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An Empirical Study of Just-in-Time and Total Quality Management Principles Implementation in Manufacturing Firms in the U.S.

Loknath Sriparavastu

AN EMPIRICAL STUDY OF JUST-IN-TIME AND TOTAL QUALITY MANAGEMENT PRINCIPLES IMPLEMENTATION IN MANUFACTURING FIRMS IN THE U.S.

by

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DEDICATION

This thesis is dedicated to my mother, Smt. Saroja. Her constant moral support, encouragement, and unselfish sacrifice of time over the years have enabled me to complete this research study and my master's degree.

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Literature in vogue points out that, in the last decade, American manufacturing companies came a long way in their renewed emphasis on the quality process. Just-in-Time (JIT) and Total Quality Management (TQM) are the two magical phrases that are being frequently used in almost all the articles published on quality and productivity. Nevertheless, the literature does not provide any satisfactory explanation as to how JIT and TQM principles are implemented in the manufacturing industries.

This research, through a nationwide empirical survey, analyzed the effects of JIT and TQM strategies implementation. Survey results showed that implementing both JIT and TQM strategies contributed to increased productivity, employee involvement, management commitment, supplier participation, enhancement in quality and reduction in costs. Even firms that implemented any of the JIT and TQM strategies reflected increased productivity and improved quality when compared to firms that implemented none of these strategies.

TABLE OF CONTENTS

Table of Contents-Continued

LIST OF TABLES

List of Tables-Continued

LIST OF FIGURES

"A customer is the most important visitor on our premises. He is not dependent on us. We are dependent on him. His is not an interruption of our work. He is the purpose of it. He is not an outsider on our business. He is a part of it. We are not doing him a favor by serving him. He is doing us a favor by giving us an opportunity to do so".

- Mahatma Gandhi

(in a speech given to immigrant Indians in Johannesburg, South Africa in 1890).

CHAPTER I

INTRODUCTION

Background Events at a Glance

In the last decade, American companies came a long way in their renewed emphasis on the quality process. Quality, as a process and as an issue, has both technical and cultural dimensions. The technical dimensions include design of experiments, regression analysis, statistical process control, Taguchi methods, quality function deployment, and measurements of the cost of quality. The cultural side includes the assumptions, values, beliefs and ideologies of total quality that shape behavior in the business organization (Schein, 1991; Sweeney 1993).

Just-In-Time (JIT) and Total Quality Management (TQM) appear to be the two magical phrases that are being frequently used in almost all the articles published on quality. Properly implemented, they could eliminate waste, increase manufacturing flexibility, eliminate most inventory and work-in-process, increase productivity, improve quality and decrease rework (Bowles & Hammond, 1991; Goddard, 1986; Jhu, 1985; Juran, 1988).

Objective of the Study

This research aims at testing the hypotheses of a set of variables in the adaptation/ implementation of JIT and TQM philosophies in U.S. industries through an empirical study. The interest in and awareness of the impact of JIT and TQM concepts have been reported in the rapidly growing literature, especially in recent years. Repeatedly it has been noted in the literature that, while some companies have registered remarkable progress due to JIT and TQM concepts (Chang, 1993; Garvin 1988), others have abandoned their efforts in pursuing the implementation at some point in time (Tabak, 1993). The published literature, however, fails to specifically identify causes/factors related to catastrophic failures of some and remarkable success of others.

Research Proposal

This research is aimed at investigating the status of Just-In-Time (JIT) and Total Quality Management (TQM) implementation in various industries at the national level. The overall attributes of this empirical research are:

1. Whether the manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units not implementing such strategies.

2. Whether the manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing only JIT strategies.

3. Whether the manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units

implementing only TQM strategies.

4. Whether the manufacturing units fully implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing such strategies at the pilot stage.

Research Process

To get a national view of the manufacturing industries using JIT and TQM principles, a survey of 600 companies (one hundred companies for the pilot study and five hundred companies for the final study) across the nation were selected.

A two-section questionnaire was designed to gather data. Section-I comprised of eight categories and was dedicated to the production and quality management practices: (1.A) production related, (1.B) production-related strategies, (2) employee related, (3) management related, (4) supplier related, (5) costs related, (6) quality related, (7) computer related tools, and (8) ISO 9000 certification. In section-II, a special emphasis was made to first identify and categorize companies into: Non JIT/-Non TQM; JIT and TQM started but abandoned; pilot program in; implementing JIT and TQM strategies for less than two years and; initial implementation successfully completed and the JIT and TQM program in use for more than two years. Questions pertaining to the respondents' job title, number of employees in the firm and the nature of their business, appear at the conclusion of the questionnaire.

Structure of the Thesis

Chapter I of this thesis provides the introduction to the entire study; Chapter II provides a view of the Just-In-Time and Total Quality Management definitions, philosophies, principles and strategies; Chapter III describes the research methodology and design, which include background information, research steps, research hypotheses, research methods, questionnaire design, and steps to test the hypotheses; Chapter IV contains the discussion of results; Chapter V provides important conclusions of the study. This chapter is concluded with the recommendations and scope for further research.

CHAPTER II

REVIEW OF RELATED LITERATURE

The definitions, philosophies, principles and the practices of Just-In-Time (JIT), Quality, and Total Quality Management (TQM) are discussed in this chapter.

Just-In-Time (JIT)

Just-In-Time (JIT) may very best be defined to produce "only [the] necessary items in a necessary quantity at a necessary time." (Goddard, 1986, p.11) It was introduced in the early 1950s by Ohno, Executive Vice President of Toyota Motor Company, and perfected by Toyota in Japan.

The JIT approach gained popularity in Japan during 1970s. Toyota, with its JIT concept, was riding the success waves while other companies were sinking due to steep increases in imported oil prices.

Just-In-Time is a systems approach to developing and operating a manufacturing system where the three vital elements of manufacturing--capital, equipment, and labor are made available at the right time, at the right place and at the right (exact) quantities (Lubben, 1988).

Philosophy of JIT

The philosophy of JIT manufacturing is to operate a simple and efficient manufacturing system capable of optimizing the use of manufacturing resources such as capital, equipment, and labor. This results in the development of a production system capable of meeting a customer's quality and delivery demands at the lowest manufacturing price (Karmarkar, 1989).

Principle of JIT

Just-In-Time production techniques are a vital part of the solution to manufacturing challenges. Properly implemented, they can eliminate waste, increase manufacturing flexibility, eliminate most inventory and work-in-progress costs, increase productivity and decrease rework (White, 1993). Many companies have successfully implemented these techniques with excellent results. Combined with other Total Quality Control practices, such as statistical process control (SPC), and where appropriate material resource planning (MRP II), it is a formidable and critical element of manufacturing success (Krafcik, 1988; Schonberger, 1982).

JIT may very best be defined as production improvement technique. Properly implemented, it can ensure stable production scheduling, increase inventory turnaround, and decrease--over production, work in process, stock of finished goods, rejection rate and, lead times.

Quality

Definitions by some of the leading quality gurus are:

W.Edwards Deming: "The consumer is the most important part of the production line. Quality should be aimed at the needs of the customer, present and future." (Deming, 1986, p. 5).

J.M.Juran: " (1) Quality consists of those product features which meet the needs of customers and thereby provide product satisfaction; (2) Quality consists of freedom from deficiencies." (Juran, 1988, p. 2.2)

Armand V.Feigenbaum: "Quality is a customer determination, not an engineer's determination, not a marketing determination or a general management determination. It is based upon the customer's actual experience with the product or service, measured against his or her requirements." (Feigenbaum, 1986, p. 7)

Phil Crosby: "Conformance to requirements." (Crosby, 1979, p. 26) In other words, the product or part must meet the design specification. Since Just-In-Time is predicated on having the right part at the right time, quality is essential.

"Quality," writes Mary Walton, Deming's disciple and the author of 'The Deming Management Method' and 'Deming Management at Work', "must become the new religion." Deming is the creator of "the quality revolution" in the theory of management; and not least among the achievements of the "the quality revolution" has been its spiritualizaion of management itself, its promotion of management to "leader-ship" and to moral authority.

Total Quality Management (TQM)

"The quality revolution" is generally referred to by its cultic acronym TQM, or Total Quality Management. TQM emerged as a generic title for the process of quality improvement (Ross, 1993). Deming does not speak of TQM, but he begat it, and he is primus inter pares among the "quality gurus" discussed in Peter Capezio and Debra Morehouse's Total Quality Management, The road of Continuous Improvement, a recent manual of the movement.

TQM means building quality into everything in every area-design, production, purchasing, vendor relations, inspection, service after sales, market research, development, financial controls, personnel rewards, training, and education (Bajaria, 1993).

TQM may be defined as a management's commitment to customer satisfaction through continuous improvement in "quality."

Philosophy of TQM

The TQM philosophy has two basic tenets that can never be abandoned. First, the customer defines quality; the customer's needs and desires, whether expressed or tacit or as yet unrecognized, define the characteristics of the product or service that the organization must strive to produce (Mahoney, 1994).

Second, one important way to produce the good or service and have that way continuously improved is to invest in and trust the work force to accomplish the task. Customer satisfaction--all customers, internal and external--is paramount (Hohner, 1988).

Principle of TQM

In TQM, quality is the job of everyone in the organization. TQM, above all, is a philosophy of management. And without adoption of and dedication to that philosophy, whatever the program is, it is not TQM (Gitlow, 1987).

Just-In-Time Strategies

Production Related

Stable Production Scheduling. Integrate and streamline all processes in the manufacturing system. Develop controllable production processes. The ideal goal of JIT is to have the entire production cycle operate without interruption and without non-value-added time costs (Mondon, 1985; White & Ruch, 1990).

Overproduction. David Lu states that overproduction is a form of waste (Jhu, 1985). He further states that "over production creates a countless number of wastes, such as over-staffing, pre-emptive use of materials and energy costs, advance payments to workers, interest charges on mechanical devices and products, storage areas needed to accommodate the excess products and the cost of transporting them" (David Lu, 1985, p.20).

Line Balancing. The capacity required to do the job at each step in the manufacturing line is equal to the demonstrated capacity of each station or piece of equipment in the line. There are times when this can be a problem, especially when one piece of equipment in the manufacturing line runs considerably slower than the rest. Line balance is extremely important to be able to reduce queues and subsequently reduce work-in-process (Gitlow, 1987; Batholomew, 1984).

Machines Waiting for Repairs. Machines and equipment that are utilized without proper maintenance are the root cause for breakdowns. Production equipment should be fixed quickly to curtail loss of production. In a JIT system, the equipment is never operated at its maximum capacity. Derating the equipment extends the useful life of equipment, allows the extra time that can be used to program preventive maintenance requirements around the production needs (Lubben, 1988).

Work in Process. Under a JIT system, material is not moved in small lots and will not remain at any given location for longer than the process cycle time. Material flow under JIT is unidirectional and does not return to stock. With a goal of single lot quantities, material flow may be "timely." The production line should be the first area to reduce inventory in the form of work in process (Lubben, 1988).

Stock of Finished Goods. Stock of finished goods is also known as finished goods inventory. Inventory is waste. It wastes space because it takes up storage room. It wastes money because it has to be financed. It wastes time because it has to be transported (Ohno, 1988).

Rejection Rate. Rejection rate is the indicator of product quality. Quality is measured not in percentage points but as defects in parts per million (Goddard, 1986).

Lead Times. Isolating the bottlenecks in the operation, balancing the production system, and reducing set up times will aid in reducing the lead times [41]. Shortening of the lead time creates the following advantages: decrease in the work not related to processing, decrease in the inventory and ease in the identification of problems. Altogether the work place becomes more manageable (Jhu, 1985).

Delivery Cycle. A key part of time-based manufacturing strategy is the Just-In-Time (JIT) manufacturing system. When JIT principles are applied from supplier delivery to customer order delivery, the overall cycle time (throughput time) is reduced (Shores, 1990).

Inventory Turnaround. The importance of good quality in a Just-In-Time environment is also directly tied to the level of inventory (Joshi & Cambell, 1991). As inventory levels are reduced, buffer stocks are eliminated, and line flow is balanced, quality must excel or it will mean shutting down the line when problems surface.

Locate and reduce all sources of inventory (Crosby, 1979). Inventory control represents a group of smaller areas that collectively control a company's inventory. The basic reasons that inventory exists can be defined as: (1) Safety stock; (2) Excess material; (3) Obsolete material; (4) Defective material and (5) Work-in-process (Jhu, 1985).

Predictive Maintenance. This is a new concept of equipment maintenance, an extension to preventive maintenance. Preventive maintenance is a plan that involves routine inspecting, servicing, and keeping facilities in good repair to prevent failure (Carbone, 1993). Predictive maintenance is a plan wherein you predict problems with the machine and fix it well before hand. It is more important to prevent problems than to fix them.

Machine Set-up Time. Set goals on reducing set-up times (Karmarkar, 1989). Set-ups usually require substantial amount of work prior to an operation that is being accomplished at the work center. Much of the preparation required by a set-up can be done prior to shutting down the machine or process. Reducing set-up times is an excellent way to contribute to a reduction in inventory investment and to improve productivity (Jhu, 1985).

Tool/Die Exchange Time. A bottleneck is often created in the load-smoothing system of production by the exchange of die. Two contributing factors for the reduction of tool/die exchange time are (1) thoroughness in the outside exchange of die and (2) thoroughness in the inside exchange of die (Beauregard, Mikulak & Olson, 1992). These factors result in increased productivity and reduction in the product cost.

Work Cell Concept. A work cell contains all of the equipment necessary to process a family of products in the order of production. Having the equipment arranged in the order of production, reduces the amount of material handling involved, allows for smaller lots to be moved between machines, reduces the need for expensive and complex material handling systems, and allows for a better flow of information and employees in the production area (Lunnen, 1988).

Production - Strategies

Group Technology. Cellular manufacturing is another specific ingredients which must be evaluated by each company to determine whether it is appropriate for their process. Basically, cellular manufacturing is a process of bringing together machinery and work stations that work on the same parts or products. The process is often equated with group technology; however, technically, cellular manufacturing is the linking of machines and operations to produce a part, whereas group technology is primarily concerned with the production of like parts, grouped by design (Lubben, 1988).

Focused Factory Concept. When a firm has identified a large family of like products and the forecast is stable with adequate volumes, a focused work center moves production from a general-purpose, process oriented facility to a large work cell called a focused factory. A facility may be focused in regard to meeting quality, new product introduction, or flexibility requirements (Skinner, 1974).

Kanban (Pull System). Toyota's definition of a Just-In-Time system is to produce "only necessary items in a necessary quantity at a necessary time." This Toyota Production System is often mistakenly referred to as the "Kanban system" (Goddard, 1986, p. 11). Kanban is the Japanese word for "sign, or visible record (Jhu, 1985)." Kanban places added emphasis on meeting schedules and reducing the time and cost required by setups.

Higher levels of quality are a requirement for parts going to a process and a benefit for those leaving a process, thereby reducing rework loops (Shores, 1990). JIT also improves the coordination of part and subassembly flows at the assembly level. Pull systems as opposed to push systems improve cycle time, while simplifying shop-floor tracking, work prioritization, and decision requirements. Fewer inventory transactions are required throughout the process with Kanban JIT process (Hay, 1988).

Employee Related

Multi-Functional Employees. The first level of employee development is in cross-training employees to be proficient at all of the processes performed in their work area (Lubben, 1988). Treat your employees as an important resource (human resources) (Juran, 1978).

Employee Training. Develop the needed competence and awareness to attain high quality (education) (Deming, 1986). The goal of education and training of employees in JIT manufacturing is to ensure the depth of understanding of the philosophy and process that is required for a commitment to the successful implementation of JIT (Lubben, 1988): (a) Understanding of the need for JIT system; (b) Understanding how the employees' participation in the process will improve the company's performance; (c) Understanding how improved company performance helps the employee; (d) Understanding new ground rules and learning new procedures; and

(e) Understanding that difficulties may be expected during the conversion process and that the commitment of employees and management alike is required to minimize such difficulties.

Line Stop. Empowerment of workers to stop the production line if line problems occur. Since the JIT and TQM production system was designed to detect defective items throughout the entire production process for early diagnosis and repair, its success often hinges on the lone-stop strategy. This strategy gives assembly workers line-stop prerogatives when abnormality occurs (Shin & Min, 1993; Sugimori, Kusunoki, Cho & Uchikawa, 1977).

Jidoka (automation or automation with a human kind) means making equipment/machines or operations stop whenever abnormal or defective conditions arise (Mondon, 1983).

The successful implementation of a line-stop strategy should lead to better quality, lower scrap, better company image, increased employee morale (Mondon, 1983).

Supplier Related

JIT Purchasing. Goals of JIT purchasing are: (a) Secure a steady flow of quality parts, (b) reduce the lead time required for ordering product, (c) reduce the amount of inventory in the supply and production pipe lines, and (d) reduce the cost of purchased material (Wantuck, 1988).

Number of Suppliers per Item. Consider choosing only one supplier for each product you need so that no source feels threatened by competition (Schonberger & Gilbert, 1983). You might feel close to your supplier and end up working with him towards the same goal: zero defects (Groocock, 1986).

Supplier Development. Establish vendor quality programs so you can rely on suppliers to have good quality materials and on-time delivery-consistently (Mahoney & Thor, 1994). Incoming materials may be sent directly to the packaging line eliminating quality-control inspection. Operators are to be trained to inspect materials as they run on the line (Tucker & Davis, 1993).

Blanket/Firm Orders. A blanket order is a contract to purchase certain items from the vendor. It is a stimulus to partnership, resulting in an optimization of quality, delivery, price, and service (Bhote, 1987).

Small, Frequent Deliveries. Increasing the frequency of delivery is required if inventory is to be minimized and if JIT is to become a reality. The supplier's ability to make frequent deliveries is dependent on the supplier's ability to produce product at the rate the customer requires delivery. An additional advantage of frequent deliveries is that a loss of one small shipment will have less significance than the loss of a large shipment (Lubben, 1988).

Exact Quantities From Suppliers. In the strict sense of JIT, the term "exact quantities," means the receipt of materials only as required to meet the production demand. In reality, a small amount of buffer stock is maintained to "time the system" and to compensate for some production and transportation time (Lubben, 1988).

Inspection of Incoming Materials. As confidence in the supplier's quality builds through, lot sampling is skipped, and as the customer approaches a near zero defect level in his production lines and in the field, the supplier achieves the status of full certification. The inspection of incoming materials will be decreased considerably (Mahoney& Thor, 1994).

Costs Related

Material-related costs according to Lubben, are reduced in a JIT system by several means (Lubben, 1988): (a) Reducing the number of suppliers that the company deals with, (b) developing long-term contracts, (c) eliminating expediting, (d) reducing order scheduling, (e) obtaining better unit pricing, (f) eliminating the need to count individual parts, (g) simplifying receiving systems, (h) eliminating receiving inspection, (i) eliminating most unpacking (j) eliminating the breaking down of large material lots, (k) limiting the stocking of inventory, and (l) limiting excess material spoilage.

The fallout of an excellent quality program is less scrap, less rework, and less buffer stock, all of which translate into less inventory and better on-time production rates. The aim in terms of quality is not to produce merely acceptable quality levels but continually improving quality levels, thus moving from defects measured in a 2.5% scrap rate to a few parts per million (Hernandes, 1992). The objective is 100%

quality.

Quality Related

Quality Circles. The Japanese established their competitive position by focusing on quality as the basis for productivity and customer satisfaction; they require high quality from suppliers of material; they use continuous process improvement to reduce defects, they use "hoshin" to create shared plans; they use quality function deployment (QFD) to synthesize customer needs into products and they use quality circles to improve harmony (Juran, 1988).

Total Quality Management Strategies

Production Related

Productivity. Productivity implies the enhancement of the production process. Enhancement of production refers to a favorable comparison of the quality of resources employed (inputs) to the quantity of goods and services produced (outputs). A reduction in inputs while output remains constant, or an increase in output while inputs remain constant represents an improvement in productivity (Groocock, 1986; White, 1990).

Product Design. It is crucial for design engineers to begin looking not only at the customer but in the other direction, toward the manufacturing floor as well. They need to be designing the products for manufacturability at zero defect level.

This means that both manufacturing engineering and design engineering have had to work hand in hand from the conceptual level right on through production to assure manufacturability. Once the product has been designed and tested, a prototype is built and tested, and then the decision is made to manufacture the product (Goddard, 1986).

Employee Related

Recognition and Rewards. A quality program works only when a chief executive officer make the change they suggest. Managers must work with employees to decide what the company should be and must show a willingness to change everything. Employees must be trained to solve problems. And, employees must be rewarded and kept informed as the process goes on (Shin & Min, 1993).

Quick Implementation of Employees Suggestions on Quality. Continuous suggestions and feedback from workers will contribute to the successful achievement of factory operations by improving quality and productivity, increasing factory utilization (machine/equipment, manpower, and space), and revising ineffective operating routines, if necessary (Cox & Crawford, 1991).

Management Support

Top Management Support. Management needs to mobilize all employees around satisfying customer requirements for good quality, reasonable process, and flexible delivery schedules (Carbone, 1993).

First, a quality program works only when a CEO actively, visibly and tirelessly backs it (Carbone, 1993).

Middle Management Support. Middle managers need to concentrate on five key actions in developing organizational teamwork and a quality culture (Becker, 1993) that values people, ideas and improvements such as: (1) communicate goals; (2) ask for ideas; (3) involve the right people; (4) reinforce teamwork and participation; (5) provide active support.

Middle managers are best able to get results from TQM programs that give companies a competitive advantage, but they have to ask, listen, and act, or TQM will fail (Ramelli, 1993).

Customer Focus. Companies must concentrate vigorously on the customer. It takes tremendous commitments of time, energy and money to achieve this. It is interesting to note that "customer" in Japanese is *okyakjusama*, meaning both "customer" and "honored guest" (Carbone, 1993).

Deming says, think and act as if you are the customer of what you sell (commitment) (Deming, 1986). Look at everything through the customer's eyes. Because quality is defined by the customer, the first step is understanding the customer's requirements (Deming, 1981).

Communication. For effective communication, it is important to keep communication open and flowing (Crosby, 1992). Everyone involved must understand why you're establishing JIT and buy into it. To make TQM work, all the pieces must fit together exactly. Not only must you work well with outside suppliers, but with internal departments as well (Mann, 1985).

Open communications and support from top management to the lowest level of hourly worker must be maintained in both directions for the successful implementation of TQM.

Product Design Review. Product design may be classified into: (a) Design information stage; (b) design development stage; and (c) production qualification stage (Sweeney, 1993).

Supplier Related

Long-term Partnership Relationship. Build business partnerships. Many qualities that are important in a personal relationship are also vital if business partnerships are to prosper: loyalty, mutual support, communication (Baldwin, 1989).

Supplier Performance. One of the main principles of JIT/TQC is to pursue a high quality level by adopting a quality-at-the-source concept (Shin & Min, 1993).

Costs Related

Inspection Costs. Inspection costs include supervision and training of the QC inspectors plus expenses for labor, equipment, and supplies involved in the actual testing process. Inspection costs in a JIT environment are reduced for the parts supplied by the suppliers as they approach near zero defect level in their production lines (Bhote, 1987).

Quality Related

Specification of Product Quality. When Phil Crosby said, "Quality is free" what he meant was that the cost of poor quality can be tremendous (Goddard, 1986, p.75). Specifically, he listed such added costs as product redesign, rework, scrap, re-servicing delivered products, and lost customer credibility. In a Just-In-Time environment, all of these costs are seen as waste. But it is important to note that quality is far more than simply a component of Just-In-Time. It is a critical issue in and of itself, and one that must be addressed by every manufacturing company over and above Just-In-Time (Mann, 1985).

Continuous Improvement. The underlying philosophy of JIT and TQM is to eliminate waste throughout a company and to seek continuous improvement of product quality via company-wide employee involvement (Robinson, McClain & Thomas, 1990).

Parts/Components Standardization. Develop products that are designed for manufacturability (Shores, 1990); build products to specifications; link product design with process design to achieve the best possible quality. This may require going through several iterations (Sweeney, 1993).

Quality Circles. The Japanese established their competitive position by (a) focusing on quality as the basis for productivity and customer satisfaction; (b) requiring high quality from suppliers of material; (c) using continuous process improvement to reduce defects--using "hoshin" to create shared plans; (d) using quality function deployment (QFD) to synthesize customer needs into products; and (e) using quality circles to improve harmony (Bhote, 1987).

Total Quality Control. Total quality control involves the managerial and technical implementation of customer-oriented quality activities as a prime responsibility of general management and of the main-line operations of marketing, engineering, production, industrial relations, finance, and service as well as of the quality-control function itself (Shin & Min, 1993).

One of the primary areas of waste in a manufacturing environment come from poor quality. Just-In-Time has as one of its objectives the notion of Zero Defects (Hall, 1983). This involves an approach known as Total Quality Control, which calls on techniques like Statistical Process Control, preventive maintenance, good housekeeping, manufacturable designs, and constructive vendor relations and programs (Hauser & Clausing, 1988).

Availability of Quality Data. Information systems for Just-In-Time are characterized by the need for and the use of current, accurate data. The type of information and the use to which it will be put determine how quickly the information must be collected, refined, disseminated, and acted upon. Some of the more important data that can be collected are: (a) Machine or process set-up time; (b) machine or process capability; (c) supplier performance-quality, delivery, cost; (d) production performance-quality, delivery, cost; (e) production process status-bottlenecks, work flow; (f) test stations-failure data and corrective action; (g) field service-failure data and corrective action; (h) production process (equipment) maintenance records (Lubben, 1988).

Statistical Process Control Charts (SPCC). Statistical Process Control Charts tells only when, not what. Yet, rarely are these actions known. A better choice is using SPC as a process-improvement tool. The SPC chart divides the complex problem into three categories: (1) off-target, (2) instability, and (3) incapability. It also offers a strategy for attacking the problem. Better to use SPC as an improvement tool than as a control tool (Noori, 1989).

CHAPTER III

RESEARCH METHODOLOGY AND DESIGN

This chapter deals with the background, research hypotheses, research methods, questionnaire design and steps to test the hypotheses.

Background

Published literature clearly points out that the manufacturing firms implementing Just-In-Time (JIT) and Total Quality Management (TQM) practices have largely gained real and larger benefits compared to the firms following traditional methods of manufacture over JIT and TQM.

The literature in vogue on JIT and TQM strategies points out to the fact that the observation or implementation of these strategies really contribute to improved quality and productivity levels of products produced in manufacturing units. The research hypotheses presented here are derived from this point of view.

Research Steps

Research steps for the thesis are shown in Figure 1.

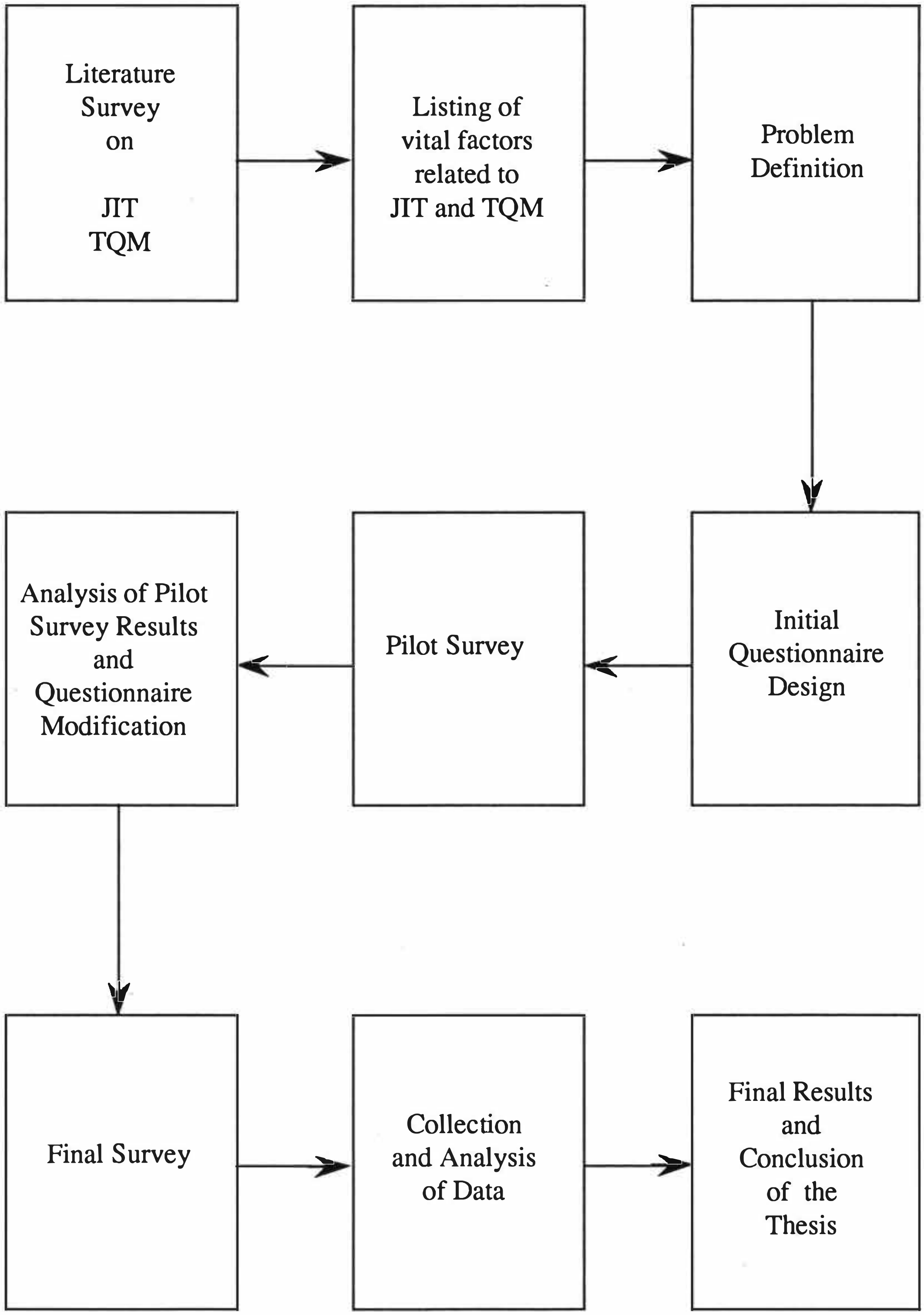

Figure 1. Research Steps.

Research Hypotheses

The overall characteristics of this empirical research are:

1. The manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units not implementing such strategies.

2. The manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing only JIT strategies.

3. The manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing only TQM strategies.

4. The manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing such strategies at the pilot stage.

Research Methods

To get a national view of the industries using JIT and TQM principles, a survey of 600 companies across the U.S. were selected.

The empirical survey is split into (a) pilot survey: comprising of 100 companies across the U.S. covering all the states and (b) final survey: 500 companies across the U.S.

Criteria for the Study

1. For the purpose of the study, manufacturing companies under Standard Industrial Classification (SIC), Division D, Range 20-39 (manufacturing) were selected.

2. Companies employing 50 or more people and less than 3000.

Human Subjects Institutional Review Board (HSIRB) Clearance

Western Michigan University's HSIRB required that a postcard be mailed along with the questionnaire so that respondents who were interested in receiving a copy of the survey results would fill it out and mail it separately. According to HSIRB, this process would maintain the anonymity of the respondents as mentioned in the covering letter to the questionnaire. HSIRB approval letter (refer Appendix A) was received to carry out the empirical survey for this thesis.

Questionnaire

Copies of the covering letter and postcard (as per the requirement of HSIRB) appear in Appendix B. The final survey questionnaire is shown in Appendix C, and the pilot survey questionnaire appears in Appendix D.

Pilot Survey

The purpose of the pilot survey was to study the feedback responses and rectify/modify and redefine the questions for the purpose of the intended study. Blank questions with no responses and questions with inconsistent responses are studied with extra caution in order to eliminate the problem of ambiguity. Since the study was extensive, covering the entire U.S. was thought to be an essential practice.

Final Survey

Modified questionnaire would be sent for the final survey. To avoid biased responses for the questions pertaining to top management, the final survey questionnaires would be addressed only to the Plant Managers. Due to this change, it is assumed that the responses would be largely unbiased and uniform in nature.

Questionnaire Design

The questionnaire is divided into two sections as (1) Section-I and (2) Section-II.

Section-I

Section-I is divided into eight divisions. Questions in each division are dedicated to one particular aspect of the manufacturing facility. The divisions are: (1. A) Production related, (1. B) Production related-strategies, (2) Employee related, (3) Management related, (4) Supplier related, (5) Costs related, (6) Quality related, (7) Computer related tools and (8) ISO 9000 certification.

Section-II

This section is mainly dedicated to the JIT and TQM program implementation. A special emphasis was made to first identify and categorize companies into: Non JIT/Non TQM; JIT and TQM started but abandoned; pilot program in; implementing JIT and TQM strategies for less than two years and; initial implementation successfully completed and the JIT and TQM program in use for more than two years.

Questions pertaining to the respondents' job title, number of employees in the firm and the nature of their business, appear at the conclusion of the questionnaire.

Steps to Test the Hypotheses

Improved quality and productivity would be measured from the first six blocks from Section-I of the questionnaire (pertaining to productivity, employee related, management related, supplier related, costs related and quality related). This would be referred as 'Variable-I.' Responses to the blocks were provided on a five-point Likert scale that ranges from 1 representing the extent or level of activity of very low (decreased considerably) to 5 representing very high (increased considerably). Some of the questions were reverse coded. To facilitate data interpretation, the scores of negatively phrased items would be reversed before analysis are conducted.

From the section-II, responses to questions 78 and 79 would be classified into four groups. They are JIT and TQM, JIT and TQM (both) and none. This would be known as 'Variable-II.'

Questions from variable-I would be tested first using reliability analysis.

Reliability analysis is used to test the degree to which measurements are free from random errors and shows the relationship between the true underlying score and observable score.

Variable-I and variable-II are tested for the first hypothesis using ANOVA.

1. Null hypothesis H_0. There is no effect due to variable-II (this means there is no difference in quality and productivity in firms implementing JIT and TQM, JIT and TQM or none, hence the classification is not true).

Alternate hypothesis H_1. There is an effect due to variable-II (this means there is difference in quality and productivity in firms implementing JIT and TQM, JIT and TQM or none, and hence the classification is true).

Using variable-I and variable-II, the second and third hypotheses will be tested, using pair-wise comparison.

2. Null hypothesis H_0. The overall average scores for JIT firms will not have significant difference in quality and productivity compared with JIT and TQM firms.

Alternate hypothesis H_1. The overall average scores for JIT firms will have significant difference in quality and productivity compared with JIT and TQM firms.

3. Null hypothesis H_0. The overall average scores for TQM firms will not have significant difference in quality and productivity compared with JIT and TQM firms.

Alternate hypothesis H_1. The overall average scores for TQM firms will have significant difference in quality and productivity compared with JIT and TQM firms.

For testing the hypothesis four, the variable-II referred earlier is replaced with two groups, which are (1) pilot stage and (2) implemented stage. t-Test would conducted to determine the following hypothesis.

4. Null hypothesis H_0. There is no effect due to variable-II (this means there is no difference in quality and productivity in firms implementing JIT and TQM at pilot stage, fully implemented stage, and hence the classification is not true).

Alternate hypothesis H_1. There is an effect due to variable-II (this means there is difference in quality and productivity in firms implementing JIT and TQM at pilot stage, fully implemented stage, and hence the classification is true).

CHAPTER IV

DISCUSSIONS OF RESULTS

Analysis of Data

Criteria for the Study

1. For the purpose of the study, manufacturing companies under Standard Industrial Classification (SIC), Division D, Range 20-39 (manufacturing) were selected.

2. Companies employing 50 or more people and less than 3000.

Pilot Survey

One hundred questionnaires were mailed to all 50 states in the U.S. Follow-up letters were sent after one month and 29 responses were received (29% response rate). Pilot survey questionnaires were addressed to different individuals in the manufacturing industry ranging from Vice President to the Factory Managers level. After a careful review of the respondents' answers to the questionnaire, a few questions were modified to convey the intended meaning, and a few more questions were added as per the suggestions received from the respondents. The changes made from the pilot survey questionnaire to the final survey questionnaire can be seen in Table 1.

Table 1

Survey Questionnaire Revisions

Pilot Survey Questionnaire	Final Survey Questionnaire
Section-I	
1.A. Production related	
(Q4) Over Production	(Q4) Over Production* (*producing more than the scheduled quantity)
(Q14) Inventory turnaround cycle	(Q14)Inventory turn around* (*number of cycles)
3. Management related	
(Q39) Response time to customers	(Q39) Response time to customers* (*time between order receipt and delivery)
(Q40) Use of MRP/MRPII concept	Changed to (Q76) and moved to 7. Computer related tools group
4. Management related	
(Q43) Supply base reduction (reduction in number of suppliers)	(Q42) Number of suppliers per item
(Q48) Value analysis	Replaced with two questions: (Q47) Supplier performance (Q48) Periodic review of supplier performance
5. Costs related	
(Q54) Unit cost	(Q54) Unit product cost

A set of new questions which were added to the final survey questionnaire are (Q89) (Q97) (Q106) (Q115) "not useful in your type of business." A new group (8) ISO 9000 certification is added to the section-I of the final questionnaire.

Final Survey

Five hundred questionnaires were mailed all over the U.S. Total number of responses received was 154 (30.8% response rate). Since the response rate had reached the anticipated mark and due to limited financial resources, no reminder letters were sent. In fact, the financial limitations were explained in the letters sent out enclosing the questionnaire.

To avoid biased responses for the questions pertaining to top management, it was decided that the final survey questionnaires would be addressed only to the Plant Managers. Due to this change, it was assumed that the responses would be largely unbiased and uniform in nature.

The concentration for the purpose of this study was limited only to manufacturing industries. Hence, one completed questionnaire from a distribution company is not taken into consideration for the analysis of the results.

The questionnaire was long and estimated to take at least half-an-hour to answer. But, the surprising fact noted was that the respondents had fully answered all the questions. A few had marked n/a (not applicable) on certain questions which do not pertain to their current manufacturing system. No question were left blank.

Preliminary Analysis

Who Answered the Questionnaire?

Though the questionnaires were addressed to the Plant Managers, 48 respondents (31%) were from the top management ranks, ranging from presidents to the general managers. One hundred and five respondents (69%) were from the middle management. Managers were from various departments such as manufacturing, materials, project and quality. Job title of each respondent is shown in Table 2.

Employees Range

From the responses, it is classified that 22 manufacturing firms have the employees in the range of 50-100. Sixty of them have 251-500 employees range. Twenty companies have 501-1000 employees and eight companies with 1001-3000 employees. The results are shown in a bar chart in Figure 2.

Nature of Business

The highest percentage of business in high volume high variety is indicated by 82 respondents followed by low volume high variety with 40 respondents. High volume low variety type of business is carried out by 17 and low volume low variety by 9. Four have responded with low volume high variety and high volumehigh variety type of business and two of them with low volume high variety and high volume low variety. The break-up is shown in the form of a pie chart in Figure 3.

Table 2

Job Title of Respondents

Job Title	No. of respondents	
Top Management		
President	4	
Chief Executive Officer	1	
Vice Presidents	17	
Controller	1	
Directors	5	
General Managers	20	Total: 48
Middle Management		
Plant Managers	57	
Manufacturing Managers	6	
Managers-Operations	9	
Factory Managers	5	
Foundry Managers	2	
Project Managers	2	
Quality Control Managers	14	Total: 93
Plant Superintendent	1	
Others		
Sr. Plant Engineer	1	
Plant Engineer	1	
QA & QC	6	
R&D	1	Total: 9

JIT Program

Fifty-two respondents (34.0%) had not implemented the JIT program (refer Table 3). Nine (5.9%) had implemented but now abandoned. Forty one (26.8%) are in the pilot stage of implementation. Thirty one (22.9%) have implemented and sixteen (10.5%) have fully implemented the program.

TQM Program

Forty-nine respondents (32.0%) had not implemented the TQM program (refer Table 3). Eight (5.2%) had implemented but now abandoned. Thirty-four (22.2%) are in the pilot stage of implementation. Forty-eight (31.4%) have implemented and fourteen (9.2%) have fully implemented the program.

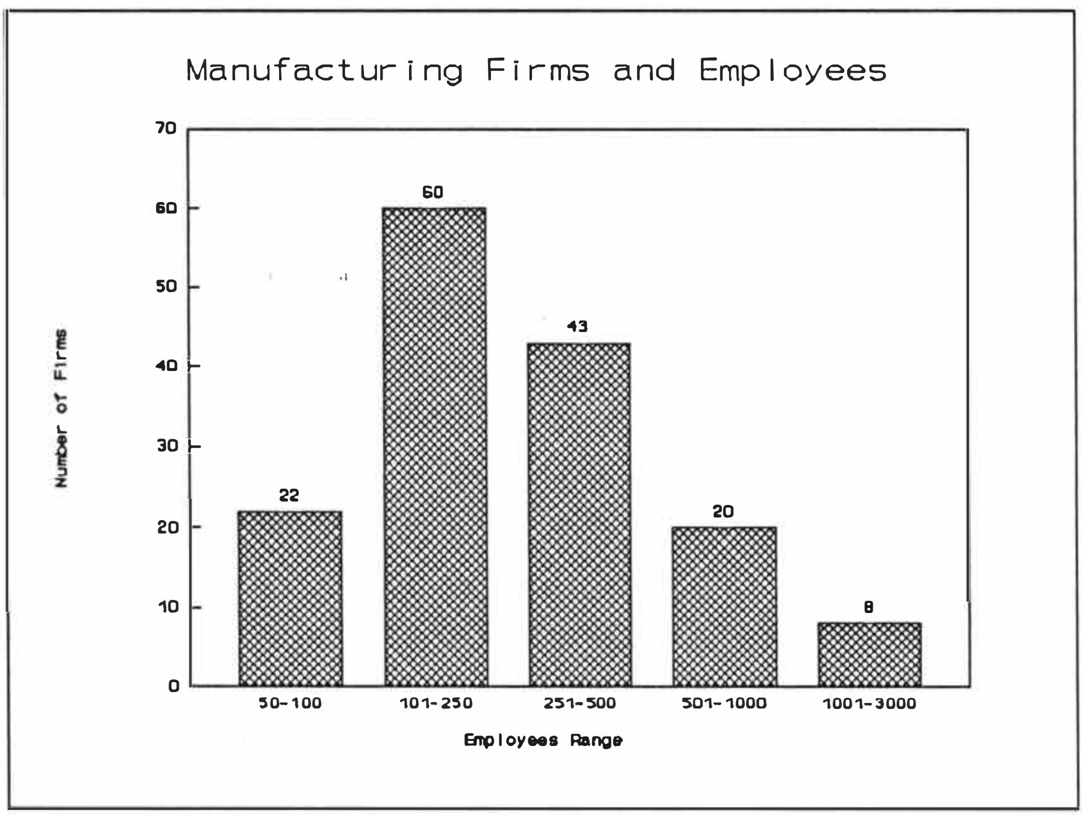

Figure 2. Manufacturing Firms and Employees.

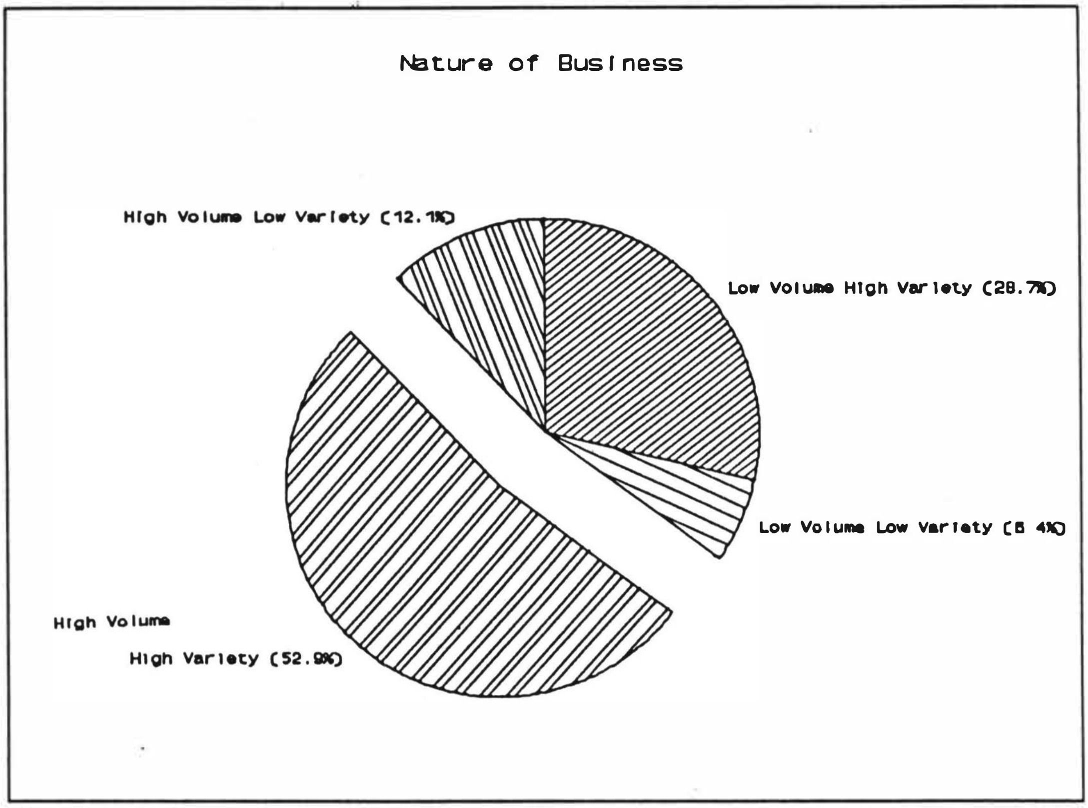

Figure 3. Nature of Business.

The JIT and TQM program implementation details are shown in Table 3, and in Figure 4.

Secondary Analysis

Status-grouping

For the purpose of the statistical analysis, based on the question numbers 78 (JIT program) and 79 (TQM program), the respondents are classified into: (1) "None"

Table 3

JIT and TQM Implementation Details*

Status	Frequency		Percent Frequency		Cumulative Percent		Cumulative	
	JIT	TQM	JIT	TQM	JIT	TQM	JIT	TQM
Not implemented	52	49	34.0%	32.0%	52	49	34.0%	32.0%
Implemented but now abandoned	9	8	5.9%	5.2%	61	57	39.9%	37.3%
Pilot stage	41	34	26.8%	22.2%	102	91	66.7%	59.5%
Implemented	35	48	22.9%	31.4%	137	139	89.5%	90.8%
Fully implemented	16	14	10.5%	9.2%	153	153	100%	100%

* empirical survey results

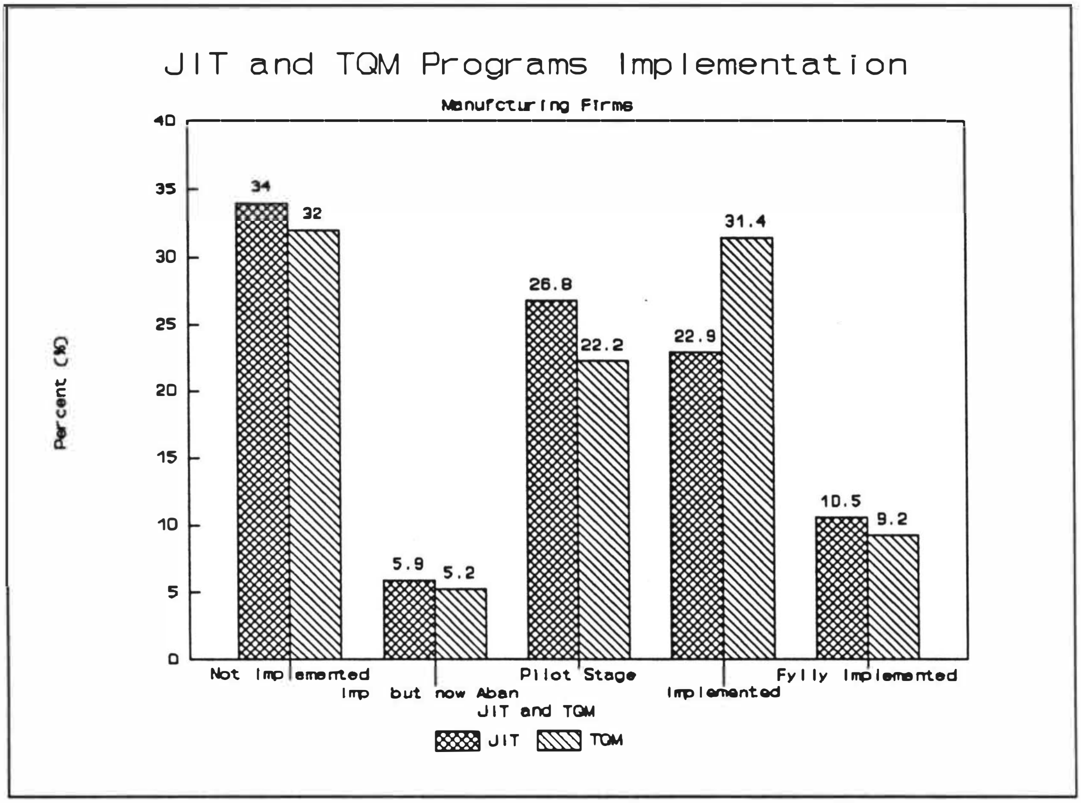

Figure 4. JIT and TQM Implementation Program Details.

the respondents not implementing either JIT or TQM practices (answered NI[1] or IA[2] for JIT and answered NI or IA for TQM in the questionnaire), (2) both-the respondents implementing both JIT and TQM practices (answered PS[3] or I[4] or FI[5] for JIT

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[1] NI= Not implemented

[2] IA = Implemented but now abandoned (discontinued)

[3] PS = Pilot stage (experimental stage)

[4] I = Implemented

[5] FI = Fully implemented

and PS or I or FI for TQM), (3) JIT-the respondents using only JIT practices (answered PS or I or FI for JIT and NI or IA for TQM), (4) TQM-the respondents using only TQM practices (answered NI or IA for TQM and PS or I or FI for TQM). The results of the classification from 153 responses received is shown in Table 4 and also the graphical representation in the form of a pie chart is shown in Figure 5.

Table 4

Classification of JIT, TQM Implementation

	Frequency	Percent	Cumulative	Cumulative
None	42	27.05%	42	27.5%
Both (JIT and TQM)	77	50.03%	119	77.8%
JIT only	15	9.8%	134	87.6%
TQM only	19	12.4%	153	100%

Manufacturing Practices - Section I

Production Related

Table 5 lists the responses to the questions with respect to production related practices. Possible responses to this section were provided on a Likert scale that ranged from 1 representing decreased considerably to 5 representing increased considerably. Questions 4, 6, 7, 8, 9, 10, 11, 12, 16 and 17 were reverse coded (for example, if a respondent marked "decreased considerably," the score was taken as 5 and likewise 1 for "increased considerably").

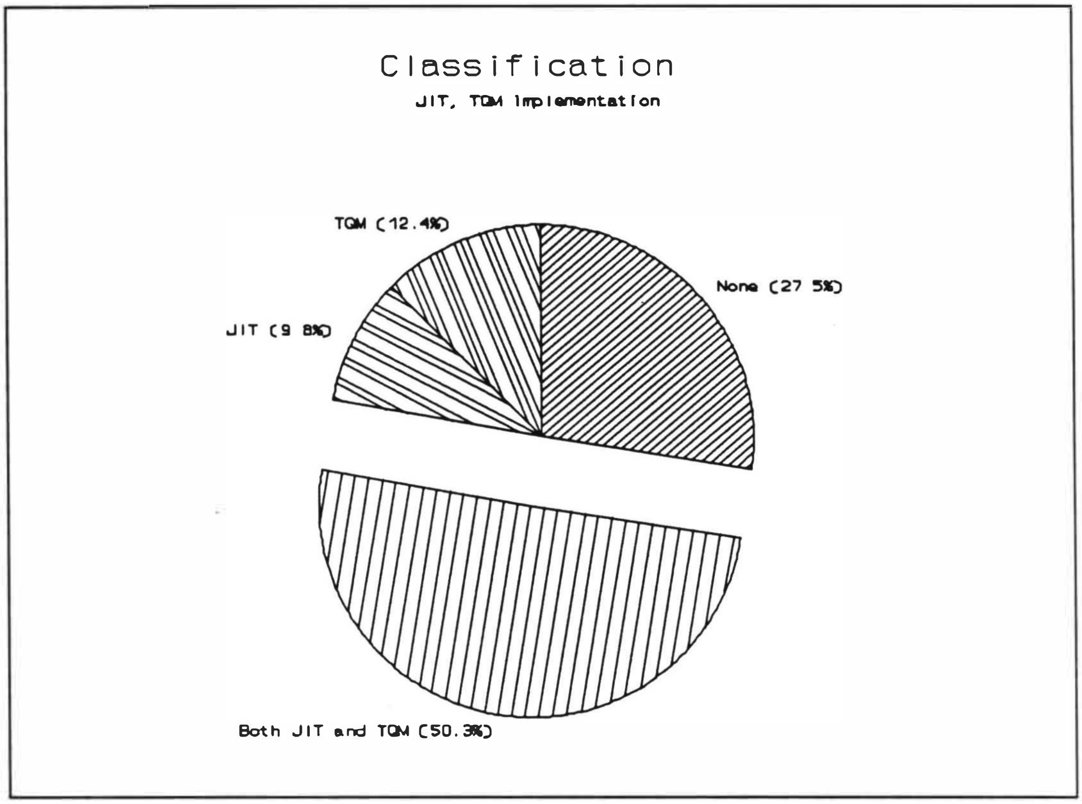

Figure 5. Classification of JIT and TQM Implementation.

The average score of responses ranged from a high of 4.02 for productivity toa low of 2.73 for minimum lot size. Only six (4%) respondents not implementing JIT and TQM had indicated decrease in productivity. Fifteen out of 22 respondents who had answered "no change" in production had also indicated that they were not implementing either JIT and or TQM principles. Eighty-two percent of the companies had indicated that their productivity had increased.

Questions 11, 18, 12 and 10 with a high average scores of 3.65, 3.63, 3.61 and 3.60 show considerable reduction in lead times, increased work-cell concept, decreased delivery cycle and rejection rates.

Table 5

Responses to Production Related Questions

Question	DC	D	NC	I	IC	Average
Productivity	1	5	22	87	38	4.02
Stable Production Scheduling	9	12	41	79	12	3.48
Product Design	1	5	67	67	12	3.53
Over Production	14	60	45	31	3	3.33
Line balancing	1	14	63	71	4	3.41
Machines waiting for repairs	16	55	51	31	0	3.37
Work in process	25	63	24	37	3	3.44
Stock of finished goods	23	72	15	39	4	3.46
Material handling distances	11	58	73	11	0	3.45
Rejection rate	20	82	23	26	2	3.60
Lead times (manufacturing cycle)	17	80	43	12	1	3.65
Delivery cycle	20	77	33	22	1	3.61
Minimum lot size	12	52	56	32	1	2.73
Inventory turnaround	5	26	38	72	12	3.39
Predictive Maintenance	2	8	84	57	2	3.32
Machine set-up times	10	82	39	21	1	3.52
Tool/Die Exchange time	19	64	54	14	0	3.54
Work cell concept	1	2	60	70	18	3.63

Ninety five respondents (62%) had indicated decrease in stock of finished goods and 86 (58%) had indicated decrease in work-in-process, which were positive signs for increased productivity.

Questions 16 and 17 which were regarding machine set-up times and tool/die exchange time had a score of 3.52 and 3.54, indicating considerable reduction in set-up times aiding in higher productivity.

Important to product design, question 3, is indicated by 79 respondents (52%) with a score of 3.53. Considering an average value of 3 for "no change" in the production related practices, 17 questions out of 18 had got the scores more than 3.00. Scores over 3.00 may be considered as an indication to the awareness of using certain JIT and TQM practices.

Production Related Strategies

Review of the responses to questions are shown in Table 6. Implementation of uniform work load, group technology, focused factory concept and Kanban/pull system, questions 19, 20, 21 and 22 were done by 45%, 46%, 44% and 38% of the respondent manufacturing companies. "Can't say" responses range from 11 to 18%, probably the respondents were not clear.

Employee Related

This division contains questions related to employees (Table 7). Possible responses to the questions were provided on a Likert scale from 1 to 5 and the reverse coded questions are 26 and 27. Employee training had the highest average score of 3.89. One hundred and twelve (73%) companies had indicated increase in employee training followed by empowerment/involvement of employees 109 (71%) companies. Multi-functional employees, quick implementation of employees suggestion on quality, production worker support and recognition and awards had average score of 3.83, 3.77 and 3.68 respectively. Only one company (0.7%) had said that employee absenteeism

Table 6

Responses to Production Related-Strategies Questions

Question	NI	CS	AA	PS	IP	FI
Uniform work load	58	21	5	27	23	19
Group technology	50	27	6	26	24	20
Focused factory concept	49	25	12	24	26	17
Kanban/pull system	69	17	9	17	20	21

had increased considerably. All 11 questions in this division scored 3.30 on the average. This "bottom-up approach," could be considered a positive sign for increased productivity and quality.

Management Related

Table 8 contains questions related to management. A high average scale of 4.00 with 117 (76%) respondents show that the management in these companies is committed to the customer focus, question 36.

Middle management support and top management support scored an average of 3.77 and 3.71. One hundred and thirteen (74%) of the respondent companies had indicated increase in communication, question 37. Interdisciplinary team approach, question 35 had an average score of 3.76. The only question that received a low

Table 7

Responses to Employee Related Questions

Question	DC	D	NC	I	IC	Average
Production workers support	2	16	37	72	26	3.68
Office staff support	3	13	62	68	7	3.41
Multi-functional employees	0	9	36	80	28	3.83
Employee absenteeism	7	67	48	30	1	3.32
Employee turnover	11	46	76	18	2	3.30
Employee training	0	4	37	84	28	3.89
Recognition and rewards	2	3	54	77	17	3.68
Empowerment/involvement	2	6	36	78	31	3.85
Quick implementation of employees suggestions on 'quality'	1	6	47	72	27	3.77
Line stop	0	2	77	65	9	3.53

customers, which had score compared to others in this section is the one dealing with response time to an average score of 3.00.

The high average scores for six out of seven question in this division indicate the increase in "top down" approach towards improving quality and productivity.

Supplier Related

Responses to supplier related questions appear in Table 9. Five point Likert

Table 8

Responses to Management Related Questions

Question	DC	D	NC	I	IC	Average
Top management Support	6	19	24	69	35	3.71
Middle management Support	1	14	33	76	29	3.77
Inter-disciplinary team approach	0	8	42	77	25	3.76
Customer focus	0	7	29	74	43	4.00
Communication	3	14	23	95	18	3.73
Product design review before production and marketing	3	4	59	68	19	3.63
Response time to customers	7	52	41	40	13	3.00
Computer resources	0	3	38	84	28	3.90

scale is used and the reverse coded questions are 42, 48 and 52. Increases in Just-In-Time purchasing (question 41) and long term partnership (question 46) are indicated by 98 (64%) and 93 (61%) by the companies at the highest average score of 3.71.

Questions 47, 50, 43, and 44 supplier, performance, small, frequent deliveries, supplier development and supplier certification had an average score of 3.61, 3.60. 3.58 and 3.57 respectively. The high scores in this division indicates a possibility of the successful implementation of JIT principles related to supplier development.

Table 9

Responses to Supplier Related Questions

Question	DC	D	NC	I	IC	Average
Just in time purchasing	0	4	50	80	18	3.71
Number of suppliers per item	11	67	44	30	1	3.37
Supplier development	0	2	66	79	6	3.58
Supplier certification	1	0	71	73	8	3.57
Blanket orders/firm orders	2	8	62	66	15	3.55
Long term partnership relationship	1	11	48	65	28	3.71
Supplier performance	1	15	38	88	11	3.61
Periodic review of supplier performance	0	3	59	79	12	2.35
Standardized containers	0	0	95	51	7	3.42
Small, frequent deliveries	0	5	68	63	17	3.60
Exact quantities from suppliers	0	9	76	58	10	3.45
Inspection of incoming materials	15	36	41	55	6	2.99

Cost Related

Responses to costs related question appear in Table 10. Five point Likert scale was used for this division. All the questions in this division are reverse coded. Decrease in scrap/re-work costs is reported by 93 (61%) companies with an average score of 3.59. Decrease in inventory costs (question 53) and unit product cost (question 54) had an average score of 3.41. Reduction in inventory costs by 61% of the companies is a direct indication of decrease in work in process (question 7) and stock of finished goods (question 8) referred earlier in the production related division.

Quality Related

Table 11 lists the questions related to quality. There are no reverse coded question in the five point Likert scale used in this division. Question 59, specification of product quality had the highest average score of 3.98. One hundred and twenty five (82%) of the companies had indicated increase in specification of product quality. 81% of the respondents' had an increase in continuous improvement. Question 64, 63 and 62, availability of quality data, total quality control and quality circles had an average score of 3.78, 3.76 and 3.51. All the seven questions in this division received average scores, which are more than 3.50. This may be an indication of how the U.S. manufacturing companies have taken "quality" seriously as an important issue for productivity.

Computer Related Tools

Ninety-eight percent of the respondents had answered "yes" for the questions 66 and 67 about the word processors and spreadsheet software usage. JIT and TQM (both), JIT and TQM groups had indicated extensive use of other computer tools referred to in questions 68, 69, 70, 71, 72, 73, 74, 75 and 76, when compared to the

Table 10

Responses to Costs Related Questions

Question	DC	D	NC	I	IC	Average
Inventory costs	13	78	21	40	1	3.41
Unit product cost	7	88	21	35	2	3.41
Scrap/re-work costs	24	69	36	22	2	3.59
Inspection costs	19	56	42	33	3	3.36
Administrative cots	0	57	56	35	5	3.08
Inbound freight (from suppliers)	0	22	100	29	2	2.93

group who had not implemented JIT and TQM or both. The details are shown in a table containing statistical data pertaining to computer related tools in Appendix E.

ISO 9000

From the group of JIT and TQM (77 respondents), 31 (40.3%) had indicated that they had or applied for ISO 9000 certification. Out of 15 JIT group companies 3 (20%) and 19 TQM group companies 5 (26.3%) had ISO 9000 certification. Even from the group not implementing JIT and TQM or both, 5 (11.9%) out of 42 had indicated that they had the certification. From the results, it is evident that the companies adopting both JIT and TQM (both) had more number of ISO 9000 certifications. This indicates that JIT and TQM implementation plays an important role

Table 11

Responses to Quality Related Questions

Question	DC	D	NC	I	IC	Average
Specification of product quality	0	1	27	99	26	3.98
Continuous improvement	0	6	23	95	29	3.96
Parts/ Components standardization	0	4	72	68	9	3.54
Quality circles	6	73	55	17	1	3.51
Total quality control	0	10	43	73	27	3.76
Availability of quality data	0	0	48	90	15	3.78
SPCC	0	2	65	65	19	3.62

for obtaining certification.

JIT and TQM Programs - Section II

The results and reasons for not implementing or implemented but now abandoned JIT and TQM programs are in Appendix F.

Reliability Analysis

Reliability test was done on the questionnaire before doing ANOVA and pair-wise comparisons. Questions 13 (minimum lot size for manufacturing), 39 (response time to customers), 48 (periodic review of supplier performance), had negative and questions 27 (employee turnover), 40 (computer resources), 58 (inbound freight from suppliers), 65 (SPCC) had very low (poor) total correlation . Hence, they were eliminated for further analysis.

Correlation Analysis

Correlation analysis with the results of linear relationships among production and quality management practices obtained from the empirical survey is listed in Table 12. There was a strong correlation between stock of finished goods, over production and work in process (questions 8, 4 and 7). Quick implementation of employees' suggestions on quality (question 31) had high positive correlation between employees empowerment/involvement, top management support, customer focus, communication, continuous improvement and total quality control (questions 30, 33, 36, 37, 60 and 63). Question 30, empowerment/involvement of employees had high correlation between quick implementation of employees suggestion of quality and line stop (questions 31 and 32). Top management support, question 33, had strong correlation between question 37, communication. The strong correlation of 0.74 wasbetween top management support (question 33) and middle management support (question 34). Customer focus, question 36, had high correlation between employee empowerment/involvement, top management support and long term partnership relationship with the suppliers, question 30, 33 and 46. Long term partnership relationship between the suppliers (question 46) had a high correlation with blanket orders/firm orders tosuppliers (question 45). Supplier performance (question 47) had

Table 12

Correlation Analysis Results

Variable	8	10	28	30	33	36	37	46	54	56	60	62	63	64
4	0.63													
7	0.61													
31				0.68	0.64	0.66	0.60				0.66		0.69	
32				0.60										
33							0.66							
34					0.74									
36				0.60	0.65			0.60						
45								0.61						
47		-0.65		0.65			0.63	-0.65	0.65					
53	0.62													
55		0.64								0.61				
60			0.61	0.62	0.64	0.65	0.64	0.60						0.66
63				0.66	0.66	0.62	0.62				0.70	0.63		0.66

strong positive correlation between top management support, long term partnership relationship between the suppliers, continuous improvement (questions 33, 46 and 60) and high negative correlation between rejection rate and unit product cost (questions 10 and 54).

Scrap/re-work costs had high correlation between rejection rate and inspection costs (questions 55, 10 and 56). Continuous improvement (question 60) had strong correlation between employee training, empowerment/involvement, top management support, customer focus, communication, long term partnership relationship with suppliers and availability of quality data (questions 28, 30, 33, 36, 37, 46 and 64).

Total quality control, question 33, had strong correlation with empowerment/ involvement of employees, top management support, customer focus, communication, continuous improvement, quality circles and availability of quality data (questions 30, 33, 36, 37, 60, 62 and 64).

Hypotheses Testing

Improved quality and productivity measures were classified into six divisions: (1) production related, (2) employee related, (3) management related, (4) supplier related, (5) costs related, and (6) quality related. These six divisions were classified as variable-I. Manufacturing companies that responded were classified into four groups. The first group was the companies implementing JIT. The second group consisted of companies implementing TQM. Companies implementing both JIT and TQM were classified as group three and group four were not implementing any of these strategies (none).

Hypothesis 1

Null Hypothesis H_0

There is no effect on quality and productivity in firms implementing JIT and TQM, JIT and TQM (both) or none, hence the classification is not true.

Alternate Hypothesis H_1

There is an effect on quality and productivity in firms implementing JIT and TQM, JIT and TQM (both) or none, hence the classification is true.

H_0: $\mu_i = \mu_j$ for all i, j

H_1: $\mu_i \neq \mu_j$ for some i, j

Analysis of variance (ANOVA) results are shown in Table 13. From the Tables 14, 15, 16, 17, 18 and 19 pair-wise comparison results show a significant difference between the four groups. There was a significant difference in the means with p=0.0001 for production, employees, management, suppliers, costs and quality. This means Pr>F was less than 0.05 and hence null hypothesis H_0 was rejected.

Hypothesis 2

Null Hypothesis H_0

The overall average scores for JIT companies will not have significant difference in quality and productivity compared to JIT and TQM (both) companies.

Alternate Hypothesis H_1

The overall average scores for JIT companies will have significant difference in quality and productivity compared to JIT and TQM (both) companies.

Table 20 shows the p values 0.0418 for the employees, 0.0017 for suppliers, 0.0208 for quality related blocks. The results show that there was a significant difference between the JIT and JIT and TQM groups. Since the values are less than 0.05, reject the null hypothesis H_0. It was also evident from the test results that there was no significant difference between JIT and JIT and TQM groups with regard to production, management and costs related blocks.

Hypothesis 3

Null Hypothesis H_0

The overall average scores for TQM companies will not have significant difference in quality and productivity compared to JIT and TQM (both) companies.

Alternate Hypothesis H_1

The overall average scores for TQM companies will have significant difference in quality and productivity compared to JIT and TQM (both) companies.

Table 21 shows the α values 0.0474 for the production related block. The results show that there was a significant difference between the TQM and JIT and

Table 13

Analysis of Variance (ANOVA)

Division	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Productivity	Model	3	4556.05	1518.68	31.39	0.0001
	Error	149	7207.92	48.38		
	Corrected	152	11763.97			
Employees	Model	3	1495.32	498.44	25.09	0.0001
	Error	149	2960.22	19.87		
	Corrected	152	4455.54			
Management	Model	3	1049.13	349.70	29.64	0.0001
	Error	149	1757.81	11.79		
	Corrected	152	2806.94			
Supplier	Model	3	1841.43	613.81	32.80	0.0001
	Error	149	2788.69	18.72		
	Corrected	152	4630.12			
Cost	Model	3	570.07	190.02	18.58	0.0001
	Error	149	1523.48	10.22		
	Corrected	152	2093.54			
Quality	Model	3	3574.30	1191.43	29.27	0.0001
	Error	149	6065.82	40.72		
	Corrected	152	9640.12			

Table 14

Production Related - Block 1

Group	Frequency N	Average	Std Err LSMEAN 2
JIT	15	61.60	1.79
JIT and TQM (both)	77	64.25	0.79
None	42	51.38	1.07
TQM	19	60.68	1.59

Pair-wise Comparison

JIT differs significantly from none	p value 0.0001
JIT and TQM significantly differ from none	p value 0.0001
TQM differs significantly from none	p value 0.0001

Pair-wise comparison - Graphical Representation

	JIT and TQM (Average)	JIT (Average)	TQM (Average)	None (Average)	
High	64.2	61.6	60.7	51.4	Low

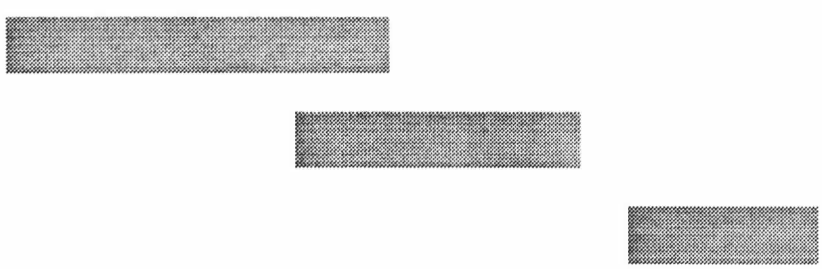

Table 15

Employee Related - Block 2

Group	Frequency N	Average	Std Err LSMEAN
JIT	15	36.07	1.15
JIT and TQM (both)	77	38.65	0.50
None	42	31.33	0.69
TQM	19	37.63	1.02

Pair-wise Comparison

JIT differs significantly from none	p value 0.0001
JIT and TQM significantly differ from none	p value 0.0001
TQM differs significantly from none	p value 0.0001

Pair-wise comparison - Graphical Representation

	JIT and TQM (Average)	TQM (Average)	JIT (Average)	None (Average)	
High	38.6	37.6	36.0	31.3	Low

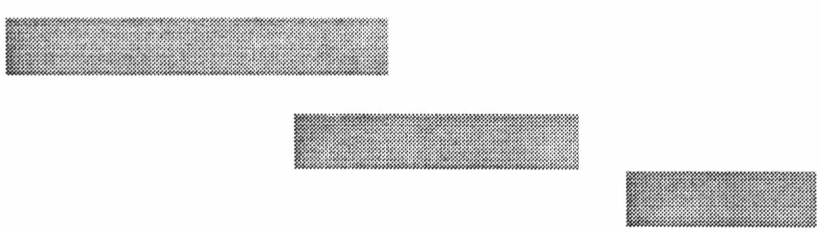

Table 16

Management Related - Block 3

Group	Frequency N	Average	Std Err LSMEAN
JIT	15	23.00	0.89
JIT and TQM (both)	77	24.32	0.39
None	42	18.45	0.52
TQM	19	24.84	0.79

Pair-wise Comparison

JIT differs significantly from none	p value 0.0001
JIT and TQM significantly differ from none	p value 0.0001
TQM differs significantly from none	p value 0.0001

Pair-wise comparison - Graphical Representation

	TQM (Average)	BOTH (Average)	JIT (Average)	None (Average)	
High	24.8	24.3	23.0	18.4	Low

Table 17

Supplier Related - Block 4

Group	Frequency N	Average	Std Err LSMEAN
JIT	15	37.40	1.12
JIT and TQM (both)	77	41.31	0.49
None	42	33.17	0.67
TQM	19	39.53	0.99

Pair-wise Comparison

JIT differs significantly from none	p value 0.0014
JIT and TQM significantly differ from none	p value 0.0001
TQM differs significantly from none	p value 0.0001

Pair-wise comparison - Graphical Representation

	JIT and TQM (Average)	TQM (Average)	JIT (Average)	None (Average)	
High	41.3	39.5	37.4	33.1	Low

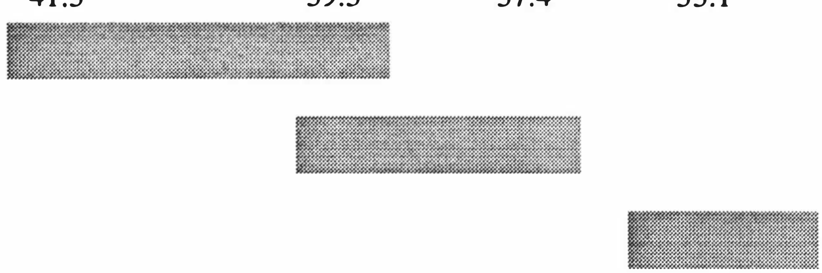

Table 18

Costs Related - Block 5

Group	Frequency N	Average	Std Err LSMEAN
JIT	15	17.53	0.82
JIT and TQM (both)	77	18.32	0.36
None	42	13.79	0.49
TQM	19	17.10	0.73

Pair-wise Comparison

JIT differs significantly from none	p value 0.0001
JIT and TQM significantly differ from none	p value 0.0001
TQM differs significantly from none	p value 0.0002

Pair-wise comparison - Graphical Representation

	JIT and TQM (Average)	JIT (Average)	TQM (Average)	None (Average)	
High	18.3	17.5	17.1	13.7	Low

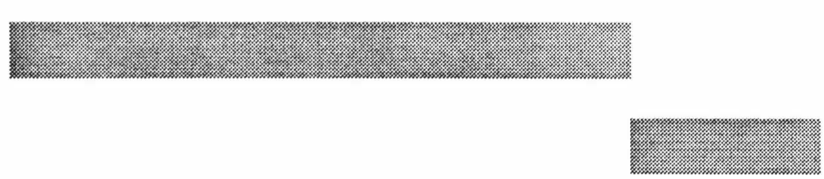

Table 19

Quality Related - Block 6

Group	Frequency N	Average	Std Err LSMEAN
JIT	15	55.00	1.64
JIT and TQM (both)	77	59.20	0.72
None	42	47.88	0.98
TQM	19	57.47	1.46

Pair-wise Comparison

JIT differs significantly from none	p value 0.0003
JIT and TQM significantly differ from none	p value 0.0001
TQM differs significantly from none	p value 0.0001

Pair-wise comparison - Graphical Representation

	JIT and TQM (Average)	TQM (Average)	JIT (Average)	None (Average)	
High	59.2	57.4	55.0	47.8	Low

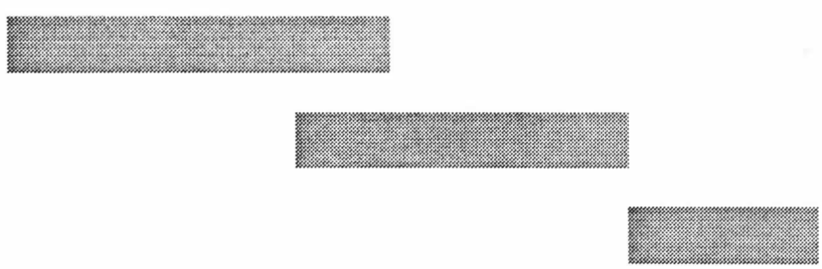

Table 20

t-Test Results for JIT Group

Block	Group	Frequency N	Average	p Value
Production	JIT	15	61.60	
	JIT and TQM	77	64.25	0.1796
Employees	JIT	15	36.07	
	JIT and TQM	77	38.65	0.0418*
Management	JIT	15	23.00	
	JIT and TQM	77	24.32	0.1738
Suppliers	JIT	15	37.40	
	JIT and TQM	77	41.31	0.0017*
Costs	JIT	15	17.53	
	JIT and TQM	77	18.32	0.3820
Quality	JIT	15	55.00	
	JIT and TQM	77	59.20	0.0208*

* Significant at the .05 level

TQM groups. Since the values are less than 0.05, reject the null hypothesis H_0.

From the test results it was also evident that there was no significant difference between TQM and JIT and TQM groups with regard to employees, management, supplier, costs and quality related blocks.

Hypothesis 4

Null Hypothesis H_0

There is no difference in quality and productivity in companies implementing JIT and TQM strategies at pilot stage compared with the fully implemented stage companies.

Alternate Hypothesis H_1

There is difference in quality and productivity in companies implementing JIT and TQM strategies at pilot stage compared with the fully implemented stage companies.

Table 22 shows the p values of 0.0072 for costs and 0.0115 for quality related blocks. The results show that there was a significant difference between the pilot stage and full implementation. Since the values are less than $\alpha = 0.05$, reject null hypothesis H_0.

It was also evident from the test results that there was no significant difference between the pilot stage and the fully implemented stage with regard to production, employees, management and supplier related blocks.

Summary of the hypotheses tested is shown in Table 23.

Table 21

t-Test Results for TQM Group

Block	Group	Frequency N	Average	p Value
Production	TQM	19	60.68	
	JIT and TQM	77	64.25	0.0474*
Employees	TQM	19	37.63	
	JIT and TQM	77	38.65	0.3742
Management	TQM	19	24.84	
	JIT and TQM	77	24.32	0.5574
Suppliers	TQM	19	39.53	
	JIT and TQM	77	41.31	0.1093
Costs	TQM	19	17.11	
	JIT and TQM	77	18.32	0.1387
Quality	TQM	19	57.47	
	JIT and TQM	77	59.20	0.2904

* Significant at the .05 level

Table 22

t-Test Results for Pilot Stage

Block	Group	Frequency N	Average	p Value
Production	PILOT	38	62.37	
	IMPLEMENTED	57	64.98	0.0522
Employees	PILOT	38	37.98	
	IMPLEMENTED	57	38.43	0.6152
Management	PILOT	38	23.76	
	IMPLEMENTED	57	24.39	0.3658
Suppliers	PILOT	38	39.68	
	IMPLEMENTED	57	41.47	0.0663
Costs	PILOT	38	17.19	
	IMPLEMENTED	57	19.00	0.0072*
Quality	PILOT	38	56.53	
	IMPLEMENTED	57	60.11	0.0115*

* Significant at the .05 level.

Table 23

Hypotheses Results

Hypotheses	Null Hypotheses	p Value	Results
Hypothesis 1	There is no effect on quality and productivity in companies implementing JIT, TQM, both or none.	0.0001	Pr>F is significant at the 0.05level, reject the null hypothesis. Alternate hypothesis accepted.
Hypothesis 2	The overall average scores for JIT companies will not have significant difference in quality and productivity compared to JIT/TQM (both) companies.	0.0017 (Supplier related)	Pr>F is significant at the 0.05level, reject the null hypothesis. Alternate hypothesis accepted.
Hypothesis 3	The overall average scores for TQM companies will not have significant difference in quality and productivity compared to JIT/TQM (both) companies.	0.0474 (Production related)	Pr>F is significant at the 0.05level, reject the null hypothesis. Alternate hypothesis accepted.
Hypothesis 4	There is no difference in quality and productivity in companies implementing JIT/TQM strategies at pilot stage compared with the fully implemented stage companies.	0.0072 (Costs relted) 0.0115 (Quality related)	Pr>F is significant at the 0.05level, reject the null hypothesis. Alternate hypothesis accepted.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This research was conducted to answer the following questions:

1. Do manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units not implementing such strategies?

2. Do manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing only JIT strategies?

3. Do manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing only TQM strategies?

4. Do manufacturing units implementing JIT and TQM strategies have improved quality and productivity levels when compared to manufacturing units implementing such strategies at the pilot stage?

Related literature (Chapter II) suggests that the manufacturing companies implementing JIT, TQM principles had improved quality and productivity.

Conclusions

The main conclusions drawn from this study are:

1. The manufacturing units implementing JIT and TQM strategies have significant increases in quality and productivity levels when compared to manufacturing units not implementing such strategies.

2. The manufacturing units implementing JIT and TQM strategies have also significant increases in employee involvement, management commitment/involvement, suppliers' participation, and reduction in costs when compared to manufacturing units not implementing such strategies.

3. The manufacturing units implementing JIT and TQM strategies have increased quality level when compared to manufacturing units implementing only JIT strategies.

4. The manufacturing units implementing JIT and TQM strategies have increased productivity level when compared to manufacturing units implementing only TQM strategies.

5. The manufacturing units implementing JIT and TQM strategies have increased employee involvement, suppliers' participation compared to manufacturing units implementing only JIT strategies.

6. The manufacturing units implementing JIT and TQM strategies have increased quality and productivity levels when compared to manufacturing units implementing such strategies at the pilot stage.

7. Firms implementing JIT and TQM strategies have increased the use of

computer related tools and an increase in ISO 9000 certification.

8. The manufacturing companies have also realized the importance of customer satisfaction. From the results discussed in Chapter IV, the question on "customer focus" had a high score of 4.00, which is a direct indication of how U.S. manufacturing companies have increased their customer focus.

9. Results also showed an increase in just-in-time purchasing and long term partnership with suppliers. Considering how Japanese gained their competitive edge in the recent past by implementing JIT, TQM strategies, it could be said that the U.S.companies are in the right pursuit to regain their competitive edge.

10. Other important factors observed from the results are the involvement of top management and employees for the successful implementation of JIT and TQM strategies.

11. Also from the survey results, the failure to implement JIT, TQM was largely attributed to the lack of management support.

12. Results also reveal that JIT, TQM programs formerly implemented but now abandoned were due to lack of continuous management and workers support.

Research results had answered an important question: "Were there any significant differences in adopting only JIT or only TQM or both strategies for the increased benefits in manufacturing practices?" The results indicated the disparity, if any, in adopting JIT, TQM or both strategies. For production related practices, there was no significant difference if between the firms that implemented only JIT or both. For quality, employee and supplier related practices, implementing only TQM or both made no difference. Management and costs related practices had indicated that there was no difference between only JIT, only TQM or if both were implemented. Adopting both JIT and TQM showed significant difference in all the six manufacturing practices used for this study--production, employee, management, supplier, costs and quality.

However, adopting--only JIT, only TQM or both showed significant difference in all the six manufacturing practices compared to the manufacturing firms not implementing any of these practices.

Limitations

Regional-wide analysis of manufacturing industries could not be carried out in this survey due to HSIRB's directive to maintain the anonymity of the respondents.

The survey was limited to (a) manufacturing industries and (b) firms employing 50-3000 employees. Firms employing more than 3000 employees were not considered for this empirical survey.

Recommendations for Further Research

1. The present survey results indicated that management and employee involvement in implementing JIT and TQM were important. Further research may be carried out in this direction.

2. Since JIT and TQM strategies are not limited to the manufacturing industries, further research needs to be conducted in other types of operations, such

as transportation, construction, communication, whole sale trade, finance, insurance, real estate and services.

3. The present research was not specific to any particular manufacturing industry. Hence, further research could be carried out with regard to different types of manufacturing industries.

4. Sample data collected from personal interviews at different industries and locations would help eliminate the potential for biased responses.

5. The results from this research with regard to manufacturing industries show that (a) implementing JIT alone is significantly same as implementing both JIT and TQM for increased productivity, management commitment and reduction in costs, and (b) implementing TQM alone is significantly same as implementing both JIT and TQM for increased employee involvement, management commitment, suppliers' participation, enhancement in quality and reduction in costs. These observations would be particularly beneficial to the companies with limited allocations of budget when they give discretion as to which of the two strategies (JIT or TQM) to implement first for the activities they would like to improve.

With further detailed research, similar conclusions can be drawn supporting the implementation of only JIT or only TQM or both strategies. Other types of operations, such as, transportation, construction, communication, wholesale trade, finance, insurance, real estate, services and business (e.g., the service rendered, or the goods produced, sold or processed), research can choose from the strategies of JIT or TQM to meet specific areas of improvement.

APPENDICES

Appendix A

Western Michigan University's
HSIRB Approval Letter

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899
616 387-8293

WESTERN MICHIGAN UNIVERSITY

Date: January 12, 1994

To: Loknath Sriparavastu

From: M. Michele Burnette, Chair M. Michele Burnette

Re: HSIRB Project Number 93-12-13

This letter will serve as confirmation that your research project entitled "A survey of production and quality management practices in manufacturing" has been **approved** under the exempt category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

You must seek reapproval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: January 12, 1995

xc: Gupta, Industrial Engineering

Appendix B

Cover Letter and Postcard

College of Engineering and Applied Sciences
Department of Industrial Engineering

Kalamazoo, Michigan 49008-5061
616 387-3737
FAX: 616 387-4024

WESTERN MICHIGAN UNIVERSITY

January 31, 1994

Dear Sir/Madam:

> *'Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.'*
>
> **- W. Edwards Deming**

To gain an insight into the actual quality management practices carried out in the American industries, I am conducting a survey to gather qualified opinions concerning production and quality practices carried out in your company. Your knowledge and experience as a professional in the field of manufacturing can be of great benefit to us.

I am a graduate industrial engineering student at Western Michigan University, and your answers to the enclosed questionnaire will prove extremely helpful in gathering primary research material for my Master's thesis,'Production and Quality Management Practices in Manufacturing.'

In carrying out this thesis, I am being guided and advised by Dr. Tarun Gupta, Associate Professor of Industrial Engineering (IE) and Chair of the thesis committee, Dr. Richard Munsterman, Chair of the IE dept., and Dr. Larry Mallak, Assistant Professor (IE).

I would greatly appreciate it if you would take a few moments to answer the questionnaire. Due to limited funding, we did not mail this questionnaire to all the Industries all over U.S. We mailed it to a few industries which were randomly selected by the computer.

You may be sure that all responses will remain confidential. A stamped self-addressed envelope is enclosed. If you would like a summary of the results, fill in the enclosed stamped self-addressed post card and mail it separately. Will you please complete and mail your questionnaire within a week?

Many thanks for your cooperation.

Sincerely,

LOKNATH SRIPARAVASTU

Enclosures

Please print your name and address if you want us to send a summary of the results.

Name:

Company name:

Company address:

Phone number:

Mr. Loknath Sriparavastu
WESTERN MICHIGAN UNIVERSITY
College of Engineering and Applied Sciences
Department of Industrial Engineering
Kalamazoo, Michigan 49008-5061

Appendix C

Final Survey Questionnaire

A SURVEY OF PRODUCTION AND QUALITY MANAGEMENT PRACTICES IN MANUFACTURING

Section - I

The following questions pertain to the Production and Quality Management practices in Manufacturing. For each of the following statements, please indicate the changes that have taken place in your factory compared to the past by circling the appropriate answer:

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

1. A. PRODUCTION RELATED

(1)	Productivity	DC	D	NC	I	IC
(2)	Stable Production Scheduling	DC	D	NC	I	IC
(3)	Product Design	DC	D	NC	I	IC
(4)	Over Production* (*producing more than the scheduled quantity)	DC	D	NC	I	IC
(5)	Line balancing	DC	D	NC	I	IC
(6)	Machines waiting for repairs	DC	D	NC	I	IC
(7)	Work in process	DC	D	NC	I	IC
(8)	Stock of finished goods	DC	D	NC	I	IC
(9)	Material handling distances	DC	D	NC	I	IC
(10)	Rejection rate	DC	D	NC	I	IC
(11)	Lead times (manufacturing cycle)	DC	D	NC	I	IC
(12)	Delivery cycle* (*order receipt to despatch time)	DC	D	NC	I	IC
(13)	Minimum lot size* (*for manufacturing)	DC	D	NC	I	IC
(14)	Inventory turnaround* (*number of cycles)	DC	D	NC	I	IC
(15)	Predictive* Maintenance (*new concept of equipment maintenance)	DC	D	NC	I	IC
(16)	Machine set-up times	DC	D	NC	I	IC
(17)	Tool/Die Exchange time	DC	D	NC	I	IC
(18)	Work cell* concept (*Formation/Identification of part families & work cells)	DC	D	NC	I	IC

1. B. **PRODUCTION RELATED- STRATEGIES**

NI = Not Implemented
CS = Can't Say
AA = Attempted but now Abandoned (discontinued)
PS = Pilot Stage
IP = Implementation in Progress
FI = Fully Implemented

(19)	Uniform work load	NI	CS	AA	PS	IP	FI
(20)	Group Technology	NI	CS	AA	PS	IP	FI
(21)	Focused Factory concept	NI	CS	AA	PS	IP	FI
(22)	Kanban*/Pull system (*don't produce more than is withdrawn)	NI	CS	AA	PS	IP	FI

2. EMPLOYEE RELATED

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

(23)	Production workers support	DC	D	NC	I	IC
(24)	Office staff support	DC	D	NC	I	IC
(25)	Multi-functional employees	DC	D	NC	I	IC
(26)	Employee absenteeism	DC	D	NC	I	IC
(27)	Employee turn over	DC	D	NC	I	IC
(28)	Employee training	DC	D	NC	I	IC
(29)	Recognition and rewards	DC	D	NC	I	IC
(30)	Empowerment/Involvement	DC	D	NC	I	IC
(31)	Quick implementation of employees suggestions on 'quality'	DC	D	NC	I	IC
(32)	Line stop* (*empowerment of workers to stop the production line if line problems occur)	DC	D	NC	I	IC

3. MANAGEMENT RELATED

(33)	Top Management support	DC	D	NC	I	IC
(34)	Middle Management support	DC	D	NC	I	IC
(35)	Inter-disciplinary* team approach to project assignments (*design, manufacturing, quality)	DC	D	NC	I	IC

Cont . . . Mgmt.

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

(36)	Customer focus	DC	D	NC	I	IC
(37)	Communication* (*Interdepartmental/Interfunctional)	DC	D	NC	I	IC
(38)	Product design review before production and marketing	DC	D	NC	I	IC
(39)	Response time to customers* (*time between order receipt and delivery)	DC	D	NC	I	IC
(40)	Computer resources	DC	D	NC	I	IC

4. SUPPLIER RELATED

(41)	Just in time purchasing	DC	D	NC	I	IC
(42)	Number of suppliers per item	DC	D	NC	I	IC
(43)	Supplier development	DC	D	NC	I	IC
(44)	Supplier Certification	DC	D	NC	I	IC
(45)	Blanket orders/firm orders	DC	D	NC	I	IC
(46)	Long term partnership* relationship (*vendor as a business partner)	DC	D	NC	I	IC
(47)	Supplier performance	DC	D	NC	I	IC
(48)	Periodic review of supplier performance	DC	D	NC	I	IC
(49)	Standardized containers	DC	D	NC	I	IC
(50)	Small, frequent deliveries	DC	D	NC	I	IC
(51)	Exact quantities from suppliers	DC	D	NC	I	IC
(52)	Inspection of incoming materials	DC	D	NC	I	IC

5. COSTS RELATED

(53)	Inventory costs	DC	D	NC	I	IC
(54)	Unit product cost	DC	D	NC	I	IC
(55)	Scrap/re-work costs	DC	D	NC	I	IC
(56)	Inspection costs	DC	D	NC	I	IC

Cont . . . Quality related

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

(57)	Administrative costs	DC	D	NC	I	IC
(58)	Inbound freight (from suppliers)	DC	D	NC	I	IC

6. QUALITY RELATED

(59)	Specification of Product quality	DC	D	NC	I	IC
(60)	Continuous Improvement	DC	D	NC	I	IC
(61)	Parts/ Components standardization	DC	D	Nc	I	IC
(62)	Quality circles* (*group approach towards quality)	DC	D	NC	I	IC
(63)	Total quality control	DC	D	NC	I	IC
(64)	Availability of quality data	DC	D	NC	I	IC
(65)	SPCC(Statistical Process Control Charts)	DC	D	NC	I	IC

7. COMPUTER RELATED TOOLS

Please answer whether you are using the following tools by circling '**yes**' or '**no**.'

(66)	Word processors	Yes	No
(67)	Spreadsheet software	Yes	No
(68)	Data base applications	Yes	No
(69)	Computer Networking with clients/suppliers	Yes	No
(70)	Office automation	Yes	No
(71)	Shop floor automation	Yes	No
(72)	Numerically controlled machine tools	Yes	No
(73)	PLCs (Programmable logic controls)	Yes	No
(74)	RF Technology (Radio Frequency)	Yes	No
(75)	Bar coding	Yes	No
(76)	Use of MRP*/MRP II (*Material requirement planning)	Yes	No

8. ISO 9000 CERTIFICATION

If you have ISO 9000 certification or applied for, please circle all that apply:

(77) ISO 9000 ISO 9001 ISO 9002 ISO 9003 ISO 9004

Section - II

The following questions pertain to JIT (Just-in-Time) and TQM (Total Quality Management) programs.

NI = Not Implemented
IA = Implemented but now Abandoned (discontinued)
PS = Pilot Stage (Experimental Stage)
I = Implemented
FI = Fully Implemented

(78)	1. JIT program	NI	IA	PS	I	FI
(79)	TQM program	NI	IA	PS	I	FI

If your answer is either NI or IA to Question 1, please skip question 2.

(80)	2. JIT program is in use	Less than 2 years	More than 2 years ➡	________Years (Please specify)
(81)	TQM program is in use	Less than 2 years	More than 2 years ➡	________Years (Please specify)

If your answer is either NI or IA to Question 1, please answer the following:

The following questions pertaining to i) non-implementation of Just-in-Time (JIT), Total Quality Management (TQM) practices and ii) implemented but now abandoned JIT, TQM practices.

3. **JIT** program not implemented due to:

(82)	Lack of Management support	Yes	No	Can't say
(83)	Lack of Workers' support	Yes	No	Can't say
(84)	Lack of Technical Expertise	Yes	No	Can't say
(85)	Lack of Feasibility study	Yes	No	Can't say
(86)	Lack of Financial resources	Yes	No	Can't say
(87)	Lack of Technical tools	Yes	No	Can't say
(88)	Lack of Vendor support	Yes	No	Can't say
(89)	Not useful in your type of business	Yes	No	Can't say

4. **TQM** program not implemented due to:

(90)	Lack of Management support	Yes	No	Can't say
(91)	Lack of Workers' support	Yes	No	Can't say
(92)	Lack of Technical Expertise	Yes	No	Can't say
(93)	Lack of Feasibility study	Yes	No	Can't say
(94)	Lack of Financial resources	Yes	No	Can't say

Cont . . . **TQM** program not implemented due to:

(95)	Lack of Technical tools	Yes	No	Can't say
(96)	Lack of Vendor support	Yes	No	Can't say
(97)	*Not useful in your type of business	Yes	No	Can't say

5. **JIT** program implemented but now abandoned due to lack of:

(98)	Continuous Management support	Yes	No	Can't say
(99)	Continuous workers' support	Yes	No	Can't say
(100)	Continuous Financial resources	Yes	No	Can't say
(101)	Continuous Vendor support	Yes	No	Can't say
(102)	Improvement in Quality	Yes	No	Can't say
(103)	Improvement in Productivity	Yes	No	Can't say
(104)	Reduction in costs	Yes	No	Can't say
(105)	Reduction in waste	Yes	No	Can't say
(106)	*Not useful in your type of business	Yes	No	Can't say

6. **TQM** program implemented but now abandoned due to lack of:

(107)	Continuous Management support	Yes	No	Can't say
(108)	Continuous workers' support	Yes	No	Can't say
(109)	Continuous Financial resources	Yes	No	Can't say
(110)	Continuous Vendor support	Yes	No	Can't say
(111)	Improvement in Quality	Yes	No	Can't say
(112)	Improvement in Productivity	Yes	No	Can't say
(113)	Reduction in costs	Yes	No	Can't say
(114)	Reduction in waste	Yes	No	Can't say
(115)	*Not useful in your type of business	Yes	No	Can't say

*If JIT & TQM are *not implemented* or implemented but *now abandoned* as they were not useful in your type of business, please comment briefly why? ____________________

____

____

Your job title ______________________________

The Number of employees in your firm ____________________

Nature of Business 1. Low Volume High Variety 2. Low Volume Low Variety
3. High Volume High Variety 4. High Volume Low Variety

Thanks for completing the questionnaire. Please return the completed questionnaire in the enclosed postage paid envelope.

Appendix D

Pilot Survey Questionnaire

A SURVEY OF PRODUCTION AND QUALITY MANAGEMENT PRACTICES IN MANUFACTURING

Section - I

The following questions pertain to the Production and Quality Management practices in Manufacturing. For each of the following statements, please indicate the changes that have taken place in your factory compared to the past by circling the appropriate answer:

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

1. A. PRODUCTION RELATED

(1)	Productivity	DC	D	NC	I	IC
(2)	Stable Production Scheduling	DC	D	NC	I	IC
(3)	Product Design	DC	D	NC	I	IC
(4)	Over Production	DC	D	NC	I	IC
(5)	Line balancing	DC	D	NC	I	IC
(6)	Machines waiting for repairs	DC	D	NC	I	IC
(7)	Work in process	DC	D	NC	I	IC
(8)	Stock of finished goods	DC	D	NC	I	IC
(9)	Material handling distances	DC	D	NC	I	IC
(10)	Rejection rate	DC	D	NC	I	IC
(11)	Lead times (manufacturing cycle)	DC	D	NC	I	IC
(12)	Delivery cycle[#] (#order receipt to despatch time)	DC	D	NC	I	IC
(13)	Minimum lot size* (*for manufacturing)	DC	D	NC	I	IC
(14)	Inventory turnaround cycle	DC	D	NC	I	IC
(15)	Predictive[@] Maintenance (@new concept of equipment maintenance)	DC	D	NC	I	IC
(16)	Set-up times	DC	D	NC	I	IC
(17)	Tool/Die Exchange time	DC	D	NC	I	IC
(18)	Work cell~ concept (~Formation/Identification of part families & work cells)	DC	D	NC	I	IC

1. B.PRODUCTION RELATED- strategies

NI = Not Implemented
CS = Can't Say
AA = Attempted but now Abandoned (discontinued)
PS = Pilot Stage
IP = Implementation in Progress
FI = Fully Implemented

(19)	Uniform work load	NI	CS	AA	PS	IP	FI
(20)	Group Technology	NI	CS	AA	PS	IP	FI
(21)	Focused Factory concept	NI	CS	AA	PS	IP	FI
(22)	Kanban*/Pull system (*don't produce more than is withdrawn)	NI	CS	AA	PS	IP	FI

2. EMPLOYEE RELATED

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

(23)	Production workers support	DC	D	NC	I	IC
(24)	Office staff support	DC	D	NC	I	IC
(25)	Multi-functional employees	DC	D	NC	I	IC
(26)	Employee absenteeism	DC	D	NC	I	IC
(27)	Employee turn over	DC	D	NC	I	IC
(28)	Employee training	DC	D	NC	I	IC
(29)	Recognition and rewards	DC	D	NC	I	IC
(30)	Empowerment/Involvement	DC	D	NC	I	IC
(31)	Quick implementation of employees suggestions on 'quality'	DC	D	NC	I	IC
(32)	Line stop (empowerment of workers to stop the production line if line problems occur)	DC	D	NC	I	IC

3. MANAGEMENT RELATED

(33)	Top Management support	DC	D	NC	I	IC
(34)	Middle Management support	DC	D	NC	I	IC
(35)	Inter-disciplinary* team approach to project assignments (*design, manufacturing, quality)	DC	D	NC	I	IC
(36)	Customer focus	DC	D	NC	I	IC
(37)	Communication (Interdepartmental/Interfunctional)	DC	D	NC	I	IC

3.Mgmt. Cont...

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

(38)	Product design review before production and marketing	DC	D	NC	I	IC
(39)	Response time to customers	DC	D	NC	I	IC
(40)	Use of MRP/MRP II concept (Material requirement planning)	DC	D	NC	I	IC
(41)	Computer resources	DC	D	NC	I	IC

4. **SUPPLIER RELATED**

(42)	Just in time purchasing	DC	D	NC	I	IC
(43)	Supply base reduction (reduction in number of suppliers)	DC	D	NC	I	IC
(44)	Supplier development	DC	D	NC	I	IC
(45)	Supplier Certification	DC	D	NC	I	IC
(46)	Blanket orders/firm orders	DC	D	NC	I	IC
(47)	Long term partnership* relationship (*vendor as a business partner)	DC	D	NC	I	IC
(48)	Value analysis	DC	D	NC	I	IC
(49)	Standardized containers	DC	D	NC	I	IC
(50)	Small, frequent deliveries	DC	D	NC	I	IC
(51)	Exact quantities from suppliers	DC	D	NC	I	IC
(52)	Inspection of incoming materials	DC	D	NC	I	IC

5. **COSTS RELATED**

(53)	Inventory costs	DC	D	NC	I	IC
(54)	Unit cost	DC	D	NC	I	IC
(55)	Scrap/re-work costs	DC	D	NC	I	IC
(56)	Inspection costs	DC	D	NC	I	IC
(57)	Administrative costs	DC	D	NC	I	IC
(58)	Inbound freight (from suppliers)	DC	D	NC	I	IC

DC = Decreased Considerably
D = Decreased
NC = No Change
I = Increased
IC = Increased Considerably

6. QUALITY RELATED

(59) Specification of Product quality	DC	D	NC	I	IC
(60) Continuous Improvement	DC	D	NC	I	IC
(61) Parts/ Components standardization	DC	D	Nc	I	IC
(62) Quality circles (Group approach towards quality)	DC	D	NC	I	IC
(63) Total quality control	DC	D	NC	I	IC
(64) Availability of quality data	DC	D	NC	I	IC
(65) SPCC (Statistical Process Control Charts)	DC	D	NC	I	IC

7. COMPUTER RELATED TOOLS

Please answer whether you are using the following tools by circling 'yes' or 'no.'

(66) Word processors	Yes	No
(67) Spreadsheet software	Yes	No
(68) Data base applications	Yes	No
(69) Computer Networking with clients/suppliers	Yes	No
(70) Office automation	Yes	No
(71) Shop floor automation	Yes	No
(72) Numerically controlled machine tools	Yes	No
(73) PLCs (Programmable logic controls)	Yes	No
(74) RF Technology (Radio Frequency)	Yes	No
(75) Bar coding	Yes	No

Section - II

The following questions pertain to JIT (Just-in-Time) and TQM (Total Quality Management) programs.

NI = Not Implemented
IA = Implemented but now Abandoned (discontinued)
PS = Pilot Stage (Experimental Stage)
I = Implemented
FI = Fully Implemented

(76)	1. JIT program	NI	IA	PS	I	FI
(77)	TQM program	NI	IA	PS	I	FI

If your answer is either NI or IA to Question 1, please skip question 2.

(78)	2. JIT program is in use	Less than 2 years	More than 2 years →	________Years (Please specify)
(79)	TQM program is in use	Less than 2 years	More than 2 years →	________Years (Please specify)

If your answer is either NI or IA to Question 1, please answer the following:

The following questions pertaining to i) non-implementation of Just-in-Time (JIT), Total Quality Management (TQM) practices and ii) implemented but now abandoned JIT, TQM practices.

3. JIT program not implemented due to:

(80)	Lack of Management support	Yes	No	Can't say
(81)	Lack of Workers' support	Yes	No	Can't say
(82)	Lack of Technical Expertise	Yes	No	Can't say
(83)	Lack of Feasibility study	Yes	No	Can't say
(84)	Lack of Financial resources	Yes	No	Can't say
(85)	Lack of Technical tools	Yes	No	Can't say
(86)	Lack of Vendor support	Yes	No	Can't say

4. TQM program not implemented due to:

(87)	Lack of Management support	Yes	No	Can't say
(88)	Lack of Workers' support	Yes	No	Can't say
(89)	Lack of Technical Expertise	Yes	No	Can't say
(90)	Lack of Feasibility study	Yes	No	Can't say

Cont... TQM program not implemented due to:

(91)	Lack of Financial resources	Yes	No	Can't say
(92)	Lack of Technical tools	Yes	No	Can't say
(93)	Lack of Vendor support	Yes	No	Can't say

5. **JIT** program implemented but now abandoned due to lack of:

(94)	Continuous Management support	Yes	No	Can't say
(95)	Continuous workers' support	Yes	No	Can't say
(96)	Continuous Financial resources	Yes	No	Can't say
(97)	Continuous Vendor support	Yes	No	Can't say
(98)	Improvement in Quality	Yes	No	Can't say
(99)	Improvement in Productivity	Yes	No	Can't say
(100)	Reduction in costs	Yes	No	Can't say
(101)	Reduction in waste	Yes	No	Can't say

6. **TQM** program implemented but now abandoned due to lack of:

(102)	Continuous Management support	Yes	No	Can't say
(103)	Continuous workers' support	Yes	No	Can't say
(104)	Continuous Financial resources	Yes	No	Can't say
(105)	Continuous Vendor support	Yes	No	Can't say
(106)	Improvement in Quality	Yes	No	Can't say
(107)	Improvement in Productivity	Yes	No	Can't say
(108)	Reduction in costs	Yes	No	Can't say
(109)	Reduction in waste	Yes	No	Can't say

Your job title ______________________________

The Number of employees in your firm ________________

Nature of Business
1. Low Volume High Variety
2. Low Volume Low Variety
3. High Volume High Variety
4. High Volume Low Variety

Thanks for completing the questionnaire. Please return the completed questionnaire in the enclosed postage paid envelope.

Appendix E

Computer Related Tools

USAGE OF COMPUTER RELATED TOOLS

	Group			
	None[1]	Both[2]	JIT[3]	TQM[4]
(Q66) Word processors	41 (97.6%)	76 (98.7%)	15 (100%)	18 (94.7%)
(Q67) Spreadsheet software	35 (83.3%)	77 (100%)	15 (100%)	18 (94.7%)
(Q68) Data base applications	24 (57.1%)	75 (97.5%)	15 (100%)	18 (94.7%)
(Q69) Computer net- working with clients/suppliers	14 (33.3%)	55 (71.4%)	9 (60.0%)	11 (57.9%)
(Q70) Office automation	33 (78.6%)	64 (83.1%)	13 (86.7%)	13 (68.4%)
(Q71) Shop floor automation	16 (38.1%)	60 (77.9%)	8 (53.3%)	4 (21.1%)
(Q72) Numerically controlled machine tools	16 (38.1%)	52 (67.9%)	11 (73.3%)	13 (68.4%)
(Q73) PLCs (programmable logic controls)	18 (42.9%)	57 (74.0%)	12 (80.0%)	16 (84.2%)
(Q74) RF technology (Radio frequency)	3 (7.1%)	16 (20.8%)	1 (6.7%)	7 (36.8%)
(Q75) Bar coding	24 (57.1%)	59 (76.6%)	11 (73.3%)	14 (73.3%)
(Q76) Use of MRP/MRP II	15 (35.7%)	60 (77.9%)	7 (46.7%)	16 (84.2%)
Frequency	42	77	15	19

[1]None: Companies not implementing JIT or TQM strategies [2]Both: Companies implementing JIT and TQM strategies

[3]JIT: Companies implementing JIT strategies only [4]TQM: Companies implementing TQM strategies only

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