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INVESTIGATING THE LINKAGE BETWEEN TOTAL QUALITY MANAGEMENT & ENVIRONMENTALLY RESPONSIBLE MANUFACTURING

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ABSTRACT

This paper explicitly examines the relationship that exists between Total Quality Management (TQM) and Environmentally Responsible Manufacturing (ERM) systems. It has been presumed in numerous past studies that such a relationship does exist. It has been argued that those firms that have successfully implemented a TQM system are better positioned to successfully implement an ERM system. This relationship, however, has not yet been statistically and empirically evaluated. In this study, the authors evaluate this relationship using a large-scale survey of plant managers as the data source and Confirmatory Factor Analysis and Structural Equation Modeling as the statistical tools. The study develops a series of measures for various aspects of both TQM and ERM. The results show that there is indeed a strong relationship between TQM and ERM. In many ways, ERM is conditioned by the presence of TQM. Furthermore, ERM systems have a parallel structure when compared to TQM systems.

INTRODUCTION

Environmentally Responsible Manufacturing (ERM) is a relatively new concept that can be viewed as a product of the 1990s. ERM has been defined as an economically-driven, system-wide and integrated approach to the reduction and elimination of all waste streams associated with the design, manufacture, use and/or disposal of products and materials (Handfield, Walton, Seegers, and Melnyk 1997). Fundamental to ERM is the recognition that pollution, irrespective of its type and form, is ultimately waste. Based on past experiences with the concepts of Just-In-Time (JIT), Total Quality Management (TQM), and Time Based Competition (TBC), we know that waste is any activity or product which consumes resources or creates costs without generating any form of offsetting stream of value (Porter 1991; Porter and Van der Linde 1995). By minimizing waste, the firm can reduce disposal costs and permit requirements, avoid environmental fines, boost profits, discover new business opportunities, rejuvenate employee moral, and protect and improve the state of the environment. When viewed in this light, it would be expected that more managers be interested in the development and use of ERM based systems. However, for most firms, ERM has yet to achieve the same degree of acceptance as have JIT, TQM, and TBC (Makower 1993, 1994; Epstein 1996).

From an operations perspective, Hanna and Newman (1995) pointed out that simultaneous cost and waste reduction are being demonstrated throughout processes in areas encompassing shipping and distribution costs, raw material costs, actual manufacturing and processing costs, packaging costs, costs of treatment or disposal of process emissions, landfill use costs, and customer disposal costs. ERM appears to have a strong potential for the development of process improvements. Yet, to date, it has received relatively little attention from operations practitioners and academics.

It has been suggested that organizations with TQM systems in place are more inclined to undertake ERM based systems than companies with less commitment to TQM (Klassen and McLaughlin 1993). This implies that a company's ability to reframe learnings from TQM is crucial to the successful implementation and use of ERM based systems and procedures. Limited evidence has been presented that TQM systems are being used as models for ERM systems. The normative literature and case studies that dominates the ERM field suggests, but does not explicitly recognize, that in TQM, there is an explainable, understandable, and documental path to ERM.

Unfortunately, while case studies and deductive arguments have emphasized TQM's role in ERM, researchers have not supported these arguments with extensive systematic empirical analyses. The overarching goal of this study is to investigate the theoretical linkage between TQM and ERM via a structural equation model by answering the following two research questions:

1. Is there a relationship between TQM and ERM systems?
2. If there is a relationship present between TQM and ERM, then what is the nature of the relationship?

These questions collectively reflect an interesting premise -- that ERM systems can be viewed as being TQM systems modified to do deal with environmental issues.

The gradual evolution of quality to include aspects of the environment has been anticipated by several authors (Mizuno 1988; May and Flannery 1995; Sarkis and Rasheed 1995; Epstein 1996). The "no waste" aim of ERM based systems closely parallels the TQM goal of "zero defects." TQM focuses on waste as it applies to process inefficiencies, whereas ERM focuses more on pollution in the form of air emissions and solid and hazardous waste. Because the two concepts share a similar focus, it makes sense to use many of the TQM tools, methods, and practices in implementing an ERM based system. Given this perspective, the structure of ERM systems can be expected to be very similar to that found in TQM systems. A linkage between overall TQM and ERM systems is also expected. Given this premise, this study is interested in assessing whether such a relationship between TQM and ERM systems exists. This study is also interested in exploring any significant similarities and differences between the structures of these two systems.

This paper begins by reviewing the ERM literature. This review serves to establish the relationship between TQM and ERM as a major research stream. Operational frameworks for TQM and ERM are then developed. This section concludes with a comparative assessment of several TQM frameworks to

determine which framework best fits the conceptual requirements of a TQM system. From this assessment, the Malcolm Baldrige National Quality Award (MBNQA) framework emerges as the most consistent with the definition of TQM (it is subsequently used as the basis for the operational frameworks of TQM and ERM). From this theoretical foundation, we proceed to the data analysis section. Here, a two-stage process is used. In the first stage, the TQM and ERM measurement models are first developed and validated using confirmatory factor analysis (CFA). In the second stage, the measurement models are "fixed" when the overall full structural equation model (SEM) is estimated. The SEM is used to assess the TQM-to-ERM linkage. The final section concludes with a discussion of the implications of this paper's findings for managerial decision-making.

ENVIRONMENTALLY RESPONSIBLE MANUFACTURING – THE LITERATURE REVIEW

DEVELOPING OPERATIONAL FRAMEWORKS OF TQM AND ERM

Given this study's focus, the first step was to develop an operational framework of TQM. During the review of the TQM literature, eight TQM frameworks were identified and compared. To better structure this comparison, several definitions of TQM (drawn from sources such as Evans (1992), Logothetis (1992), and Melnyk and Denzler (1996)) were identified. From these sources, ten TQM traits were developed. Using these traits, eight frameworks and the constructs contained within them were reviewed to determine which framework best satisfied the definition of TQM.

The Malcolm Baldrige National Quality Award (MBNQA) framework best satisfies the requirements of TQM. As a result, this award will be used as the operational framework of TQM for the purposes of this study. Many other researchers have also adopted the MBNQA framework as the basic operational model of TQM. Dean and Bowen (1994), for example, used it to explore the relationship between the principles of TQM and management theories. Black and Porter (1996) used it to develop their TQM survey questions, while Capon, Kaye, and Wood (1995) used it to identify measures of TQM success.

A review of the ERM literature revealed the lack of well-developed, reliable, and valid measures for important dimensions of ERM. The ERM literature is not at a level of development necessary for a more rigorous evaluation and formulation of ERM constructs and issues. As a result, an adaptation of the MBNQA framework was used as an operational framework of ERM.

THE OPERATIONALIZATION OF TQM AND ERM

RESEARCH DESIGN

DISCUSSION OF RESULTS

The overarching goal of this study was to investigate the theoretical linkage between TQM and ERM by answering the following research question: Is there a relationship between TQM and ERM based systems? It was hypothesized that the presence of a TQM based system encourages the emergence and acceptance of an ERM based system. The empirical results of this study support the TQM-to-ERM linkage. The results suggest that firms with advanced TQM systems in place also have more advanced ERM systems than firms just initiating TQM. In other words, ERM based systems will be stronger in firms as TQM based systems become more developed.

Companies can utilize TQM approaches to developing a system-wide and integrated approach to the reduction and elimination of all waste streams associated with the design, manufacture, use, and/or disposal of products and materials. Relevant TQM principles which can be integrated into waste minimization programs include: 1) a systems analysis process orientation that aims to reduce inefficiencies and identify product problems; 2) data-driven tools, such as cause and effect diagrams, quality evolution charts, pareto analysis, and control charts; and, 3) a team orientation that uses the knowledge of employees to develop solutions for waste problems.

For example, based on eight detailed case studies of Dutch companies, Cramer and Roes (1993) showed that employee involvement can be promoted by improving employee-management interaction and promoting responsibility for the environment among all levels of management including individual employees. A team orientation which used the knowledge of employees to develop solutions for waste problems was a relevant TQM principle that was integrated into ERM. Using such a team orientation for ERM has also been advocated by a number of groups, most notably the Global Environmental Management Initiative (GEMI) and the Council on Environmental Quality.

GEMI (1993) also cites a member company facility that uses quality tools to discover opportunities for pollution prevention and to measure the effectiveness of improvements made. The facility, whose environmental managers complained that soil contamination analyses were taking too long to complete, assembled a team to: 1) arrive at a specification for turnaround time; and, 2) analyze the reasons for existing turnaround time. The team first agreed on the major causes of the delayed turnaround time; then, they constructed a diagram that listed the detailed causes contributing to each major factor. The same facility proceeded to make use of Pareto charts which is a graphic tool that organizes data to identify and focus on major problems. A Pareto chart takes data on a situation or process, ranks it in order, and thus focuses attention on opportunities to maximize improvement. The team working on the soil contamination analyses delays organized the data relating to the causes of those delays into a Pareto chart that showed 80 percent of the turnaround delay could be attributed

to two factors: 1) a lack of communication between divisions within the company to anticipate information needs; and, 2) a lack of a standard analytic format for lab technicians. Shortly after beginning their improvement process, the soil contamination analyses team used a histogram to measure how close they were to achieving their time-reduction goal. The histogram showed that they had reduced the mean delivery time from 56 to 31 days and the dispersion had decreased from 64 to 37 percent.

3M and AT&T are also excellent examples of companies which were among the first to extend their TQM initiatives to ERM (Shedroff & Bitters 1991; Thompson & Rauck 1993; Sandelands 1994). These companies utilized TQM approaches to work towards a goal of zero waste discharges. TQM tools that were integrated into their waste minimization programs included Pareto analysis and control charts to signal pollution problems in the manufacturing process. Each company now reports aggregate savings and significant environmental benefits generated by using TQM concepts in environmental management.

Proctor & Gamble has used benchmarking techniques to assess conformance with elements of its own environmental management system. The company regularly audits its facilities throughout the world in the areas of government and public relations, people capability, direct environmental impact, incident prevention, and continuous improvement. Standards in each of these areas are developed at the facility level ensuring business unit commitment and support, and a score is generated for each facility.

Sonoco's experience with materials reclamation illustrates how it used quality management principles to integrate environmental objectives (Rondinelli & Berry 1997). Sonoco's success with materials reclamation resulted mainly from the corporation's quality-based culture. A strong and consistent vision from top leadership of the company was essential for environmental management. This was reflected by the chairman's "if we make it, we take it back" pronouncement. His clear environmental vision laid out an objective that each division and the corporation as a whole could strive to attain. The quality-based principles also encouraged managers to seek solutions with multiple benefits. Division managers realized that interdivisional cooperation and cross-functional communication could lead to economies and opportunities both for them and for Sonoco.

ERM systems can be viewed as TQM systems modified to deal with environmental issues. The gradual evolution of quality to include aspects of the environment has been anticipated by several authors (Mizuno 1988; May & Flannery 1995; Sarkis & Rasheed 1995; Epstein 1996). The "no waste" aim of ERM based systems closely parallels the TQM goal of "zero defects." TQM focuses on waste as it applies to process inefficiencies, whereas ERM tends to focus more on concrete outputs, such as solid and hazardous waste. Because the two concepts share a similar focus, it makes sense to use many of the tools, methods, and practices of TQM in implementing an ERM based system.

There was no reason, a priori, to believe that the structures associated with TQM and ERM based systems would be different. Therefore, the parallel structures between TQM and ERM based systems were hypothesized to be similar to one another in magnitude. The structural coefficients that paralleled one another in the TQM and ERM based systems were very similar in magnitude. Even though the univariate and multivariate analyses reflected noninvariance for three parts of the structure (e.g., Strategic Systems, Operational Systems, Information Systems), all parallel structural paths were close in magnitude. These results suggest that TQM can serve as a ready bridge for an ERM based system.

Concluding Comments

This study clarifies much of the confusion surrounding the relationship between TQM and ERM. It does so by pointing to the potential synergies between TQM and ERM. Meaning, firms that have developed capabilities in TQM will be more likely to develop the capabilities necessary for being environmentally responsible. Furthermore, they will be able to develop the capabilities for being environmentally responsible more quickly than firms without a TQM based system because they will be able to reframe their learnings from existing quality tools, methods, and practices.

This study has developed an integrated theory about how TQM based capabilities can be leveraged for ERM. It suggests that efforts should be coordinated to take advantage of the potential synergies between TQM and ERM. The means for capturing these synergies can be accomplished by using the MBNQA framework. Eastman Kodak, a former recipient of the MBNQA, has already begun to apply the principles of TQM to its environmental management program (CGLI 1994).

The TQM measurement model was operationalized using a set of four multi-item scales corresponding to the four factors of the MBNQA framework. Likewise, ERM was operationalized in terms of the four first-order factors described by the MBNQA framework. The MBNQA framework was adapted to address environmental issues and furthermore, it was shown that the framework can be used as a basis for an integrative definition of ERM. The four-factor structures (e.g., Strategic Systems, Operational Systems, Information Systems, Results) of the initially hypothesized TQM and ERM CFA measurement models were retained in the final models. In other words, the TQM constructs were indeed good predictors of the ERM constructs. This adaptation of the MBNQA framework suggests that quality principles can be seamlessly integrated into the practice of managing environmental issues.