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Improving IT Project Outcomes With the Deming Management Method:
A Quality Management Approach

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ABSTRACT

Introducing technological change into an organization is a difficult undertaking, so it is not unexpected that firms struggle in their pursuit to achieve the desired level of quality for IT project outcomes. The purpose of this research is to examine the Deming management method to determine if its theories about quality management can be applied to IT projects. Survey data was collected from 168 IT professionals and analyzed. The results provide strong empirical support for the application of the Deming management method to address this persistent problem. In particular, the results support all hypothesized relationships among the quality management concepts comprising the Deming model, while at the same time the Deming model provides strong predictive ability for both customer satisfaction with IT project deliverables and meeting project performance goals of budget, schedule, and system functionality.

KEYWORDS

Deming Management Method, IT Project Management, PLS, Quality Management, Survey Research

1. INTRODUCTION

Information technology (IT) systems are crucial to the success of contemporary businesses. They facilitate processes improvement (Davenport, 2013), enable communication between organizational departments (Wang, et al., 2022), facilitate the integration of supply chain partners, and are central components for executing many organizational strategies (Drnevich & Croson, 2013). Given the importance of IT, it is unsurprising that in 2021 U.S. companies invested approximately $1.94 trillion on technology (Sava, 2021).

Despite the importance of IT to organizational success, many firms fail to effectively manage the quality aspects of their technology initiatives. The negative repercussions of this persistent problem are considerable. For example, 11.4% of the investment spent on technology projects is wasted due to poor project performance (PMI, 2021); one report found that 80% of technology professionals

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working on software projects spent more than half their time correcting quality issues (Geneca, 2017). The consequences of poor quality management for IT projects are not limited to the performance of the systems development process. The desired level of business value received from IT projects is often not achieved; 41% of firms report mixed results for the delivered value provided by completed IT initiatives (Feldman, 2014). In 2020, U.S. companies experienced $1.56 trillion in total costs from operational failures caused by poor quality software solutions (Krasner, 2020). As these statistics illustrate, organizations need to reconsider their approach to managing the quality aspects of their IT initiatives.

Quality management can be broadly defined as a formalized approach to managing business processes in an effort to achieve quality goals and objectives. The concepts and philosophies of quality management have been adopted by firms throughout the world in the form of quality programs, such as ISO certification and Six Sigma, to improve products and services. The core values shared by these quality programs include a focus on the customer, leadership, incremental or continuous improvement, and the idea that prevention is less expensive than correction. While quality management has received a great deal of attention in manufacturing and services contexts, its concepts have only recently been applied to IT projects (Marchewka, 2012). The focus of this research is project quality management, which focuses on the processes used to execute an IT project. Project quality management ensures that the outcome of a completed project will meet or exceed client/project sponsor expectations, while also satisfying the needs for which the technology initiative was undertaken.

Of particular interest to this study is the quality management approach articulated by W. Edwards Deming. In his book, *Out of the Crisis* (1986), Deming provides a foundation for quality management based on his set of 14 Points for Management. While Deming's philosophies on quality management have been embraced around the world, minimal research has empirically tested the Deming model, a theoretical model grounded in the Deming management method (DMM). Given that many of Deming's 14 Points for Management are being applied to project management in practice in an effort to improve quality, the aim of this research is to conduct a rigorous empirical examination of the Deming model in the context of IT projects.

The findings of this research should be of interest to both the academic and business communities. For academics, our results broadly provide further insights into the debate over the degree that quality management practices articulated in the DMM can be applied equally to any size or type of organization. For the information systems (IS) and project management literatures in particular, we test quality management theories that have received a great deal of interest and application in the practice of technology management that have only received limited attention from researchers. For managers, our results demonstrate that the DMM provides a practical approach for effective project quality management. As such, the DMM represents one viable avenue for addressing the quality issues that often challenge firms attempting to adopt new IT systems.

The remainder of this study is organized as follows. In section 2, we provide a review of systems development research that has examined quality management concepts, as well as a review of previous research assessing the Deming model. In section 3, we present our research model and develop a set of hypotheses for testing. In section 4, we discuss the research methodology used in our study. Section 5 summarizes the results of our research, including details about the characteristics for our respondent and their organizations. Section 6 provides conclusions based on our results, a brief discussion of our study's limitations, and suggestions for further research.

2. LITERATURE REVIEW

2.1 Information System Quality

The concept of information system quality is not new to academia. Identifying dimensions of system quality and studying the effect that quality has on system success have long been pursuits of IS researchers (e.g., Lucas, 1974). This research stream has adopted a wide variety of constructs to represent system quality, including perceived ease of use, system reliability, and intuitiveness of system features. An equally diverse set of outcomes affected by system quality has been examined in the literature, such as system use at the individual and organizational levels, user satisfaction, and net benefits (for review see Petter, et al., 2008). While recent interest in the IS literature has declined, researchers continue to discover important insights into the effect that system quality has on the success of IT solutions. For instance, system quality has been found to be positively associated with system use, user satisfaction (Hsu, et al., 2015), extended system use over time (Hsieh, et al., 2010), and information quality (Gorla, et al., 2010).

This study is concerned with the processes used to develop and implement information systems into organizations. Given this project management context, we define quality broadly as the totality of features and characteristics for an IT project's deliverables that support their ability to satisfy customer or stakeholder needs. We note that research examining system quality has largely focused on its consequences, with less attention being given to the how the systems development processes can be better managed to improve quality. A limited number of studies grounded in the philosophies of total quality management (TQM) have attempted to address this gap. Results from this research stream have generally provided support for the proposition that adopting a quality management approach helps to improve outcomes for the systems development process (Fok, et al., 2001; Ravichandran & Rai, 2000). Quality management tenets, such as management commitment to quality (Prybutok, et al., 2008; Ravichandran & Rai, 1999), learning, continuous improvement, quality goals, quality orientation, and skills development, have all been demonstrated to have positive relationships with system quality (Ravichandran & Rai, 1999).

2.2 The Deming Model

The Deming management method represents a practical approach to managing business processes. With an emphasis on quality management and continuous process improvement, the goal of the DMM is to transform business effectiveness. To empirically test the fundamental principles of the DMM, Anderson, et al. (1994) operationalized Deming's management theories into a model, including six constructs representing critical quality management concepts and a set of hypothesized relationships. There have been a minimal number of empirical studies that have tested the Deming model developed by Anderson, et al. Results from this research area have provided strong overall support for the model, but somewhat mixed results with respect to the hypothesized relationships among the quality management concepts. First, using data from 41 manufacturing plants, Anderson, et al. (1995) used a path analysis approach to assess the Deming model. While they found general support for the model, paths from learning to process management and from continuous improvement to customer satisfaction were not significant. Rungtusanatham, et al. (1995) replicated the study using 43 manufacturing plants located in Italy. This research found general support for the model as well, though paths from learning to process management, process management to employee satisfaction, and employee satisfaction to customer satisfaction were not found to be significant. More recently, Douglas and Fredendall (2004) used structural equation modeling (SEM) to assess the Deming model using a sample of 193 U.S. hospitals. Their research found full support for the hypothesized relationships of the Deming model, while the model provided a good overall fit for the data. Interestingly, Douglas and Fredendall extended the model by adding financial performance for the organization as an additional outcome variable; their study produced mixed results with respect to this amendment. Fisher, et al. (2005) used a mixed sample of 100 manufacturing and service organizations to assess the Deming model. Their path analysis found overall support for the model, though relationships involving employee fulfillment were not significant. Lastly, in a preliminary examination of the Deming model in context of IT projects, Marchewka (2007) used a small sample of 63 IT professionals to examine the correlations between the first-order constructs articulated in the Deming model. While not employing the same level of rigor as other studies discussed, the results of this research found general support for the Deming model. Taken together, this research stream has provided general support for all the hypothesized relationships in the Deming model, and we note that the specific hypothesized relationships failing to find support have varied across studies.

3. HYPOTHESES DEVELOPMENT

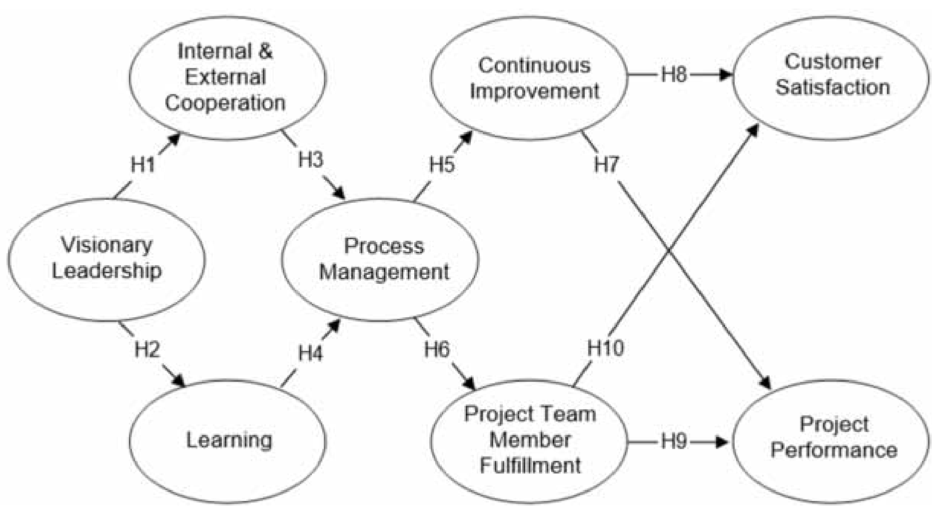
The Deming model provides a set of hypotheses that can be examined in the context of IT development projects. Figure 1 provides a summary of our research model.

3.1 Visionary Leadership

Visionary leadership refers to the ability of management to establish, practice, and lead a long-term vision for an organization, as well as respond to changing customer requirements. Visionary leadership is positively related to perceived organizational effectiveness (Taylor, et al., 2014), employee creativity (Zhou, et al., 2018), and the ability to facilitate organizational change (Groves, 2006). Transformation leadership, which is defined in part by being visionary in nature, is positively associated with perceived success when implementing a new information system into an organization (Cho, et al., 2011), while leadership's commitment to quality is positively related to IT quality (Prybutok, et al., 2008).

In the context of IT projects, visionary leadership is defined as ability of top management to establish a clear vision for IT project outcomes, as well as provide a work environment that enables the project team to satisfy customer expectations. Visionary leadership is one of the core tenets of Deming's approach to quality management, and the Deming model has two hypotheses relating to it. First, top management plays a critical role in fostering cooperation internally among project team members and with other external stakeholders. For this research, we define internal and external cooperation as the IT project team's ability to engage in cooperative, noncompetitive activities internally with each other while acting in concert with external project stakeholders. A visionary leader possesses the ability to create a shared vision related to project outcomes. A shared vision helps to establish shared goals and a sense of identification with the project among all project stakeholders. In turn, this provides internal motivation for project team members to cooperate with each other to achieve project success. Project management research has generally supported the idea that mutual and clear objectives are one of the key factors for creating cooperation in projects (Heinz, et al., 2006).

Figure 1. Research model



Hypothesis 1: Visionary leadership is positively related to internal and external cooperation.

The second hypothesis related to visionary leadership is concerned with its effect on learning. Learning refers to the IT project team's ability to build upon an existing knowledge base while developing lessons learned that can be accumulated into a set of shared best practices for future IT projects. Organizations often fail to remove barriers to organizational learning from mistakes experienced during the execution of technology initiatives. Consequently, the same failures are repeated again in future IT projects (Atkinson, 1999; Lyytinen & Robey, 1999). Research has also shown learning to be directly related to system quality (Ravichandran & Rai, 1999). Learning can be controlled by top management through the allocation of resources for training and other learning-related activities. Moreover, management can choose whether to encourage and reward experiential learning and the sharing of experiences in terms of lessons learned or best practices. Therefore, a visionary leader sees the importance of continuously improving the process of implementing IT into an organization and consequently removes barriers to organizational learning. Research in the area of systems development has shown that top management support for quality is positively related to the commitment to develop the skills of IS personnel (Ravichandran & Rai, 2000).

Hypothesis 2: Visionary leadership is positively related to learning.

3.2 Process Management

Process management refers to a set of methodologies and behavioral practices that emphasize the management of the process, rather than results of the process. Process management is one of the key tenets of quality management, and adopting a process management approach can help firms increase productivity and realize cost savings (see Nadarajah & Latifah Syed Abdul Kadir, 2014). In the context of systems development, process management has been shown to have a positive relationship with system quality (Ravichandran & Rai, 2000).

Processes management is achieved in systems development when IT project management and software development processes are documented, integrated, and made repeatable by project team members and members of the organization's IT function. IT project teams work on highly complicated, interdependent tasks. A variety of experts from differing backgrounds are required to effectively coordination their efforts to complete an IT project, as individual knowledge is not sufficient for project success (Chiocchio & Essiembre, 2009). If project team members and external stakeholders cooperate, it can be expected that new ideas for better managing projects and building technology solutions will emerge and contribute to the capabilities possessed by the IT function. Research suggests that encouragement by project leaders for members of a project team to work together is associated with improved outcomes for IT projects (Faraj & Sambamurthy, 2006).

Hypothesis 3: Internal and external cooperation is positively related to process management.

Organizational learning plays a central role in developing firm capabilities (see Dodgson, 1993), and research has supported the argument that learning is positively related to process management (Douglas & Fredendall, 2004). Learning leads to improved process management by means of lessons learned, identification of new best practices, and the refinement of existing processes. This theory is similar to the concept of process maturity and capability used in the Capability Maturity Model framework. Some evidence of the learning-process management relationship can be found in the IS literature. Ravichandran and Rai (2000), for example, demonstrated that skill development is associated with user participation, which in turn is positively related to process control.

Hypothesis 4: Learning is positively related to process management.

The DMM argues that process management is essential to improving process outcomes, and research has supported this assertion in a variety of contexts (e.g., Douglas & Fredendall, 2004; Fisher, et al., 2005; Rungtusanatham, et al., 1995). A key practice for firms pursing quality management is continuous process improvement. Continuous process improvement refers to an organization's propensity to pursue incremental and innovative improvements for its processes, products, and services. Continuously improving business processes is critical for sustaining competitive advantage gained from a firm's process management practices (Trkman, 2010), and in the context of systems development, it is positively associated with system quality (Ravichandran & Rai, 1999).

We posit that process management leads to continuous process improvement for IT initiatives, as it does for manufacturing and service processes. Continuous improvement is defined as the propensity of an organization to pursue incremental and innovative improvements of its project management and software development processes. Given the competitive environment that firms operate within and the limited resources available for the pursuit of technology initiatives, there is considerable pressure to deliver IT projects on schedule and within budget that provide value to the firm. Consequently, it can be expected that project team members will look for ways to improve project performance. Process management provides a means for continuous improvement of project and software development activities via process refinement and standardization. Preliminary research examining the applicability of the Deming model to IT projects provides some support for this hypothesis (Marchewka, 2007).

Hypothesis 5: Process management is positively related to continuous improvement.

The Deming model posits that process management leads to employee fulfillment. Employee fulfillment refers to the degree to which individuals feel that their employment at an organization continually satisfies their needs. The relationship between process management and employee fulfillment can be explained by Self-Determination Theory (SDT). According to SDT, individuals possess an inherent psychological need for competence (Deci & Ryan, 2001). Because of this need, employees are intrinsically motivated to control the outcome of their work and develop a level of mastery for their job duties. Given that the purpose of process management is to improve process outcomes, it can be expected that greater degrees of process management adoption in an organization will result in a higher likelihood of employees executing the duties of their job effectively. Consequently, employees will derive a greater sense of satisfaction from their work. Research has generally demonstrated that SDT provides strong predictive ability for employee motivations and work outcomes in organizational situations (see Deci, et al., 2017).

Specific to our research, project team member fulfillment is defined as the degree to which IT project team members feel that their contributions to an IT initiative are meaningful and satisfies their intrinsic psychological needs. As suggested by SDT, project team members are motivated to control the outcome of their work and develop proficiency in carrying out their job duties. Since process management provides project team members the information and tools that enable them to execute their jobs effectively (Ravichandran & Rai, 1999), we argue that project team members will leverage these tools in the pursuit of fulfilling their need for competence. As such, highly-effective process management methods should help improve team members' job performance, which in turn increases a project team members' satisfaction. While SDT's theory about employee motivation and work outcomes has received considerable attention in the IS literature when examining phenomena such as continued system use (Rezvani, et al, 2017), employee fulfillment and its role in IT projects has received little attention.

Hypothesis 6: Process management is positively related to project team member fulfillment.

3.3 Project Outcomes

When an organization continually attempts to improve IT project management and software development processes, its ability to execute IT initiatives should improve over time. We argue that this provides improved project performance and improved product performance (i.e., customer satisfaction). Project performance refers to the success or failure of the project itself. In this research, three dimensions of project performance are taken into consideration: budget, schedule, and system functionality. Referred to as the triple constraint (Marchewka, 2012), budget, schedule, and functionality have been argued to be the main measures of project performance (i.e., Xia & Lee, 2004). We posit that if the organizational processes required for executing an IT development project improve, the outcome on the development processes, namely performance of the IT project, will improve accordingly. Research examining the application of TQM practices to systems development has supported this assertion (Ravichandran & Rai, 1999).

Hypothesis 7: Continuous improvement is positively related to project performance.

In the same vein, IT project management has been described as the art of managing tradeoffs between project outcomes (Marchewka, 2012). For example, a project manager may need to make compromises between the quality of a delivered IT system and aspects of project performance (e.g. reducing the amount of allotted testing in an effort to avoid cost or schedule overruns). Customer satisfaction is defined to the degree to which IT solutions meet or exceed the expectations or needs of the organization; therefore, it broadly reflects the quality of the delivered system. We posit that if an IT project is effectively managed, the performance of the IT project will improve. Given that performance requirements of the project will be better met, fewer tradeoffs will be necessary to meet project performance requirements, and the overall quality of the IT initiative will improve correspondingly. The systems development literature does provide some evidence for this argument, because process control and fact-based management have been shown to be positively associated with system quality (Ravichandran & Rai, 2000).

Hypothesis 8: Continuous improvement is positively related to customer satisfaction.

Lastly, we argue that project team member fulfillment has several important consequences. Again, SDT argues that an individual's psychological desire for competence creates motivation to perform well in the execution of job duties. In turn, motivation manifests in the workplace as realized improvements in job performance (Deci & Ryan, 2001). In the context of an IT project, this suggests that as the degree to which IT project team members feel that their contributions to an IT project are meaningful increases, motivations to work are satisfied and commitment to be a positive contributor to a project increases. The outcome of increased commitment to the project by the project team should result in improvements in both project quality and project performance. Research has generally found relationships to exist between employee fulfillment and important business outcomes, such as business performance and customer satisfaction (Douglas & Fredendall, 2004).

Hypothesis 9: Project team member fulfillment is positively related to project performance.
Hypothesis 10: Project team member fulfillment is positively related to customer satisfaction.

4. METHODOLOGY

4.1 Data Collection Strategy

A survey methodology was used to collect data for testing our hypotheses. The sampling frame targeted IT project managers. Respondents were asked questions about IT project management practices adopted by their organizations and to consider customers as either internal (e.g., the accounting department) or external (e.g., a particular client), depending on the particular projects they manage.

4.2 Instrument Development

To measure the theoretical constructs comprising the Deming model, a previously validated instrument used by Douglas and Fredendall (2004) was adopted and modified to reflect an IT project environment. To measure project performance, we developed a new instrument. Given the long history of schedule, budget, and functionality as measures of project performance in the IT project management literature (Atkinson, 1999; Marchewka, 2012), we modeled project performance as a formative construct with items representing each of these aspects of project success as contributing dimensions. The Appendix provides the survey instrument used for this study.

4.3 Common Method Bias

Common-method bias was a concern for this research. We used procedural remedies to mitigate this issue (Podsakoff, et al., 2003). In particular, we provided verbal labels for our survey scales and avoided the use of bipolar numerical scale values. Additionally, we carefully constructed our survey items to be specific, concise, simple, and avoid the use of double-barreled questions. Lastly, the survey administration software used to gather data randomized the question order presented to respondents.

4.4 Data Analysis

To test our hypotheses, partial least squares (PLS) path modeling was used. The use of PLS has several advantages in the context of this research. PLS does not assume measurement is without error, so it outperforms many other statistical techniques, such as regression (Wold, 1982). PLS allows for the testing of multiple independent and dependent variables simultaneously (Haenlein & Kaplan, 2004), while performing well when the number of constructs is large compared to the sample size (Wold, 1982). Lastly, PLS allows for the modeling of both reflective and formative second-order constructs (Wetzels, et al., 2009).

We note that Douglas and Fredendall (2004) employed a multi-dimensional operationalization for several of the constructs from the Deming model. To maintain consistency for our research, we fully retained Douglas and Fredendall’s instrumentation. To address the multi-dimensional operationalization, we used formative second-order constructs in our PLS model. The advantage of using second-order constructs is that they provide a more parsimonious and interpretable modeling of the Deming model than would be provided by an examination of the relationships among the underlying lower-order factors. To model the second-order constructs in this research, a two-stage approach was used (Becker, et al., 2012). All first-order constructs were modeled reflectively.

5. RESULTS

5.1 Data Collection and Screening

Respondents were recruited to complete an electronic questionnaire through a posting on the Project Manager Institute (PMI) website. 169 respondents began the survey, but one questionnaire was not completed. A visual inspection of the data revealed no problematic cases, and an analysis of the Mahalanobis distance measure indicated that there were no outliers. After the data screening process was complete a total of 168 cases were retained for hypotheses testing. The minimum sample size suggested for conducting PLS is at least 10 times larger than the most complex endogenous construct (Chin, 1998), which, given our research model, is 60.

Organizations where respondents worked averaged 4270 IT personnel and 23,897 total employees. Respondents occupied a number of project management related positions within their respective

Table 1. Respondent characteristics

Gender:			**Education Completed:**	
Male	126		Some High School	1
Female	42		High School Degree	0
			Some College	2
Current Age (in years):			2 Year College Degree	7
less than 20	0		4 Year College Degree	72
20 to 29	26		Master's Degree	83
30 to 39	59		Doctorate	0
40 to 49	50		Other	2
50 to 59	24			
Over 60	9		**Years of Work Experience:**	
			Less than 2	2
Years in Current Position:			2 to 5	13
Less than 1	37		6 to 10	32
1 to 3	50		11 to 15	31
4 to 6	47		16 to 20	25
7 to 10	18		More than 20	64
More than 10	15			

firms, including project manager, consultant, and CIO. Table 1 provides details about the individual respondent characteristics.

5.2 Instrument Validation and Latent Variable Statistics

Using the data gathered for hypotheses testing, we assessed the validity and reliability of our measurement model using PLS (Gefen & Straub, 2005). Convergent validity was confirmed at the item level by examining item loadings on their respective constructs. A bootstrap resampling technique using a resample size of 5000 was used to calculate t-values for indicator loadings. The results of this assessment confirmed that all items loaded significantly on their respective constructs. However, correlations between item scores and latent variable scores produced during model estimation indicated that two items from supplier involvement, one item from customer driven information, two items from total quality training, and one item from total quality methods did not load above the suggested .7 level. To ensure convergence validity, these items were removed from subsequent analyses. To confirm convergent validity at the construct level, average variance extracted (AVE) statistics were calculated. The AVE for all constructs exceeded the suggested value of .50. Discriminant validity at the item level was assessed by examining the correlations between item scores and latent variable scores. One item from perceived customer satisfaction loaded higher on project performance than it did on its designated construct, and as such, the item was removed from subsequent analyses. To assess overall discriminant validity, the heterotrait-monotrait ratio (HTMT) was calculated; the HTMT statistic was well below the suggested .85 level, indicating that our model demonstrates satisfactory discriminant validity. A final PLS analysis indicated that all statistical criteria for convergent and divergent validity were met. To assess instrument reliability the composite reliability for each of our theoretical constructs was calculated. The reliability statistics for all of our constructs exceeded the recommended .70 level, suggesting acceptable instrument reliability. Table 2 provides composite reliability and AVE statistics. Table 3 provides the correlation matrix for our study's constructs of interest.

For our formative second-order constructs, we established the indicator validity of our second order constructs statistically by carrying out significance tests between our first-order indicators and our second-order constructs. As shown in Table 2, all indicators were significantly related to their respective higher order constructs, suggesting all first-order constructs contribute to the formation of their respective second-order constructs.

As previously discussed, we attempted to control for common-method bias by implementing a number procedural remedies prior to data collection. Harman's Single Factor Test was conducted as an ex-post statistical analysis to assess the severity of common-method bias for this research. All measurement items for the first-order constructs comprising our research model were loaded into an exploratory factor analysis, and the unrotated factor solution was examined to determine if a single factor explains the covariance among our study's constructs of interest. The results indicated a single factor only explained 36.751% of the observed variance, which is below the suggested 50% threshold indicating common method bias is a problem (Podsakoff & Organ, 1986).

5.3 Hypotheses Testing

The results of our PLS analysis show strong support for the proposed research model. Hypotheses 1 and 2 are supported, with visionary leadership demonstrating a significant positive relationship with

Table 2. Latent variable statistics

Constructs	Composite Reliability	AVE	β	t-Statistic
Continuous Improvement	0.886	0.661	-	-
Customer Satisfaction	0.959	0.921	-	-
Project Team Member Fulfillment	0.899	0.641	-	-
Visionary Leadership	0.891	0.622	-	-
Internal & External Cooperation				
Quality Philosophy	0.887	0.611	0.763**	9.652
Supplier/Subcontractor Involvement	0.871	0.611	0.339**	3.581
Learning				
Total Quality Training	0.935	0.782	0.624**	8.248
Customer Driven Information	0.841	0.638	0.586**	8.193
Process Management				
Process Mgmt - Process	0.903	0.650	0.256**	2.849
Process Mgmt - Software Engineering	0.916	0.684	0.348**	2.799
Management by Fact	0.943	0.733	0.272**	3.042
Total Quality Methods	0.890	0.669	0.258**	3.007
Project Performance				
Budget	-	-	0.248**	14.063
Schedule	-	-	0.220**	20.633
Functionality	-	-	0.598**	22.081

Table 3. Correlation matrix

Constructs	1	2	3	4	5	6	7	8
Continuous Improvement	1.000							
Customer Satisfaction	0.424	1.000						
Project Team Member Fulfillment	0.603	0.482	1.000					
Internal & External Coop.	0.647	0.502	0.569	1.000				
Learning	0.594	0.456	0.456	0.717	1.000			
Process Management	0.617	0.513	0.484	0.721	0.716	1.000		
Project Performance	0.490	0.664	0.476	0.562	0.519	0.597	1.000	
Visionary Leadership	0.583	0.476	0.383	0.732	0.664	0.683	0.521	1.000

both internal and external cooperation (β = .732, p < .01) and learning (β = .664, p < .01). Both internal and external cooperation (β = .428, p < .01) and learning (β = .409, p < .01) are significant antecedents to process management, supporting hypotheses 3 and 4. In turn, process management has significant positive relationships with both continuous improvement (β = .617, p < .01) and project team member fulfillment (β = .484, p < .01), supporting hypotheses 5 and 6. Continuous improvement has significant positive relationships with both project performance (β = .389, p < .01) and customer satisfaction (β = .251, p < .01), thus supporting hypotheses 7 and 8. Project team member fulfillment has significant positive relationships with project performance (β = .331, p < .01) and customer satisfaction (β = .320, p < .01), supporting hypotheses 9 and 10.

The R^2 statistic for customer satisfaction is .334 (F = 41.374, p < .01). The f^2 effect size statistic (Cohen, 1988) was calculated to be .501, suggesting that the Deming model has a large effect size on customer satisfaction. Large effects are "characterized by the study of potent variables or the presence of good experimental control or both" (Cohen, 1988, p. 13). The R^2 statistic for project performance is .327 (F = 40.085, p < .01). The f^2 effect size statistic was calculated to be .486, suggesting that our model has a large effect size on project performance.

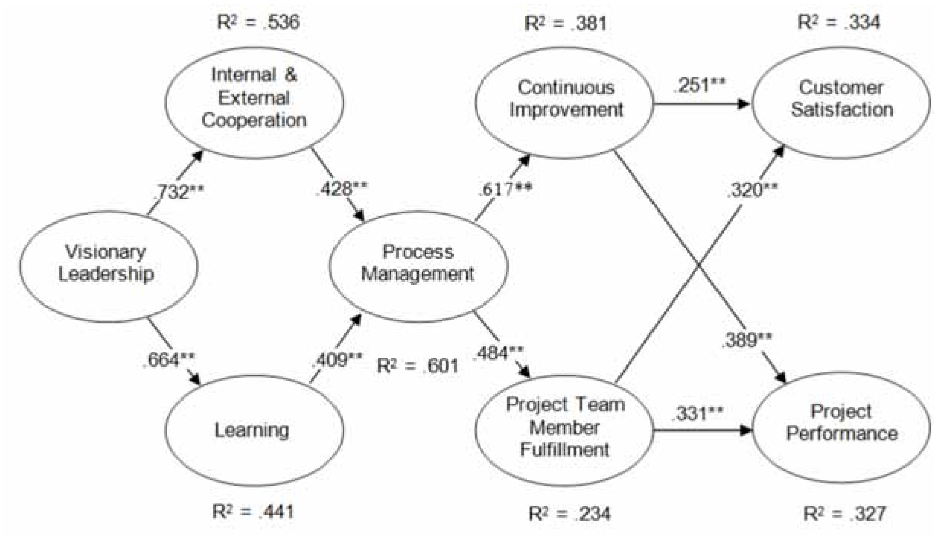
Lastly, the standardized root mean square residual (SRMR) was assessed to determine the fit of our proposed research model to the data. The SRMR statistic for our model is .055. Given that a value less than 0.08 is proposed to provide good fit in PLS (Hu & Bentler, 1999), we conclude that our model provides a good fit for the data. Figure 2 provides a summary of our test results.

6. DISCUSSION

The purpose of this research is to provide a rigorous evaluation of the Deming management method in the context of IT projects. Using data collected from IT project managers, our results provide strong support for applying the teachings and ideas of W. Edwards Deming to the processes used to carry out new technology implementation into organizations. The outcomes of this research have important implications for both academics and practitioners.

One interesting outcome for this research is that all hypothesized relationships of the Deming model are supported. While the theoretical support for these relationships is strong and the significant results for our hypotheses testing were expected, a similar level of empirical support was not achieved for several of the principal studies previously examining the model (Anderson, et al., 1995; Fisher, et al. 2005; Rungtusanatham, et al., 1995). Given that the authors of these articles devoted considerable discussion as to why some of the anticipated relationships from the Deming model were not supported, our research outcomes warrant some consideration. We believe the most compelling explanation for the contrast in results across studies is that there are important differences in the methodologies

Figure 2. Research results



used for data collection and analysis. The research in this stream has not been consistent in the operationalization for the constructs comprising the model. Our survey instrument was adapted from Douglas and Fredendall (2004), whose study results generally supported all the relationships of the Deming model. Douglas and Fredendall developed their instrumentation using previously validated measures from the TQM literature, while studies producing mixed results for the relationships used measures developed by Anderson, et al. (1995). Another important methodological inconsistency among studies from this research stream is that a variety of different statistical techniques have been used for model assessment. All studies producing mixed results for hypotheses testing used a series of regression models to conduct a path analysis (Anderson, et al., 1995; Fisher, et al., 2005; Rungtusanatham, et al., 1995). We employed component-based SEM (PLS). PLS outperforms a sum scores approaches to regression in the case where item weights used in factor score calculation are not equal (see Hair, et al., 2017). Given that the item weights in our final model were not equal, PLS provides a better statistical approach for testing our hypotheses than regression. A second possible explanation worth considering for the differences across studies is that the context of our research may have contributed favorably to our results. Previous research from the IS literature has generally found TQM-related concepts to be positively related to systems development outcomes (Fok, et al., 2001; Marchewka, 2007; Prybutok, et al., 2008; Ravichandran & Rai, 1999; 2000). Given the apparent effectiveness of quality management practices for technology management, perhaps the hypothesized relationships of the Deming model are realized to a remarkably high degree within an IT project management context when compared to other situations; early research examining the Deming model in an IT context has generally supported the model (Marchewka, 2007). Unfortunately, the Deming model has received very little replicate assessment in any context, so it is difficult to draw a firm conclusion about the cause for the mixed results in this research stream.

For researchers, this study provides a much needed reexamination of the DMM and contributes to the discussion concerning its generalizability. A debate among academics emerged following the popularization of quality management philosophies. Some proponents of the DMM argue its concepts and practices possess a wide breadth of applicability and therefore a quality management approach provides a "one-size-fits-all" solution to managing processes for most organizations. Others have argued that the application of quality management practices is limited. Because organizational context influences the effectiveness of Deming's approach to process management, factors such as culture and firm competencies can enhance or diminish the impact of quality management practices (Foster, 2006). In the same vein, there has also been some disagreement over the usefulness of quality management practices in the IS discipline. Statistical process control provides one example; some proponents of agile methodologies have argued that attempts to control software development through statistical means is "futile" (Dingsøyr, 2012), while other researchers assert that statistical methods can be highly effective in controlling software development processes (Brito, et al., 2018). Our results provide additional insights to this discourse. Manufacturing and customer-facing service processes have most typically provided the context for academics debating the applicability of quality management practices. Implementing technology into an organization involves considerably different processes than value chain-related activities, and our results suggest the quality management principles composing the DMM are strongly associated with process outcomes for IT projects. Broadly, our study provides support for the proposition that quality management practices can be applied to a variety of situations to improve organizational outcomes. For IS researchers in particular, while our study does not provide a definitive conclusion to the debate, it does add to accumulating evidence (e.g., Fok, et al., 2001; Prybutok, et al., 2008; Ravichandran & Rai, 1999; 2000) suggesting that quality management practices can be used effectively for the management of technology-related processes.

A contribution of this research to the IS discipline is the rigorous examination of the Deming model to the IT project management context. A review of the correlation matrix for this research reveals that all the constructs from the Deming model have significant positive relationships with our project outcome variables, suggesting that quality management practices offer a potential means for improving the quality aspects of IT projects. Unfortunately, except for early research examining the application of TQM practices to IS management (Fok, et al., 2001; Prybutok, et al., 2008; Ravichandran & Rai, 1999; 2000) and a preliminary examination of the Deming model (Marchewka, 2007), the quality management concepts of the DMM have received very little attention from IS researchers. Leadership, for example, is a concept that has been examined extensively in the IS literature (see Chou & Naimi, 2020). However, in the context of Deming's principles of management, which is concerned with establishing a clear vision for quality, research has been limited to the TQM articles previously discussed. Moreover, in our review of the IS literature we were unable to find any instances where the effect of team member/employee fulfillment on systems development outcomes has been rigorously examined. As such, given the lack of recent attention in the IS discipline to TQM-related practices, our study provides a needed reassessment of quality management concepts in an IS context, while also providing a better understanding about the role quality management tools play in supporting the quality initiative for IT projects.

An important contribution provided by this study is the examination of the relationships among quality management concepts. Two constructs in our research model, continuous improvement and project team member fulfillment, were specified to directly predict customer satisfaction and project performance. Given the large effect sizes that were found for our target variables, one might erroneously conclude that focusing on continuous improvement and employee fulfillment alone would be sufficient for improving IT project outcomes. However, in his book *Out of the Crisis* (1986), Deming articulated his 14 Points for Management as being a highly integrated framework. The DMM represents a holistic approach to improving the effectiveness of business processes. Fundamentally, the quality management concepts and practices of the DMM are interrelated, because they reinforce and enhance each other. The results from our study support this point, as our research model specified a series of antecedents that contribute to continuous improvement and project team member fulfillment, thus providing indirect effects on project outcomes. Both practitioners and academics need to possess a well-informed understanding about how quality management practices can lead to positive process transformation. Research demonstrating that the DMM provides holistic approach to improving project outcomes is essential.

For organizations, our study's results suggest that the DMM may provide a way to managing the quality aspects of IT projects. Many firms throughout the world have initiated quality management programs to improve manufacturing and service processes. Adopting a similar approach to managing technology projects appears to have the same potential for improving processes and outcomes. Given the widespread popularity of quality management programs, using such a solution to address poor quality management of technology initiatives seems practical; a number of quality management programs already exist and have resources readily available to facilitate their adoption, while potential employees possessing the TQM knowledge and skillsets needed to adopt a quality management approach are obtainable in the talent marketplace. We caution practitioners, however, that the results from our research suggest that adopting quality management practices to improve IT project outcomes requires a holistic approach to fully realize benefits. The quality-related philosophies comprising the DMM represents a system, so selectively implementing targeted practices will not result in the same level of success as adopting the collective framework presented in Deming's 14 Points for Management. The conclusions we draw from our research about the importance of adopting the entirety of the DMM are congruent with previous studies in this regard. For example, Fisher, et al., (2005) concluded from their results that implementing a continuous improvement effort without first implementing the other quality management practices of the Deming model would likely result in a failure of the quality initiative.

6.1 Limitations

As with all research, several limitations exist for this study. Methodologically, because of the difficulty ensuring the accuracy of information provided by the respondents, the use of surveys to gather data raises some validity concerns. The measures used in this study were based on the respondents' perceptions, such as perceived project performance and perceived customer satisfaction. Future research should attempt to collect more objective information about project performance and customer perceptions data directly from stakeholders. While the causality implied by the model is well supported by theory, causality cannot be inferred from this study due to all the data being gathered at a single point in time. Future research utilizing longitudinal data would be helpful to address this issue. Obtaining objective data sources that can measure the constructs of the Deming model may not be feasible, particularly when larger sample sizes are required to use statistical techniques such as PLS or SEM. Likewise, obtaining longitudinal data presents a similar challenge. We conclude that for this reason, all the studies that have assessed the Deming model share a similar set methodological concerns.

An additional concern for our research is common-method bias. We attempted to control this issue through both procedural and statistical remedies. We note that Harman's Single Factor Test was used to establish if a meaningful amount of common method variance is present in our data. While our analysis suggested that common method bias was not a problem, the use of Harman's Single Factor Test has been criticized as being unreliable (e.g. Podsakoff, et al., 2003). Therefore, Harman's Single Factor Test should not be considered a state-of-the-practice statistical remedy and future research might better address concerns about common-method bias by using alternative statistical remedies, such as a "marker variable" technique (Lindell & Whitney, 2001).

6.2 Future Research

The quality aspect of IT project deliverables has remained stubbornly problematic for many organizations, highlighting the importance of continued research in this domain by academics. Further research into which management practices are most effective for mitigating quality issues related to systems development may help advance our understanding on how to best address this problem. In particular, investigating the interrelated nature of quality management practices could provide important insights to maximizing the benefits gained from adopting a quality management approach to IT project management. Some of the quality concepts in our research, such as project team member/employee fulfillment, have received surprisingly little attention in the systems development literature. Given the results of our study, additional examination of these constructs appears warranted. While the results of this research demonstrate that the quality management concepts of the DMM are positively related to IT project outcomes, no significant insights were provided about the organizational conditions necessary to implement this managerial approach. Certainly, challenges related to implementing quality management programs have received considerable attention in the literature (see Hietschold, et al., 2014), but this research stream has focused on manufacturing and service contexts. If practitioners are to exploit the benefits of quality management practices when carrying out IT projects, identifying the critical success factors for implementing quality management programs within a firm's project management function would be highly beneficial.

More generally, despite the popularity of quality management programs, the Deming model has only received minimal attention in the literature. Additional studies assessing the Deming model would help to provide greater clarity about the mixed results in this research stream with respect to the hypothesized relationships among the model's constructs. Additionally, replicate research could also provide further insights into the applicability of the DMM to different contexts.

6.3 Conclusion

IT projects are a challenging undertaking and many organizations struggle to achieve the desired level of quality for the information systems produced by these initiatives. Given the importance of information technology to modern organizations, it is critical to identify management practices that might mitigate these persistent quality issues. Adoption of a quality management program has proven to be an effective solution for many firms to address quality deficiencies for manufacturing and service processes, and the results from our research demonstrate that the Deming management method provides one viable approach firms might adopt in the pursuit to achieve the desired level of quality for IT initiatives. In particular, the results (table 4) from our study suggest all the relationships articulated in the Deming model are significant in the context of IT projects, and the fit statistics from the analysis of our structural equation model indicate that the Deming model provides a good overall fit for data collected from our sample of IT project managers. Moreover, all theoretical constructs comprising the Deming model demonstrated significant correlations with the outcome variables of customer satisfaction and project performance, supporting the idea that total quality management practices can be applied to IT initiatives as a means of improving project results. We conclude that this study highlights the enduring relevance of Deming's philosophies to quality management and therefore the DMM should remain a topic of interest for academics and IS researchers in particular.

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APPENDIX: SURVEY INSTRUMENT

This section of questions is answered using the following scale: Strongly disagree, disagree, neutral, agree, strongly agree.

Visionary Leadership

1. My organization's top executives assume responsibility for the quality performance of IT projects.
2. All managers in my organization participate in the quality improvement process for IT projects.
3. The goal-setting process for quality of IT projects within my organization is comprehensive.
4. My organization's top management has objectives for quality performance of IT projects.
5. The goal-setting process for quality IT projects within my organization is comprehensive.

Supplier Involvement

1. Suppliers/subcontractors are selected based on quality rather than price.
2. My organization's supplier/subcontractor rating system is thorough.
3. My organization relies on reasonably few, but dependable suppliers/subcontractors.
4. My organization provides education to its suppliers/subcontractors.*
5. Longer term relationships are offered to suppliers/subcontractors.*
6. Clear specifications are provided to suppliers/subcontractors.

Quality Philosophy

1. There is a strong commitment to the quality of IT projects at all levels of this organization.
2. People in this organization are aware of its overall mission.
3. Members of this organization show concern for the need for quality.
4. Continuous quality improvement is an important goal of this organization.
5. Managers of this organization try to plan ahead for changes that might affect project performance.

Total Quality Training

1. Quality-related training is given to all IT project team members.
2. Quality-related training is given to IT project managers and other IT project leaders throughout the organization.
3. Training is given in the "total quality concept" (i.e., philosophy of organization-wide responsibility for quality) for all IT project team members.*
4. Training is given in the basic statistical techniques (such as histograms and control charts) to all IT project team members.*
5. My organization's top management is committed to employee training for quality.
6. Resources are provided for employee training in quality.

Customer Driven Info

1. IT project team members know who their (internal or external) customers are.
2. IT project team members attempt to measure their customers' needs.
3. My organization uses customer requirements as the basis for quality.
4. My organization is more customer focused than our competitors.*

PM – Process

1. A realistic project plan is developed to outline phases, tasks, and resources to estimate the project's schedule and budget.
2. Project plans are used to monitor and communicate the project's status to plan.
3. Qualified supplier/subcontractors are selected and then their progress and performance are tracked by monitoring work products and processes (i.e., acceptance reviews and tests).
4. Software engineering and project management processes are tailored to fit the current project environment and technical needs of the project.
5. A proactive approach that includes risk identification, risk assessment, and risk mitigation is used to manage risk throughout all phases of the project.

PM – Software Engineering

1. Accurate requirements are documented for developing the project's design and code.
2. Procedures are in place for obtaining and managing requirement changes to ensure that all approved changes are reflected in changes to the project plan.
3. Defined life-cycle processes support the technical activities of the project (i.e., evaluate alternatives, design, code, test, document) in order to design, develop, and implement solutions to requirements.
4. A defined process ensures that system components meet specified requirements (i.e., peer reviews).
5. A defined process ensures that the system or system components meet internal or external customer expectations (i.e., acceptance testing).

Management by Fact

1. Quality data (defects, complaints, outcomes, time, satisfaction, etc.) are available.
2. Quality data are timely.
3. Quality data area used as tools to manage quality.
4. Quality data are available to IT project team members.
5. Quality data are available to IT project managers and IT project leaders.
6. Quality data are used to evaluate IT project team member and managerial performance.

Total Quality Methods

1. IT project team members use the basic statistical techniques (such as histograms and control charts) to study their work processes.

2. IT project team members analyze the time it takes to get the job done.*
3. IT project team members keep records and charts measuring the quality of work displayed in their work area or have access to this information electronically.
4. Statistical techniques are used to reduce variation in project processes.
5. Total Quality Management (TQM) procedures (such as brainstorming, cause-and-effect diagrams, Pareto charts) are used to analyze information for process improvement.

Continuous Improvement

1. IT project team members in the organization try to improve the quality of their project work.
2. IT project team members in the organization believe that quality improvement is their responsibility.
3. IT project team members in the organization analyze their work products to look for ways of doing a better job.
4. Best practices are identified, documented, and made available to others within the organization.*

Project Team Member Fulfillment

1. I take pride of accomplishment or achievement from being able to deliver a quality information technology solution.
2. In general, I enjoy my work.
3. In general, I find my work challenging.
4. I am likely to stay with my present organization for the next 12 months (not including planned or unplanned leave of absence or retirement).
5. Overall, I have performed the duties of my job well over the past year.

The next sets of questions are answered using the following scale: Much worse, worse, same, better, much better.

Project Performance

The following scale represents your organization's relative performance of IT project performance over the PAST 3 YEARS.

1. Ability to meet project schedules
2. Ability to meet project budgets
3. Ability to complete project scope or system requirements

Customer Satisfaction

The following scale represents your customer satisfaction over the PAST 3 YEARS. Customers can be internal (e.g., human resources department) or external (a particular client).

1. Overall satisfaction of the customer*
2. Perceived value of the delivered project to the customer
3. Potential for future work with the customer

 * Indicates item was dropped from analysis

Table 4. Results

Hypothesis	Relationship	Result	β	p-Statistic
H1	Visionary Leadership → Internal and External Coop.	Supported	.732	< .01
H2	Visionary Leadership → Learning	Supported	.664	< .01
H3	Internal and External Coop. → Process Management	Supported	.428	< .01
H4	Learning → Process Management	Supported	.409	< .01
H5	Process Management → Continuous Improvement	Supported	.617	< .01
H6	Process Management → Project Team Member Fulfillment	Supported	.484	< .01
H7	Continuous Improvement → Project Performance	Supported	.389	< .01
H8	Continuous Improvement → Customer Satisfaction	Supported	.251	< .01
H9	Project Team Member Fulfillment → Project Performance	Supported	.331	< .01
H10	Project Team Member Fulfillment → Customer Satisfaction	Supported	.320	< .01