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The Deming Management Method: An Examination of Information Technology Projects

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ABSTRACT

Introducing technological change into an organization is a challenging and complex undertaking, so it is not surprising that organizations continue to struggle in their pursuit to achieve the desired level of quality for IT project outcomes. The aim of this study is to address this persistent problem by examining the Deming Management Method to determine if its theories about quality management are applicable to the processes involved in managing IT projects. Analysis of survey data collected from 168 IT professionals provides strong empirical support for the Deming Management Method and its application to IT projects.

KEYWORDS: IT Project Management, Quality Management, Deming Management Method, and Survey Research

INTRODUCTION

Although the concepts and philosophies of quality management were popularized by the Japanese, many organizations throughout the world have initiated quality management programs. Such programs include ISO certification, Six Steps to Six Sigma initiatives, or awards such as the Deming Prize or the Malcolm Baldrige National Quality Award (MBNQA). Based on the writings and teachings of such quality gurus as Shewhart, Deming, Juran, Ishikawa, and Crosby, the core values of these quality programs have a central theme that includes a focus on the customer, leadership, incremental or continuous improvement, and the idea that prevention is less expensive than correction.

Quality management has received a great deal of attention over the last fifty years in the manufacturing and services sectors; however, many of these same ideas are just beginning to be applied to information technology (IT) projects (Marchewka, 2012). A relatively new knowledge area called project quality management (PQM) focuses on project products and processes so that organizations may invest resources more efficiently and effectively, minimize errors, and meet or exceed client/project sponsor expectations. Project quality management is becoming increasingly important because failure to meet project quality requirements and standards can have negative consequences for all project stakeholders. For example, IT project objectives can be adversely affected if additional work and repeating project activities extend the IT project schedule or budget (Marchewka & Keil, 1995). One recent study found that 80% of IT executives spend at least half their time on rework for projects they manage (Geneca, 2011). Similarly, the business value derived from many IT projects is often uncertain; 41% of firms report mixed results with respect to the value delivered by completed IT initiatives (Feldman, 2014). In fact, the outcome for 17% of large IT projects is so poor that the viability of the implementing firm is jeopardized (Bloch et al., 2012). Given the challenges many IT initiatives face relating to quality, practical tools and techniques that can be employed by organizations to better manage the quality aspects of IT projects appear to be needed.

W. Edwards Deming was one of the strongest proponents of quality management, and in his book, *Out of the Crisis* (1986), Deming outlined a set of 14 points that provide a foundation for quality management. Although Deming's philosophies have been embraced around the world, only three studies have empirically tested a theoretical model grounded in the Deming Management Method. Two of these studies focused on manufacturing organizations (see Anderson et al., 1995; Rungtusanatham et al.,1998), and the other on service organizations (see Douglas & Fredendall, 2004). Given that many of Deming's philosophies, teachings, and fundamental principles are being applied to IT project management in practice, the objectives of this proposed research includes:

- Evaluating the constructs and relationships of the model to assess their relevance to information technology projects
- Testing a conceptually-based, empirically-tested model to evaluate the generalization of the Deming Management Method to information technology projects.

The findings of this study should be of interest to both academics and the business community. For academics, this study will provide an empirical examination of the Deming Model in a new context: IT projects. Hence, we will test quality management theories that have received a great deal of interest, attention, and application in practice that have not previously received attention in the IS literature. This could potentially provide important new insights in the area project quality management for IT projects. For managers, this study should be useful in identifying and understanding various constructs and relationships that support quality outcomes for an IT initiative, which potentially could allow for organizations to better execute IT development projects.

THE DEMING MANAGEMENT METHOD

The Deming Management Method (DMM) was developed by Anderson, Rungtusanatham, and Schroeder (1994) based on the work of W. Edwards Deming as well as other quality management experts. Subsequently, there have been only three empirical studies of the DMM in the literature. First, Anderson, Rungtusanatham, Schroeder, and Devaraj (1995) found general support for the model, while Rungtusanatham, Forza, Filippini, and Anderson (1995) replicated the study using manufacturing plants located in Italy and found general support for the model as well. More recently, Douglas and Fredendall (2004) tested the model using U.S. hospitals as the unit of analysis and found general support for the model.

The construct definitions for the DMM are summarized in Table 1 below, both in the manufacturing and services context as well, as how they may be generalized to an IT project management context.

HYPOTHESES

The DMM allows for the testing of several hypotheses relating to the processes of an IT development project. The hypotheses relating to the DMM are summarized at the end of the hypotheses section in Figure 1.

Table 1. Construct Definitions

CONSTRUCT	MANUFACTURING & SERVICE CONTEXT	IT PROJECT CONTEXT
Visionary Leadership	Management's ability to establish, practice, and lead a long-term vision for the organization, as well as respond to changing customer requirements.	Management's ability to establish a clear vision as it relates to the outcome of IT projects, as well as provide an effective project environment that enables the project team to meet or exceed customer expectations.
Internal & External Cooperation	The organization's propensity to engage in noncompetitive activities internally with its employees and externally with suppliers.	The IT project team's ability to engage in cooperative activities internally with each other while acting in concert with external project stakeholders.
Learning	The organization's ability to recognize and nurture employee skills, abilities, and knowledge base.	The IT project team's skills, experience, and ability to build upon an existing knowledge base while developing lessons learned that can be developed into a set of shared best practices for future IT projects.
Process Management	A set of methodologies and behavioral practices that emphasize the management of processes, or means of action, rather than results.	IT project management and software development processes are documented, integrated, and repeatable by project team members and by the IT project organization.
Continuous Improvement	The organization's propensity to pursue incremental and innovative improvements of its processes, products, and services.	The organization's propensity to pursue incremental and innovative improvements of its project management and software development processes.
Employee Fulfillment	The degree to which employees of an organization feel that the organization continually satisfies their need.	The degree to which IT project team members feel that their contributions to are IT initiative are meaningful and satisfies their intrinsic psychological needs.
Customer Satisfaction	The degree to which an organization's customers believe that their needs are being met by the organization's products or services.	The degree to which an IT project's internal or external customers perceive that completed IT initiatives meet or exceed their expectations or needs.

A leader with vision is one of the core tenants of Deming's philosophies and the DMM has two hypotheses relating to visionary leadership. First, it is essential that top management play a leadership role to foster cooperation internally among project team members and with other external stakeholders. A visionary leader has the ability to create a shared vision for the outcome of a project. This shared vision not only creates shared goals for all project stakeholders to work towards, but it also creates a sense of identification with the project among stakeholders. This provides internal motivation for project team members to corporate with other group members in the pursuit of project success. Research has supported the idea that mutual and clear objectives are one of the key factors for creating cooperation in projects (Heinz et al., 2006).

H1: Visionary leadership is positively related to internal and external cooperation

The second hypothesis relating to leadership argues that visionary leadership brings about learning. In the IS literature, it has been demonstrated that organizations often fail to remove barriers to organizational learning from mistakes experienced during implementing IT initiatives. Consequently, this results in repeating the same failures again in future IT projects (Atkinson, 1999). Top management has the ability to control learning through the allocation of resources for such things as training. 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 as such removes barriers to organizational learning.

H2: Visionary leadership is positively related to learning

IT project teams work on highly complex, interdependent tasks. Individual knowledge is not sufficient for successfully completing IT projects, so it is necessary for a variety of experts with highly differing backgrounds to collaborate (Chiocchio & Essiembre, 2009). Consequently, coordination is essential to completing a project effectively. Cooperation among project team members and external stakeholders should lead to new ideas for better managing the project and/or building information systems. In the IS literature, research has suggested that when project leaders encourages members of a project team to work together that the outcomes for IT projects are improved (Faraj & Sambamurthy, 2006).

H3: Internal and external cooperation is positively related to process management.

Organizational learning has long been argued to play a central role in the development of firm capabilities (see Dodgson, 1993), and in particular research has supported the argument that learning is positively related to process management (Douglas & Fredendall, 2004). Learning should lead to improved process management in terms of lessons learned and the identification of new best practices or the refinement of existing processes. This is similar to the Capability Maturity Model's concept of process maturity and capability.

H4: 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., Anderson et al., 1995; Douglas & Fredendall, 2004; Rungtusanatham et al., 1995). We posit that this tenant holds true for IT projects as well. Due to constraints in resources and competitive forces, there is considerable pressure to deliver IT projects that provide value to the organization on time and within budget. Given these pressures, project team members will seek ways to improve project performance. Process management should provide a means for continuous improvement as the project team constantly looks for ways to refine and standardize project and software development processes.

H5: Process management is positively related to continuous improvement

According to Self-Determination Theory, individuals possess an innate psychological need for competence (Deci & Ryan, 2001). This suggests that project team members will seek to control the outcome of their work and develop a level of mastery in their job duties. Since process management provides project teams members the information and tools necessary to execute their jobs effectively, we argue that project team members will leverage these tools in the pursuit of fulfilling their need for competence. It follows then that superior process management methods should help improve team members' job performance, consequently increasing a project team members' satisfaction.

H6: Process management is positively related to project team member fulfillment

When an organization continually attempts to improve IT project management processes, its ability to effectively and efficiently execute IT initiatives improves over time. This provides two important outcomes: improved customer satisfaction and improved project performance. Project performance refers to measures of success or failure in the execution of the IT project itself. In this research, three dimensions of project performance are taken into consideration: budget, schedule, and functionality. Referred to as the triple constraint (Marchewka, 2012), meeting budget, schedule, and functionality goals have been argued to be the primary measures of project performance (Xia & Lee, 2004). In this paper we posit that if the organizational processes required in executing an IT development project improve, then it follows that the outcome on the development processes, performance of the IT project, will improve accordingly. In the same vein, the practice of IT project management has been described as the art of managing tradeoffs between IT project outcomes (Marchewka, 2012). For example, a project manager may need to make compromises between the delivered IT initiative's performance and aspects of project performance (e.g. reducing the amount of allotted testing in an effort to avoid cost or schedule overruns). Customer satisfaction refers to the degree that IT solutions meet or exceed the expectations or needs of the organization; as such, it broadly refers to the quality of the delivered system. In this research we argue 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 required to meet project performance requirements and the overall quality of the IT initiative will improve correspondingly.

H7: Continuous improvement is positively related to project performance

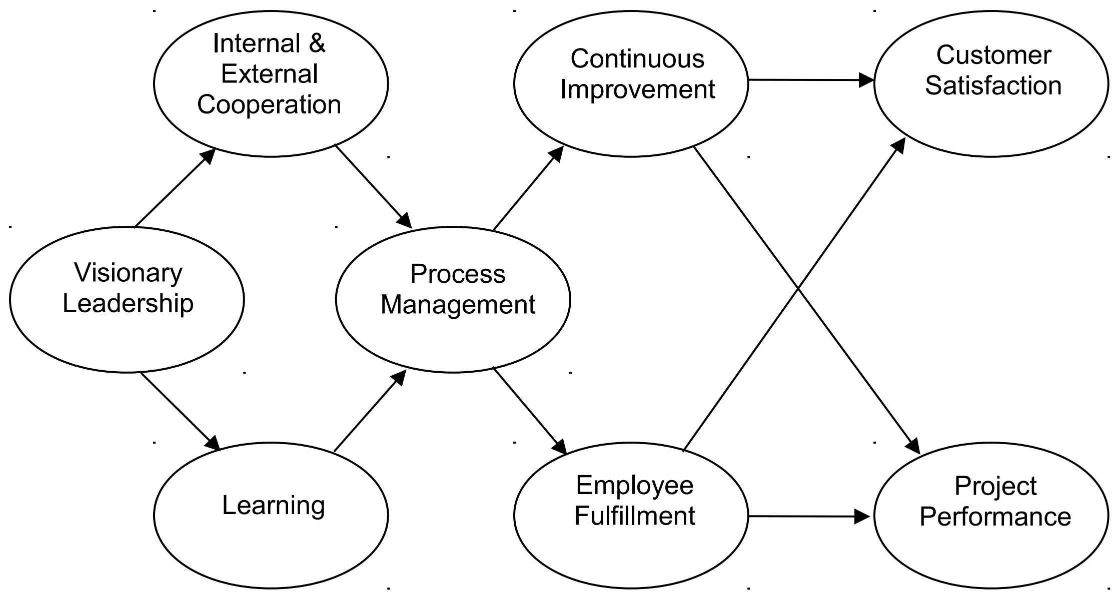
H8: Continuous improvement is positively related to customer satisfaction

Lastly, we assert that employee fulfillment has several important consequences in the DMM. According to Self-Determination Theory, an individual's psychological need for competence results in intrinsic motivation to fulfill that need, which in turn positively influences 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, internal motivations to work are satisfied and commitment and desire to contribute positively to the development project increases. Consequently, this should result in improved project team performance for both project quality and project performance. Research has found strong relationships to exist between employee fulfillment and important business outcomes such as business performance and customer satisfaction (Douglas & Fredendall, 2004).

H9: Project team member fulfillment is positively related to project performance

H10: Project team member fulfillment is positively related to customer satisfaction.

Figure 1: Research Model



METHODOLOGY

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

To measure our constructs related to the Deming Management Method, a previously validated instrument used by Douglas and Fredendall (2004) was adopted and modified to reflect an IT project environment. To measure project performance, a new instrument was developed. The IT project management literature has long recognized three dimensions of IT project success: schedule, budget, and functionality (Atkinson, 1999; Marchewka, 2012). We modeled project performance in our study as a formative construct with contributing items representing each of these dimensions of project success. All items in our survey instrument were measured using a five-point Likert scale.

To test our hypotheses, partial least squares (PLS) path modeling was utilized. The use of PLS was appropriate for our research for several reasons. First, PLS does not assume measurement is without error, so it is preferable over statistical techniques such as regression (Wold 1982). Moreover, PLS allows for the testing of complex models, as multiple independent and dependent variables can be analyzed simultaneously (Haenlein & Kaplan, 2004), while performing well when the number of constructs is large when compared to the sample size (Wold, 1982). Lastly, PLS is capable of modeling both reflective and formative second-order constructs (Wetzels et al., 2009).

The PLS representation of our research model required the use of formative second-order constructs. We chose to utilize second-order constructs to provide a more parsimonious and interpretable modeling of the Deming Management Method than would be provided by an examination of the relationships among the underlying lower-order factors. All first-order constructs in our research were measured reflectively. Because our second-order constructs were endogenous, we used the two-stage approach discussed by Becker, et al. (2012) to model them.

DATA COLLECTION AND RESULTS

Data was collected via the use of an electronic questionnaire. Respondents were solicited to participate through a posting on the Project Manager Institute (PMI) web site. A total of 169 respondents began our survey. One survey questionnaire was not completed and was removed from the data sample. A visual inspection revealed no cases where invalid responses were provided. Using the Mahalanobis distance measure, no cases were identified as outliers. After data screening, a total sample of 168 cases were retained for analysis. The minimum sample size to conduct PLS should be at least 10 times larger than the most complex endogenous construct (Chin, 1998). Given our research model and use of formative constructs, the minimum number of suggested cases was 60, which our sample size exceeded.

Our respondents represented a variety project management related positions, including vice president of IT, CIO, business/systems analyst, project manager, and consultant. Organizations where respondents worked averaged approximately 23,897 employees and 4270 IT personnel. Table 2 provides details about the individual respondent characteristics.

Table 2: 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		

Construct Validity and Reliability

Using data gathered for hypothesis testing, the validity and reliability of our measurement model was assessed using PLS (Gefen & Straub, 2005). To confirm convergent validity, a bootstrap resampling technique using a resample size of 5000 was used to calculate t-values for indicator loadings. An examination of item loadings indicated 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. These items were dropped from additional analyses. A second PLS analysis confirmed all retained items loaded significantly above the suggested .7 level, while the average variance extracted (AVE) statistics for all constructs exceeded the minimum suggested value of .50. To assess discriminant validity, correlations between item scores and latent variable scores were examined. Our results indicated that one item from perceived customer satisfaction loaded higher on project performance than it did on its designated construct. This item was removed from further analysis. A final PLS analysis revealed that all retained indicators loaded substantially higher on their respective constructs than on other constructs, while all AVE statistics were greater than the squared correlations between constructs. Additionally, we assessed the heterotrait-monotrait ratio (HTMT); this analysis revealed all HTMT statistics were well below the conservative .85 threshold, suggesting our model demonstrates satisfactory discriminant validity. To assess the reliability of our instrument we examined the composite reliability statistics for our theoretical constructs. The reliability statistics for each of our constructs exceeded the recommended minimum of .70. Table 3 provides composite reliability and AVE statistics. Table 4 provides the correlation matrix for the study's constructs of interest.

With respect to our formative second-order constructs, we statistically assessed the indicator validity of our second order constructs by carrying out significance tests between our first-order indicators and our second-order constructs. As can be seen in Table 3, all indicators were significantly related to their respective higher order constructs, suggesting all first-order constructs significantly contribute to the formation of their respective second-order constructs.

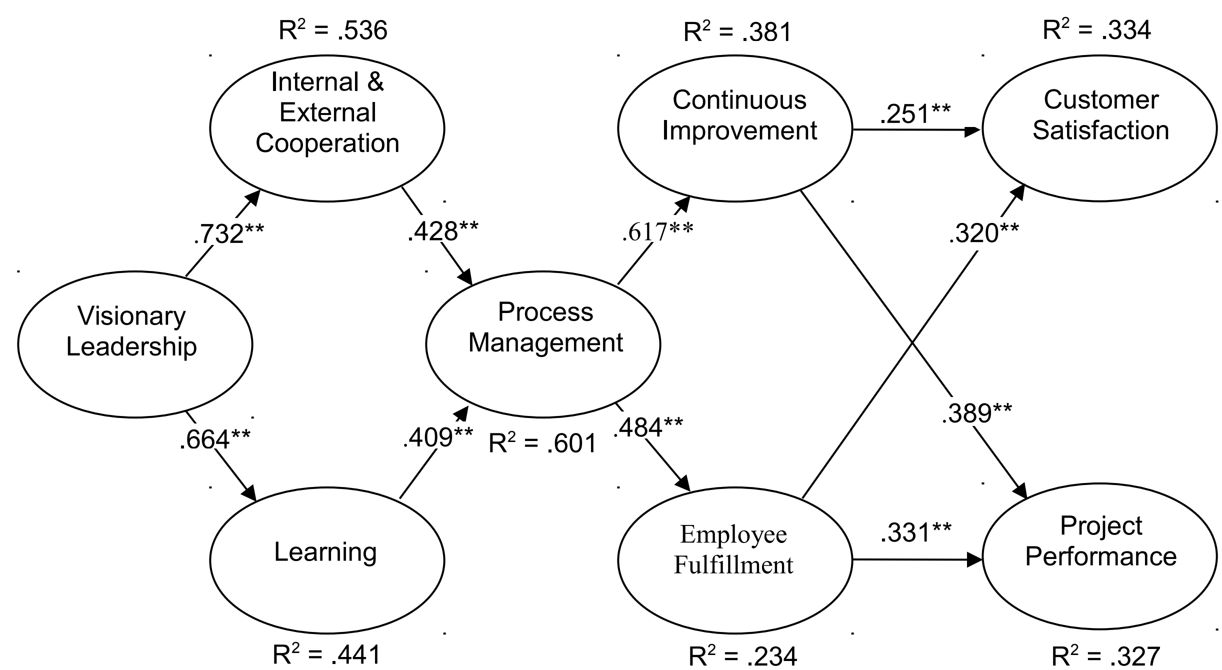
Table 3: Latent Variable Statistics

	Composite Reliability	**AVE**	**β**	**t-statistic**
Continuous Improvement	0.886	0.661	-	-
Customer Satisfaction	0.959	0.921	-	-
Employee 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 4: Correlation Matrix

	1	2	3	4	5	6	7	8
Continuous Improvement	1.000							
Customer Satisfaction	0.424	1.000						
Employee 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 Success	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

Figure 2: Results



Hypotheses Testing

The results of our PLS analysis showed strong support for the proposed research model. H1 and H2 were supported, with visionary leadership demonstrating a significant positive relationship with 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) were significant antecedents to process management, supporting H3 and H4. In turn, process management had significant positive relationships with both continuous improvement (β = .617, p < .01) and employee fulfillment (β = .484, p < .01), supporting H5 and H6. Continuous improvement had significant positive relationships with both project performance (β = .389, p < .01) and customer satisfaction (β = .251, p < .01), thus supporting H7 and H8. Employee fulfillment had significant positive relationships with project performance (β = .331, p < .01) and customer satisfaction (β = .320, p < .01), supporting H9 and H10.

To assess whether our research model fits the data, we examined the standardized root mean square residual (SRMR) for our research model, as provided by SmartPLS. The SRMR statistic for our research model was .055. A value less than 0.08 is considered to provide good fit in PLS-SEM (Hu & Bentler, 1999). As such, we conclude that our model provides a good fit for the data. Figure 2 provides a summary of our test results.

CONCLUSIONS

Based on the results of this study, it appears that there is strong support for applying the teachings and ideas of W. Edwards Deming to IT project quality management. While the correlation analysis provides support for the Deming Management Method, the descriptive statistical analysis provides some insight into how many of Deming's ideas and teachings are being applied explicitly or implicitly in the development of information systems.

The application of the Deming Management Method to IT projects provides a new area of study for IS researchers. This study provides a first step for adapting and expanding the model to understand the role software development tools play in supporting the quality initiative for IT projects. For example, Post and Kegan (2005) investigated current system development trends and report that certain tools, such as a database management system, make it significantly more likely that projects will be completed on time and within budget. In addition, the role of statistical analysis is a tenant of Deming in order to manage by fact. Subsequently, previous research such as a study by Anand and Chung (2005) suggest that engineering IT support issues can be well managed using statistical process control chart (SPC) to help engineering IT management determine whether a support incident is in control. Moreover, Allison and Merali (2006) describe how statistical process improvement (SPI) programs can be understood as a form of active learning whereby various project team members reflect upon their actions, make sense of the current context, and then design processes to best suit their needs at that time. Another consideration may be on the geographical dispersion of project team members and subcontractors as many project processes are outsourced or off-shored. For example, Chen, Romano, and Nunamaker (2006) contend that projects today involve members from different geographical locations and suggest a collaborative project management approach to better manage distributed projects

For organizations, greater insight into the application of the Deming Management Method may increase the likelihood of projects meeting scope, schedule, and budget objectives, while improving internal or external customer satisfaction. More specifically, the importance of leadership may be critical to a learning IT organization that focuses on both project and software engineering processes in order to support continuous learning and encourage project team member morale. This is also supported by prior research by Wu, Hwang, Chen, and Jiang (2002) who report that a more mature software development process reduces certain risks in the project and supports better project performance.

However, all studies have limitations, and this study is no different. For example, 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 direct customer perceptions.

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