# A theory of integrated manufacturing practices: Relating Total Quality Management, Just-in-Time and total productive maintenance

**PUBLICATION NUMBER** AAT 9975753

**TITLE** A theory of integrated manufacturing practices: Relating Total Quality Management, Just-in-Time and Total Productive Maintenance

**AUTHOR** Cua, Kristy Ong;

**DEGREE** PhD

**SCHOOL** UNIVERSITY OF MINNESOTA

**DATE** 2000

**Page 1**

Thumbnail Index    Next Page ->

# A THEORY OF INTEGRATED MANUFACTURING PRACTICES: RELATING TOTAL QUALITY MANAGEMENT, JUST-IN-TIME AND TOTAL PRODUCTIVE MAINTENANCE

A THESIS
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

KRISTY ONG CUA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Roger G. Schroeder and Kathleen E. McKone, Advisers

July 2000

UMI Number: 9975753





Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

# UNIVERSITY OF MINNESOTA

This is to certify that I have examined this copy of a doctoral thesis by

Kristy Ong Cua

and have found that it is complete and satisfactory in all respects, and that any and all revisions required by the final examining committee have been made.

Roger G. Schroeder and Kathleen E. McKone
*Name of Faculty Adviser(s)*

Roger Schroeder Kathleen E. McKone
*Signature of Faculty Adviser(s)*

July 25, 2000
*Date*

# GRADUATE SCHOOL

ACKNOWLEDGEMENTS

I have been blessed with intellectual guidance, inspiration, and financial contribution from many dedicated supporters without whom the completion of this milestone would only be a dream. I am sure that this acknowledgement cannot be complete and words are not enough to express my sincerest appreciation to these people.

I am grateful to my advisers, Roger Schroeder and Kate McKone, who guided me throughout my dissertation research. They patiently gave me their time and encouragement since my first year in the Ph.D. program. They unselfishly shared with me their expertise in teaching and research and supported me in all my academic endeavors.

My other committee members, Terry Childers and Dave Knoke, deserve my sincerest appreciation. They not only contributed to my dissertation but also provided me with assistance and encouragement in many ways. I am also thankful for their generosity of time and spirit.

My special thanks to K.K. Sinha for the precious time and effort that he spent listening to my concerns, encouraging me, and providing advice beyond the duties of a Ph.D. coordinator. I am also thankful to Art Hill, Mike Taaffe, William Li, Chris Nachtsheim, and John Anderson for they contributed to my intellectual development in different ways and provided help whenever needed. My Ph.D. experience would not be complete without the support and companionship of my fellow students in the OMS Department.

I was very fortunate to receive fellowship awards from the Carlson School of Management and the Juran Center for Leadership in Quality. These awards provided valuable financial contributions for my dissertation research. I am thankful to the management of manufacturing plants and the World Class Manufacturing Project team that contributed to my field research and large sample data.

I wish to express my heartfelt gratitude to my parents, aunties, sisters, other relatives, and friends who provided me with love, inspiration, and confidence. Thank you for always being there and for making this pursuit worthwhile.

Finally, I owe my deepest thanks to the Almighty. In humility, I thank You for Your grace and mercy that allowed me to complete this milestone.

## TABLE OF CONTENTS

**CHAPTER 3 .................................................................................................... 51**
**DEVELOPMENT OF A THEORY OF INTEGRATED MANUFACTURING PRACTICES**



**CHAPTER 4 .................................................................................................... 80**
**CASE-BASED RESEARCH**

## LIST OF TABLES

## ABSTRACT

Manufacturing programs such as Total Quality Management (TQM), Just-in-Time (JIT), and Total Productive Maintenance (TPM) have often been referred to as components of "World-Class Manufacturing". While there are many success stories and much research on TQM, JIT, and TPM, there are also documented cases of failure in the implementation of these programs. There has been insufficient research on the relationships between these programs and their combined impact on manufacturing performance. In this study, we examine the interrelationship between the three programs by proposing a single theoretical framework.

We identify both the common and unique practices of TQM, JIT, and TPM that constitute a set of Integrated Manufacturing Practices. We develop a theoretical framework for understanding the effect of the implementation of Integrated Manufacturing Practices on manufacturing performance that is grounded on the concept of fit, the socio-technical systems theory, and Operations Management theories. The theoretical framework is enriched by information obtained from the case studies of three manufacturing plants. We also use survey data from 163 manufacturing plants to empirically test the theoretical framework and its associated propositions. Multi-item scales are used to measure manufacturing practices and the psychometric properties of these scales are verified using confirmatory methods. The methods of analysis that are used in this study include hierarchical multiple regression analysis, discriminant analysis, and structural equation modeling.

We find that higher levels of implementation of Integrated Manufacturing Practices are positively associated with manufacturing performance, indicating that manufacturing plants should implement both socially- and technically-oriented practices. We find specific configurations of practices that best support the improvement of particular performance dimensions. Also, while contextual factors affect manufacturing performance, the implementation of Integrated Manufacturing Practices provides a more significant explanation of performance differences.

# CHAPTER 1
# INTRODUCTION

## *1.1. RESEARCH BACKGROUND*

The global marketplace has led many companies to implement new manufacturing programs and organizational structures to enhance their competitive position. Among the many manufacturing programs, Total Quality Management (TQM), Just-in-Time (JIT), Total Productive Maintenance (TPM), and Employee Involvement (EI) programs have often been referred to as components of "World-Class Manufacturing" (Schonberger, 1986; Steinbacher and Steinbacher, 1993; Schonberger, 1996). Though there may be some differing notions of what constitutes world-class manufacturing, the cited authors and others recognize that continuous improvement to sustain competitive advantage and profitability is dependent upon the synthesis of several reinforcing world-class manufacturing programs. While some researchers consider EI a separate manufacturing program, the concept of employee involvement permeates TQM, JIT, and TPM, and forms an integral part of their implementation. Hence, EI can also be considered part of the other three programs.

The importance of TQM, JIT, and TPM, cannot be overemphasized. There is an increasing number of organizations that apply some form of TQM, including non-manufacturing organizations in construction (Lurz, 1998), health services (Rouse et al., 1998), and information systems (Ward, 1998) industries to name a few. Firms that implement effective TQM, as evidenced by winning the Malcolm Baldrige National Quality Award, are found to have better sales growth and a change in operating income over a 10-year period that is 48% higher than that for non-winning firms (Hendricks and Singhal, 1997).

The success of JIT at the Toyota Motor Company has spread to many firms in the Western industrialized countries and various industries (Inman and Mehra, 1990, 1993). A JIT approach to production has been shown to lead to performance improvements (e.g., Sugimori et al., 1977; Flynn et al., 1995). A number of authors have provided lists of benefits for plants implementing JIT (e.g., Schonberger, 1982; Voss and Robinson, 1987). Some of the benefits cited are lower inventory, improved quality, reduced waste and rework, lower overhead, flexibility, and reduced lead time.

While TPM may not be as commonly implemented as TQM and JIT, the number of plants applying for the TPM/PM awards being given by the Japan Institute of Plant Maintenance (JIPM) has been increasing. In 1999 alone, 150 plants/factories won awards for TPM excellence including 41 non-Japanese plants (Japan Institute of Plant Maintenance, 1999). Constance Dyer, Director of Research and TPM Product Development points out that companies implementing TPM have on average achieved a 50% reduction in breakdown labor rates, a 70% reduction in lost production, a 50-90% reduction in setups, a 25-40% increase in capacity, a 50% increase in labor productivity, and a 60% reduction in costs per maintenance unit (Koelsch, 1993).

Academic research on TQM and JIT abounds. A total of 226 TQM-related articles was identified from 44-refereed management journals and reviewed by Ahire et al. (1995). There are over 700 JIT-related articles published between 1985 and 1990 (Inman and Mehra, 1990). While there are few academic articles that specifically address TPM, there are numerous books and articles in trade journals that espouse the benefits of TPM implementation (e.g., Nakajima, 1988; Suzuki, 1992; Teresko, 1992; Tsuchiya, 1992; Koelsch, 1993; Mahmudar, 1996; Patterson et al., 1996). However, the literature primarily considers the TQM, JIT, and TPM programs in isolation and mostly ignores the investigation of simultaneous implementation and combined benefits of interrelated and complementary manufacturing programs.

While there are many success stories and much research on TQM, JIT, and TPM, there are also documented cases of failure in the implementation of these programs. For instance, Wallace Company, a Malcolm Baldrige National Quality Award winner, filed for bankruptcy protection; and Florida Power and Light, the winner of Deming Prize for Quality Management, slashed its quality department staff from 85 to three since management feared that the "quality improvement process had become a tyrannical bureaucracy" (Choi and Behling, 1997). The widespread use of JIT also has mixed success and failure (Safayeni et al., 1991). Only 5% of companies surveyed by Giffi et al. (1990) that have some kind of maintenance program believed that their program was effective.

Many authors have tried to explain why failures and undesirable effects occur. Some of the suggested reasons for failure of TQM include partial implementation of TQM (Becker, 1993), overly optimistic expectations (Doyle, 1992), lack of a well-defined routine for attaining quality (Westphal et al., 1997), and implementation of TQM to conform to societal norms rather than for its instrumentality (Campbell, 1994).

Crawford et al. (1988) point out several problems faced by JIT implementation, such as: cultural resistance of change, lack of training and education, lack of organizational communication, use of inappropriate performance measurement, and poor quality. Moreover, Safayeni et al. (1991) contend that failure of JIT implementation is partly due to confusion over what exactly constitutes JIT and its implementation within an existing organization structure that does not provide the necessary support. Many of the problems of JIT implementation cited by Crawford et al. (1988) are also observed as hindrances to the successful implementation of TPM (Patterson et al., 1995). The major barrier that will possibly affect TPM implementation is the inability of a company to coordinate its human resource practices, management policies and technology (Fredendall et al., 1997). Together, these problems reflect the lack of a system that supports the implementation of world-class manufacturing programs such as TQM, JIT, and TPM.

## *1.2. RESEARCH PROBLEMS*

The mixed evidence of success and failure from the different manufacturing programs calls for more in-depth study. The goal of this study is to understand the drivers of improved manufacturing performance. Rather than considering TQM, JIT, and TPM as distinct programs, we seek to identify both their common and unique practices that constitute a set of Integrated Manufacturing Practices.

This study considers strategic and human resource related practices common to TQM, JIT, and TPM as the common strategic- and human resource-oriented practices of the set of Integrated Manufacturing Practices. This set of common practices is similar to Rehder's (1989) notion of building manufacturing competitiveness with a synergy between the strategy, structure, culture, and human resources subsystems of varying manufacturing practices. This is also consistent with Hayes and Wheelwright's (1984) emphasis on the human elements of organization in their discussion of the infrastructure category of manufacturing strategy decisions. The other core procedures and practices of TQM, JIT, and TPM that are unique to each of these programs and that are technical or process oriented are considered the basic techniques in the set of Integrated Manufacturing Practices. Following are the questions that this research attempts to delineate.

1. What are the theoretical and historical foundations for studying manufacturing programs such as TQM, JIT, and TPM within a single framework?

2. What constitutes the common strategic- and human resource-oriented practices and basic techniques of TQM, JIT, and TPM?
3. How does the development of the common strategic- and human resource-oriented practices directly affect manufacturing performance and enhance or constrain the effect of implementation of basic TQM, JIT, and TPM techniques on manufacturing performance?

## *1.3. RESEARCH METHOD*

The goal of this research is to build and test a theory that explains the effect of the implementation of a set of Integrated Manufacturing Practices on manufacturing performance. Therefore, this research draws on methodologies that are suitable for theoretically driven empirical research. Weick (1989) suggests that theories should be developed using three systematic processes involving literature review, use of data, and use of intuition and assumptions. Lewis (1998) applies Weick's suggestions in building Operations Management theory and proposes the principle of iterative triangulation. The processes of theory development are not meant to be sequential (Lewis, 1998) and are to be used in conjunction and in balance (Eisenhardt, 1989).

Traditionally, Operations Management is dominated by deductive approaches (Swamidass, 1991) and mathematical modeling and simulation analysis are the common tools of analysis. In the 1990's, attention was drawn to the potential of empirical research involving cross-sectional and longitudinal data analysis. More recently case study is considered an indispensable complement to quantitative analysis (see McCutcheon and Meredith, 1993; Meredith, 1998). These empirical research methods highlight the use of natural vis-à-vis artificial data in understanding real-life Operations Management phenomenon.

In the following we describe how the methodologies of literature review, case studies and large-sample cross-sectional data analysis are used in conducting this research. These three methodologies are not conducted in strict sequence. Instead, they are used complementarily to develop, enhance, and empirically verify a Theory of Integrated Manufacturing Practices.

To address the research questions of this study a literature review of the relationships among TQM, JIT, and TPM and other relevant Operations Management studies is conducted. This study is theoretically grounded on management principles such as the concept of fit and the socio-technical systems theory. Using literature in Operations Management and general management principles, we explicitly articulate a single theoretical framework for a set of Integrated Manufacturing Practices that synthesizes and explains the combined impact of TQM, JIT, and TPM on manufacturing performance.

We conduct case studies of three manufacturing plants to provide a "reality check" of the relevance of the theoretically developed framework. Case studies can also serve as a source of analytic generalization to theory (Yin, 1994), hence information obtained from case studies is used to enhance the theoretical framework.

Case analysis also helps answer the "why" and "how" questions in the natural setting of the phenomenon under observation and provides direction for subsequent research.

To systematically test the theoretical framework and its associated propositions, we conduct large-sample cross-sectional data analysis. We use data of 163 manufacturing plants collected as part of the ongoing World Class Manufacturing Project (Sakakibara et al., 1993; Flynn et al., 1994). We operationalize the constructs in the theoretical framework for empirical validation and use multiple regression analysis, discriminant analysis, and structural equation modeling to test the hypothesis of this study.

## *1.4. IMPORTANCE AND CONTRIBUTION OF THIS RESEARCH*

There have been various comments about the inadequacies of theory in the field of Operations Management (Swamidass and Newell, 1987; Anderson et al., 1989; Flynn et al., 1990; Ahire et al., 1995; Swink and Way, 1995). Recently, Schmenner and Swink (1998) contend that many building blocks of theory are prevalent in existing Operations Management literature. They suggest that careful organization of our thinking can lead to the development of useful and productive theories. This study will contribute to theory development in Operations Management by building a single theoretical framework for examining a set of Integrated Manufacturing Practices using established management principles and Operations Management theories.

There is an abundance of literature that considers TQM and JIT but there is still confusion on why their implementation yields variable results. On the other hand,