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RETESTING A MODEL OF THE DEMING MANAGEMENT METHOD

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Retesting A Model of the Deming Management Method

Abstract

Anderson, Rungtusanatham, and Schroeder (1994) developed a model of the theory of quality management underlying the Deming management method; Anderson, Rungtusanatham, Schroeder, and Devaraj (1995) tested that model using path analysis. They used data from an existing database collected from 41 manufacturing plants in the electronics, machinery, and transportation industries with 100 or more employees. In this study, which retested their model, data was gathered from over 100 manufacturing and service companies of all sizes across the United States and Canada. The measures used in the original study were modified to apply to both service and manufacturing organizations. The data were analyzed using similar statistical analysis procedures, and comparisons were made with the results of the Anderson et al. (1995) study. The results showed strong support for the model developed by Anderson et al. (1994) with the exception of one construct, Employee Fulfillment. The findings suggest that implementing a continuous improvement effort without first implementing Visionary Leadership, Cooperation, Learning, and Process Management is a recipe for failure.

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Introduction

D. Edwards Deming was one of the major proponents of quality management, along with Walter Shewhart, Joseph Juran, Philip Crosby, and others. He was among those given credit for contributing to the rapid revitalization of the Japanese economy after World War II (Deming 1986, Walton 1986, Yoshida 1989). After his success in Japan, he took his management method to Ford Motor Company (Scherkenbach 1986b). As Ford's success increased, other companies adopted his approach (Elmuti and AlDiab 1995, Hodgson 1987).

In his long career, Deming wrote a few books and articles about his theory, with Out of the Crisis (Deming 1986) and The New Economics for Government, Economics, Education (Deming 1994) being two notable examples. Others have written a number of books about him and his management methods (e.g., Kilian 1988, Mann 1989, McCoy 1994, Neave 1990, Scherkenbach 1986a, Walton 1986). These sources elucidate Deming's Theory of Profound Knowledge and his 14 points.

While a number of case studies have shown the positive impact of Deming's theory on a variety of organizations, little empirical research exists that tests his theory. One important reason is that Deming's theory had not been adequately operationalized (Anderson, Rungtusanatham, and Schroeder 1994; Anderson, Rungtusanatham, Schroeder, and Devaraj 1995; Tamimi, Gershon and Currall 1995). The concepts underlying his theory had not been turned into operational constructs and no relationships between the concepts had been hypothesized before 1994.

At that time, Anderson et al. (1994) conceptualized the crucial components of Deming's management theory (based on his 14 points), organized these components into seven constructs, and hypothesized the relationships between those constructs. Later, Anderson et al. (1995)

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empirically examined the theory using the model they had developed, operationalizing the constructs using measurement statements developed by the World-Class Manufacturing research project team at the University of Minnesota and Iowa State University. They did not consider their results to conclusively test the theory, however, because of the secondary nature of the construct operationalization and of the data. In addition, they discouraged the interpretation of their findings as formal statistical tests of the relationships in their proposed theory and suggested that other research should overcome the limitations posed by their data source.

The current paper tests the model developed by Anderson et al. (1994) using an independent data set collected just for this purpose. This study eliminates some of the limits of the Anderson et al. 1995 study to check the validity and reliability of their model.

Theoretical Model

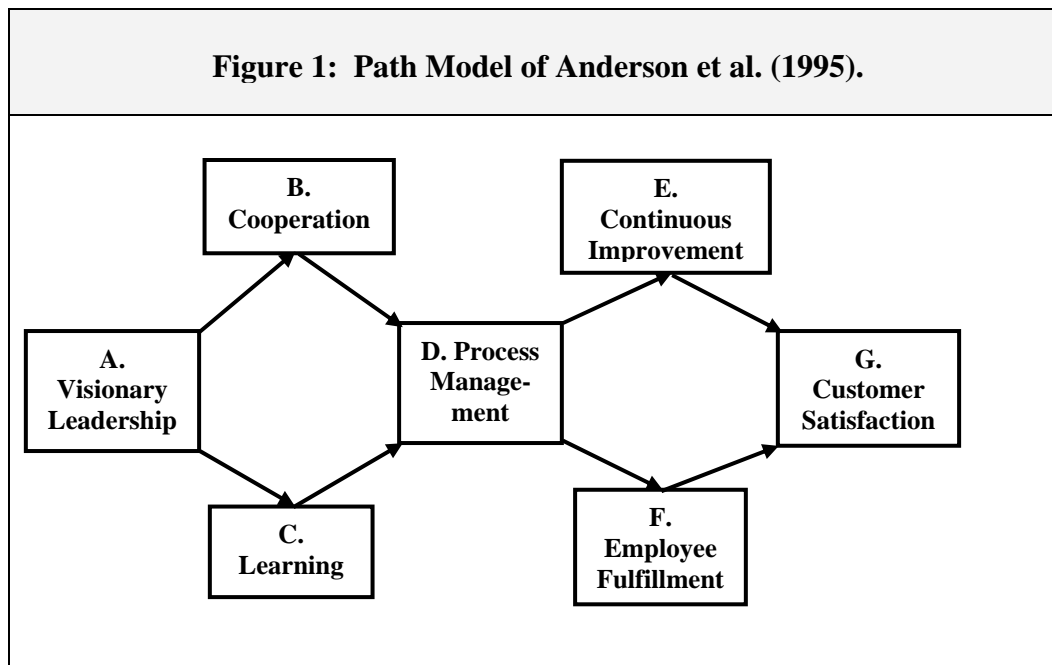
Anderson et al. (1994) developed a theory based on Deming's writings, literature on the Deming management method, observations of organizations using Deming's method, and a Delphi study. The seven members of the Delphi panel, all highly knowledgeable of Deming's management method, identified and defined 37 concepts from Deming's 14 points. Anderson et al. honed these down to seven more-abstract concepts using "cluster analysis." These seven concepts are visionary leadership, internal and external cooperation, learning, process management, continuous improvement, employee fulfillment, and customer satisfaction.

Anderson et al. (1994) used a relations diagram to organize these seven constructs into a system or causal network that is presented in Figure 1 below. Their model suggests that Visionary Leadership exerts direct, linear influences on both Internal and External Cooperation and Learning. These two concepts jointly influence Process Management, which in turn has a causal effect on Continuous Improvement and Employee Fulfillment. Finally, these latter two

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concepts influence Customer Satisfaction. All other influences are assumed indirect. Anderson et al. (1994, pg. 479) summarized the theoretical statement underlying the Deming management method as:

“The effectiveness of the Deming management method arises from leadership efforts toward the simultaneous creation of a cooperative and learning organization to facilitate the implementation of process-management practices, which, when implemented, support customer satisfaction and organizational survival through sustained employee fulfillment and continuous improvement of processes, products, and services.”



Operational Constructs

In a follow-up study, Anderson et al. (1995) empirically examined their theory using a sample of 41 manufacturing plants from an existing database. They operationalized the seven constructs by selecting measurement statements from the World-Class Manufacturing research project jointly written by a team of researchers from the University of Minnesota and Iowa State University. They pooled the measurement statements they selected to create multi-item

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perceptual scales for each of the seven constructs. These measurement statements are shown in Appendix A.

Anderson et al. used the database from the World-Class Manufacturing research project mentioned above, restricting their sample to manufacturers in three industries, electronics, machinery, and transportation components. They selected only three types of plants, United States (U.S.) plants with Japanese ownership, U.S. plants with a reputation for being world-class, and U.S. plants selected from the three industries at large, all with more than 100 employees. Multiple employees with different job titles and responsibilities from each plant completed the questionnaire.

The combined measurement statements formed internally consistent and reliable scales, as shown by Cronbach's alphas between 0.60 and 0.86 (Cronbach 1951). Using path analysis to test the relationships between these constructs and the theory as defined by the relations diagram shown in Figure 1, Anderson et al. found support for six of the eight relationships in the proposed theory. They also reported the presence of large unexplained effects, which they suggested meant that the theory might not be exhaustive in its specification of plausible causal and correlational relationships.

While Anderson et al. (1995) found support for the Deming management theory as defined by Anderson et al. (1994), they did not consider their findings to be a formal conclusive test of the theory, but rather a preliminary empirical observation. They point out that both the operational definitions of the constructs and the data itself are secondary, developed for another purpose. In addition, the data came from only 41 plants in three manufacturing industries, electronics, machinery, and transportation components, limiting its generalizability. The

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aggregation of multiple respondents from each plant may have decreased the variability in the data and affected the results.

Even without these weaknesses in the data, replication of the findings would be needed to further test the theory developed by Anderson et al. (1994), for a theory requires multiple tests under different circumstances to give it credence. Thus, the current study uses the operational definitions (measurement scales) developed by Anderson et al. (1995) to collect information from a new set of respondents. The respondents come from a wide variety of industries, both manufacturing and service with no size restrictions. In addition, only one response was collected from each organization. If we arrive at similar results to those of the Anderson et al. study, the business community will have substantially greater assurance about the critical concepts and relationships in the Deming management theory.

Research Methodology

Questionnaire Development

A self-administered questionnaire was developed to gather information about issues pertaining to total quality management in manufacturing and service organizations from managers.

Construct Operationalizations

The scales originally developed by Anderson et al. (1995) were modified for this study. Twenty-nine items, which are presented in Appendix A, assessed the following six quality management issues: (1) Visionary leadership; (2) Internal and External Cooperation; (3) Learning; (4) Process Management; (5) Continuous Improvement; and (6) Employee Fulfillment. The measure of customer satisfaction consisted of four items. The response scale for the items ranged from “strongly disagree” (1) to “strongly agree” (5). A number of items were reverse

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coded, as they were by Anderson et al. (1995), to adjust for their wording. See Appendix A for identification of these items. The composite value for each construct was computed by summing and then averaging the score for all items representing each factor.

Sample, Data Collection Procedure and Response Rate

The convenience sample included 153 executives from graduate program in quality management, who represented manufacturing and service organizations, including not-for-profit firms and government institutions that were in various stages of implementing quality management. As principal key respondents, these practitioners, who are actively involved in making quality related decisions, would be in a suitable position to provide reliable and valid data on quality factors valid (Campbell 1995; Schwenk 1985).

The survey was administered using a two-step procedure. In the first phase, a packet containing a cover letter, the survey, and a pre-addressed, postage-paid reply envelope was mailed to all sample members. The cover letter that accompanied the questionnaire explained the purpose of the study, importance of respondent participation, and timeframe within which to return the questionnaire. Respondents were assured that their responses would be kept confidential. The second phase of the data collection process consisted of a follow-up letter that reminded participants to complete and return the survey within the pre-specified time. Respondents completed 101 questionnaires, all of which were usable. This yielded an overall response rate of 66.01%.

Results

Assessment of Construct Validity and Internal Consistency

Before analyzing the data, the psychometric properties of each of the seven measurement scales were assessed for construct validity (Peter 1979, Peter 1981), following the lead of Anderson et al. (1995). Exploratory factor analysis using principal components with no rotation supported uni-dimensionality of most measurement scales. The exceptions were the visionary leadership and the internal and external cooperation scales. Three factors emerged for the Visionary Leadership scale, with two item statements loading on the second factor more strongly than they did on the first, main factor. Two other items loaded on the third factor and not on either of the first two factors. Uni-dimensionality was not supported for this scale.

For internal and external cooperation, one item statement loaded on the second factor more strongly than it did on the first, main factor. Uni-dimensionality was not strongly contradicted for this scale. Despite the lack of support for visionary leadership as a uni-dimensional scale, the authors chose to duplicate the analyses conducted by Anderson et al. (1995) and the remainder of the results was consistent with those they reported. Thus, the factor analyses indicate that the measures seemingly demonstrated adequate construct validity.

Assessment of Internal Consistency and Reliability

Both the uni-dimensionality and internal consistency/reliability of the measurement scales were appraised in the same manner that Anderson et al. (1995) calculated them. The reliability of these scales was tested by calculating Cronbach's alpha (Cronbach 1951) for each scale. Presented in Table 1, all scales exhibited Cronbach's alphas greater than the minimum criterion value of 0.60 suggested by Nunnally (1978) and are similar to those reported by Anderson et al. (1995). Thus, the internal consistency of the scales appears to be established.

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TABLE 1: Reliability of Scales.		
Conceptual Scale	Cronbach's Coefficient Alpha	
	Current Study	Anderson et al. (1995)
Visionary Leadership	0.7703	0.8602
Internal and External Cooperation	0.7678	0.8595
Learning	0.6834	0.8526
Process Management	0.8495	0.7624
Continuous Improvement	0.7014	0.6032
Employee Fulfillment	0.6690	0.6438
Customer Satisfaction	0.8334	0.8210

Testing the Model Using Path Analysis

The data was subjected to statistical analyses using SPSS. No comparisons were made between industries since the sample represented a wide variety of companies and industries; the results were pooled for all industries and companies. In addition to assessing the reliability of the model, the data were analyzed using path analytic procedures. Path analysis is a multivariate analytical method used to test the causal ordering of a set of hypothesized linear relationships specified in a model.

Path analysis is used to test a set of linear relationships in a multivariate model using linear causality. It tests the causal ordering of the variables in a system of relationships that are hypothesized by the model. The Anderson et al. model (1994) shown in Figure 1 is such a model. Anderson et al. (1995) tested this model using path analysis and found support for many of the relationships.

The first step in the path analysis method used by Anderson et al. was to determine the empirical correlations or covariances among the conceptual scales. A comparison between the correlations found by Anderson et al. (1995) and those found in this study are shown in Table 2.

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Table 2: Correlation Coefficients Among Study Constructs.

	Visionary Leadership A	Cooperation B	Learning C	Process Management D	Continuous Improvement E	Employee Fulfillment F	Customer Satisfaction G
A		0.69**	0.53**	0.37**	0.63**	0.20	0.64**
B	0.59**		0.48**	0.40**	0.61**	0.25*	0.58**
C	0.46**	0.76**		0.39**	0.57**	0.12	0.46**
D	0.58**	0.58**	0.37*		0.53**	0.05	0.46**
E	0.35*	0.64**	0.43**	0.45**		0.17	0.61**
F	0.38*	0.26	0.31*	0.27	0.26		0.17
G	0.57**	0.21	0.10	0.30	0.24	0.39*	

* Significant at the 0.05 level (2-tailed).

** Significant at the 0.01 level (2-tailed).

Note: Correlation coefficients for current study are above the diagonal
Correlation coefficients for Anderson et al. (1995) are below the diagonal

The major differences noted between these two studies were found for the Employee Fulfillment scale. This scale showed the least number of significant correlations with the other scales in both studies, suggesting that it is the weakest link in the model. In the Anderson et al. study, it was significantly correlated with Visionary Leadership, Learning, and Customer Satisfaction. In the current study, it was significantly correlated with Internal and External Cooperation and with Customer Satisfaction.

The next step in path analysis is to determine the path coefficients. These are equal to the standardized regression coefficients between the dependent variable and its independent variables (Li 1975; Wright 1960). This study followed the methodology of Anderson et al. (1995) by using separate regressions for each pair of variables to allow direct comparisons. This approach is more valid for the Process Management dependent variable because of the correlation between Cooperation and Learning, as shown in Table 2. Table 3 shows the standardized regression coefficients values for the current study in addition to a comparison of the

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path coefficients in the Anderson et al. (1995) study. The path coefficients and the model are evaluated similarly to regression analysis, using t-tests and coefficients of determination.

Table 3: Comparison of Results of Path Analysis With Anderson et al. (1995).

Path	Path Coefficient	R Squared	Significance	Standard Error	Anderson et al. (1995) Path Coefficient
Leadership - Cooperation	0.69	0.48	.000	0.068	0.59
Leadership - Learning	0.53	0.27	.000	0.102	0.46
Cooperation – Process Management	0.27	0.15	.015	.0147	0.71
Learning – Process Management	0.27	0.14	.015	0.112	-0.17
Process Management – Continuous Improvement	0.53	0.27	.000	0.091	0.21
Process Management – Employee Fulfillment	0.05	-0.01	.606	0.064	0.27
Continuous Improvement – Customer Satisfaction	0.60	0.36	.000	0.281	0.15
Employee Fulfillment – Customer Satisfaction	0.07	0.19	.369	0.587	0.35

All of the path coefficients were statistically significant at the $p = 0.05$ level except for those that involved Employee Fulfillment (Process Management – Employee Fulfillment and Employee Fulfillment – Customer Satisfaction). The following relationships were found:

1. Visionary Leadership had a significant effect on Internal and External Cooperation ($R^2 = 0.48$) and on Learning ($R^2 = 0.27$). The path coefficients from Visionary Leadership to

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Internal and External Cooperation (0.69) and from Visionary Leadership to Learning (0.53) were both statistically significant at $p < 0.05$.

2. Both Internal and External Cooperation ($R^2 = 0.15$) and Learning ($R^2 = 0.14$) had significant effects on Process Management. The path coefficients from Internal and External Cooperation (0.27) and from Learning (0.27) to Process Management were both statistically significant at $p < 0.05$.
3. Process Management significantly affected Continuous Improvement ($R^2 = 0.27$) with a path coefficient of 0.53 ($p < 0.05$).
4. Continuous Improvement had a significant effect on Customer Satisfaction ($R^2 = 0.36$) with a path coefficient of 0.60 ($p < 0.05$).

Finally, the effectiveness of the model can be analyzed by breaking down the correlations between each set of variables into three parts: direct influence, indirect influence, and the unexplained portion. The results found in the current study are shown in Table 4. The direct influence is equal to the standardized regression coefficient determined using linear regression analysis between the two variables.

Table 4: Results of Direct, Indirect, and Total Effects for the Model.							
Effect of	Effect on						
		B	C	D	E	F	G
A. Visionary Leadership	Direct	0.69	0.53	0.00	0.00	0.00	0.00
	Indirect	0.00	0.00	0.33	0.17	0.02	0.10
	Unexplained	0.00	0.00	0.04	0.46	0.18	0.54
B. Cooperation	Direct		0.00	0.27	0.00	0.00	0.00
	Indirect		0.00	0.00	0.14	0.01	0.09
	Unexplained		0.48	0.00	0.47	0.24	0.49
C. Learning	Direct			0.27	0.00	0.00	0.00
	Indirect			0.00	0.14	0.01	0.09
	Unexplained			0.00	0.43	0.00	0.37
D. Process Management	Direct				0.53	0.05	0.00
	Indirect				0.00	0.00	0.32

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	Unexplained				0.00	0.00	0.14
E. Continuous Improvement	Direct					0.00	0.60
	Indirect					0.00	0.00
	Unexplained					0.17	0.00
F. Employee Fulfillment	Direct						0.07
	Indirect						0.00
	Unexplained						0.00

Of special note in Table 4 are the levels of unexplained covariation between the scales. These numbers represent the error in the model, or the amount of covariation for which the model cannot account. The model predicts that Visionary Leadership will have a direct influence on only Internal and External Cooperation and Learning and no indirect influence on any other variables. As shown in Table 4, Visionary Leadership had indirect influences on each of the other variables, most notably on Process Management where its indirect influence (0.33) was higher than the direct influences of either Internal and External Cooperation (0.27) or Learning (0.27). This suggests that Visionary Leadership impacts Process Management in ways other than through its effects on Internal or External Cooperation or Learning and that a line may need to be added to the model.

Similarly, both Internal and External Cooperation and Learning had unpredicted indirect effects on Continuous Improvement (0.14 each), although not nearly of the magnitude of the direct effect of Process Management on Continuous Improvement (0.53). Finally, while Continuous Improvement had a large direct impact on Customer Satisfaction (0.60), Process Management had a sizable indirect impact (0.32) on it as well. These results may also indicate the need to modify the Anderson et al. model of the Deming management method.

Discussion

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Deming (1993) offered the global business community his 14 Points for management. Anderson et al. (1994) structured Deming's 14 Points into a model with seven constructs, beginning with Visionary Leadership and culminating with Customer Satisfaction. Anderson et al. (1995) tested this model using path analysis on data collected from 41 manufacturing plants in the electronics, machinery, and transportation industries.

The current study replicated the research of Anderson et al. (1995) using a larger and more diverse sample including service companies, not-for-profit organizations, and government institutions of all sizes. The sample was not restricted to manufacturing plants with over 100 employees and included 101 different organizations, rather than the 41 in the Anderson study. Only one response was elicited per organization, perhaps decreasing reliability of the measure, but eliminating the possibility that aggregation of response decreased the variability of the data.

Overall, the results of Anderson et al. (1995) were replicated with only a few exceptions. In fact, some of the exceptions eliminated troublesome findings from their study. Two path relationships that were not statistically significant in the Anderson et al. study, between Learning and Process Management and between Continuous Improvement and Customer Satisfaction, were statistically significant in the current study. The Anderson et al. measure of Continuous Improvement does not appear to have been the problem. Whether, as they hypothesized, the difference is due to the secondary nature of the data or the aggregation of individual perceptions into a plant-level response, the current study eliminated these problems and found results that support the model. Likewise, the low coefficient of determination found by Anderson et al. between Process Management and Continuous Improvement was found to be much stronger in the current study.

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The sample for this study differed in many ways from that of the original, lending greater credence to the similarity of findings. It provided an independent assessment of the validity and reliability of the model in a very different sample and, thus, represents a contribution to the extant body of literature on the Deming management method. The Anderson model is not only supported, but also extended beyond the scope of the 1994 study. The only exception found was the construct of Employee Fulfillment, which was not significantly correlated with any other construct except Internal and External Cooperation. In addition, the coefficients for the paths starting and ending with Employee Fulfillment were not statistically significant.

Employee Fulfillment was measured using only three questions, the least for any construct in the model except continuous improvement. Since the model was supported overall, the questions measuring this construct need to be reconsidered. Perhaps the position of this construct within the model would be supported if it were measured differently with more items and/or items written expressly for this purpose.

Even without this component, the model adds important knowledge to our study of TQM. The model received enough support for business organizations to consider it when implementing or evaluating their management methods. Based on our findings and those of Anderson et al. (1995), Deming's (1993) famous 14 Points and the model derived from it (Anderson et al. 1994) are a formula that supports customer satisfaction. Any company whose management is interested in long-term business excellence should consider implementing the Deming management method. The study suggests that Visionary Leadership, Internal and External Cooperation, Learning, and Process Management causally affect Continuous Improvement. Implementing a continuous improvement effort without first implementing the others is a recipe for ineffectiveness or even failure.

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In business, there is no promise that application of any particular model ensures success. However, as in sports such as baseball, golf, and tennis, consistent success demands hitting the ball with a consistent, structured swing. Many managers believe that a disciplined and structured swing for consistent business success begins with perseverance in the application of an effective business model. The model described in this paper, based on Deming's (1993) 14 Points and developed by Anderson et al. (1994), is strongly supported by the data as such a business model.

Limitations and Directions for Future Research

The findings of this investigation should be viewed in light of some limitations. First, several of the scales were measured using a small number questions, those used by Anderson et al. (1995). These questions were not written specifically to measure the seven constructs, but were adopted from a prior study. Measurement items written specifically to test the Anderson et al. theory would be a logical next step.

Second, although the response rate was very high, self-selection for participation could still introduce some bias into the results. Third, all the measures used were self-reports. Extension to more objective measures, especially of outcomes like customer satisfaction, would increase confidence in the validity of the results. Fourth, the study was extended to different industries than the originally intended and a correlation was not assessed upon each industry involved. Further analysis might assess differences among the industries.

An interesting future study would be to analyze some of the TQM failures according to the model. Did these organizations implement all parts of the model? Alternatively, did they leave out some components? What about the organizations that were successful? Did they implement all components identified in the model?

Conclusion

The original empirical study done by Anderson et al. (1995) provides support for the Anderson et al. (1994) theory of the Deming management method by developing and testing a path model to represent the cause and effect factors that drive the quality goal of enhancing customer satisfaction. In other words, their study afforded reasons why the Deming model works with empirical results that strengthen the belief in its effectiveness. One empirical test does not adequately support a theory, however. The current study was intended to determine if we could replicate the findings of the original study to either support or reject its findings. Using a different sample, we asked the same questions to determine whether the results could be generalized to more manufacturing industries and service organizations. Our findings were remarkably close to those of the original study. We not only generally confirm the findings of the original study, but we also strengthen the case that the Deming management method is effective and that some of the factors that make it work have been identified and related in a cause and effect pattern by Anderson et al. (1994, 1995).

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Retesting A Model of the Deming Management Method

Appendix A: Multi-Item Scales
Visionary Leadership
<ol style="list-style-type: none"> 1. All major department heads in my company accept responsibility for quality. 2. Management provides personal leadership for quality products and quality improvement. 3. Our top management strongly encourages employee involvement. 4. Financial goals are the most important in our department. 5. Management is primarily concerned with short-range financial performance. 6. Short-term losses affect our decision-making, but are less important than pursuing long-term goals. 7. Our organizational goals, objectives, and strategies are communicated to me. 8. Strategies and goals are communicated primarily to managers.
Internal and External Cooperation
<ol style="list-style-type: none"> 9. Generally speaking, everyone in my department works well together. 10. Departments in the company communicate frequently with each other. 11. Departments within the firm seem to be in constant conflict. 12. Management works well together on all important decisions. 13. Our department is organized into permanent teams. 14. During problem-solving sessions, we make an effort to get all team members' opinions and ideas before making a decision. 15. Problems are usually solved by my superiors. 16. In the past three years, many problems have been solved through small group sessions.
Learning
<ol style="list-style-type: none"> 17. Employees receive training to perform multiple tasks. 18. Employees are rewarded for learning new skills. 19. Technical competence is high in this firm.
Process Management
<ol style="list-style-type: none"> 20. Charts showing defect rates are posted/circulated. 21. Charts plotting frequency of machine breakdowns are posted/circulated. 22. We have standardized process instructions, which are given to personnel. 23. A large percent of our processes on the shop floor are currently under statistical quality control. 24. We make extensive use of statistical techniques to reduce variance in processes.
Continuous Improvement
<ol style="list-style-type: none"> 25. All employees believe that it is their responsibility to improve quality in the firm. 26. Continuous improvement of quality is stressed in all work processes throughout our firm.
Employee Fulfillment
<ol style="list-style-type: none"> 27. I would feel unhappy if I could not take pride in my job. 28. Doing a good job should mean as much to a worker as a good paycheck. 29. If I do a sloppy job at work, I feel a little ashamed of myself.
Customer Satisfaction
<ol style="list-style-type: none"> 30. In general, our firm's level of quality performance over the past three years has been low relative to industry norms. 31. Our customers have been well satisfied with the quality of our products/services overall. 32. Our firm is better than the competition in customer relations. 33. Our firm is better than the competition in quality of product conformance.

Items 4, 5, 8, 11, 15, and 30 are reverse coded.