
F3a	95	1	5	3.38	1.150
F3b	95	1	5	3.40	1.143
F3c	95	1	5	3.51	1.147
F3d	95	1	5	3.60	1.086
F3e	95	1	5	3.60	1.066
F4a	95	1	5	3.48	1.157
F4b	95	1	5	3.47	1.090
F4c	95	1	5	3.34	1.088
F4d	95	1	5	3.42	1.126
F4e	95	1	5	3.28	1.173
Valid N (listwise)	95				

T-TEST

Top Management Leadership

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
B1	95	4.21	.667	.068
B2	95	4.01	.805	.083
B3	95	4.20	.709	.073
B4	95	4.16	.776	.080
B5	95	4.18	.699	.072

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
B1	61.550	94	.000	4.211	4.07	4.35
B2	48.529	94	.000	4.011	3.85	4.17
B3	57.770	94	.000	4.200	4.06	4.34
B4	52.212	94	.000	4.158	4.00	4.32
B5	58.252	94	.000	4.179	4.04	4.32

Information System Focus

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
C1	95	4.32	.490	.050
C2	95	4.20	.594	.061
C3	95	4.26	.622	.064
C4	95	4.31	.507	.052
C5	95	4.27	.493	.051

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
C1	85.929	94	.000	4.316	4.22	4.42
C2	68.882	94	.000	4.200	4.08	4.32
C3	66.755	94	.000	4.263	4.14	4.39
C4	82.792	94	.000	4.305	4.20	4.41
C5	84.423	94	.000	4.274	4.17	4.37

Employee Involvement

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
D1	95	4.33	.643	.066
D2	95	4.36	.667	.068
D3	95	3.16	1.188	.122
D4	95	2.76	1.269	.130
D5	95	2.84	1.170	.120

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
D1	65.563	94	.000	4.326	4.20	4.46
D2	63.672	94	.000	4.358	4.22	4.49
D3	25.912	94	.000	3.158	2.92	3.40
D4	21.178	94	.000	2.758	2.50	3.02
D5	23.681	94	.000	2.842	2.60	3.08

Autonomous and Planned Maintenance

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
E1	95	3.82	.911	.093
E2	95	4.05	.790	.081
E3	95	3.74	.959	.098
E4	95	3.83	.895	.092
E5	95	3.80	.963	.099
E6	95	4.02	.758	.078
E7	95	3.85	.967	.099
E8	95	3.81	1.065	.109

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
E1	40.896	94	.000	3.821	3.64	4.01
E2	49.970	94	.000	4.053	3.89	4.21
E3	37.986	94	.000	3.737	3.54	3.93
E4	41.724	94	.000	3.832	3.65	4.01
E5	38.455	94	.000	3.800	3.60	4.00
E6	51.729	94	.000	4.021	3.87	4.18
E7	38.824	94	.000	3.853	3.66	4.05
E8	34.878	94	.000	3.811	3.59	4.03

Manufacturing Performance

Cost

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
F1a	95	3.67	1.026	.105
F1b	95	3.56	1.127	.116
F1c	95	3.54	1.099	.113
F1d	95	3.34	1.182	.121
F1e	95	3.32	1.074	.110

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
F1a	34.911	94	.000	3.674	3.46	3.88
F1b	30.765	94	.000	3.558	3.33	3.79
F1c	31.355	94	.000	3.537	3.31	3.76
F1d	27.527	94	.000	3.337	3.10	3.58
F1e	30.078	94	.000	3.316	3.10	3.53

Quality

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
F2a	95	3.63	1.167	.120
F2b	95	3.71	1.138	.117
F2c	95	3.55	1.137	.117
F2d	95	3.65	1.050	.108
F2e	95	3.77	1.076	.110

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
F2a	30.321	94	.000	3.632	3.39	3.87
F2b	31.733	94	.000	3.705	3.47	3.94
F2c	30.407	94	.000	3.547	3.32	3.78
F2d	33.922	94	.000	3.653	3.44	3.87
F2e	34.124	94	.000	3.768	3.55	3.99

Delivery

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
F3a	95	3.38	1.150	.118
F3b	95	3.40	1.143	.117
F3c	95	3.51	1.147	.118
F3d	95	3.60	1.086	.111
F3e	95	3.60	1.066	.109

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
F3a	28.633	94	.000	3.379	3.14	3.61
F3b	28.994	94	.000	3.400	3.17	3.63
F3c	29.777	94	.000	3.505	3.27	3.74
F3d	32.319	94	.000	3.600	3.38	3.82
F3e	32.919	94	.000	3.600	3.38	3.82

Flexibility

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
F4a	95	3.48	1.157	.119
F4b	95	3.47	1.090	.112
F4c	95	3.34	1.088	.112
F4d	95	3.42	1.126	.116
F4e	95	3.28	1.173	.120

One-Sample Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
F4a	29.364	94	.000	3.484	3.25	3.72
F4b	31.061	94	.000	3.474	3.25	3.70
F4c	29.900	94	.000	3.337	3.12	3.56
F4d	29.616	94	.000	3.421	3.19	3.65
F4e	27.291	94	.000	3.284	3.05	3.52