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Determinants of Process Maturity in English-speaking Caribbean Firms

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Abstract

For decades the IS community has been struggling with the delivery of low quality systems. Software process improvement (SPI) programs are accepted as one of the remedies to overcome this problem, with process maturity being a key element. A major contributor of process maturity is the capability maturity model integration (CMMI). However, most studies regarding process maturity and the determinants of IS quality have been conducted in large firms in developed countries. But it is imperative for software development firms both large and small to understand what is needed to deploy high quality systems. This study seeks to assess the determinants of process maturity in firms in the English-speaking Caribbean (ESC), using the established practices in the CMMI as a baseline for discussion and analysis. Applying PLS as the analytical tool, it was found that project monitoring and control, and verification and validation are major determinants of process maturity in the ESC. These findings can assist practitioners in their pursuit to produce higher quality software products, as well as provide a platform for further refinement of the research model by IS researchers.

Keywords

Capability maturity model integration, Information systems quality, English-speaking Caribbean firms, and process maturity.

1. Introduction

For decades the IS community has been struggling with the delivery of low quality systems (Niazi, Babar, & Verner, 2010), which in turn negatively affects the intended benefits (Barclay, 2008). This condition is more adverse in developing countries which suffers from severe resource constraints (Kimaro, 2006). It is also felt that the failure rate of IS projects in developing countries is higher than those in developed countries (Heeks, 2002), which keep small firms in developing countries on the wrong side of the digital divide (Heeks, 2002). In addition, it is widely accepted that small firms in developing countries has less capacity to absorb such failures (Heeks, 2002; Lawler, 1997).

In an effort to improve the quality of the delivered systems and reduce the failure rate of IS projects, it is important that developers and practitioners have a better understanding of the key factors that influence process maturity (Kamhawi, 2007). Process maturity is an indication of how close an evolving process is near to completion, and is capable of continuous improvement through performance measures and feedback (Srinivasan, 2010). This concept of process maturity can give firms a competitive edge (Srinivasan, 2010). High

levels of process maturity can enhance the likelihood of producing higher quality software products (Humphrey, 1989; Paulk, Weber. C.V., Curtis, & Chrissis, 1995; SEI, 2006).

However, most studies on the determinants of process maturity and the delivery of higher quality software products are conducted in large firms in developed countries (Gefen & Zviran, 2006; Gorla & Lin, 2010), with only a few being empirical study (Krishnan & Keller, 1999; Niazi & Babar, 2009), and even less being conducted on small firms in developing countries (beecherou, 2008; Horvat, Rozman, & Gyorkos, 2000; Niazi et al., 2010; Pino, Pardo, Garcia, & Piattini, 2010; Richardson & Wangenheim, 2007). It was also found that there is little research in this domain in the English-speaking Caribbean (Chevers & Duggan, 2007).

An improved understanding of the determinants of process maturity can increase the delivery of higher quality software products, which by extension can enhance the possibility of earning much needed foreign exchange by winning global contracts. These reasons have motivated this study, in which the research question seeks to ascertain, "what factors influence process maturity in English-speaking Caribbean software development firms?"

The expected contribution of the study is for IS practitioners in the English-speaking Caribbean to gain rich insights regarding the factors with the greatest influence on process maturity, which can assist with the development of more successful IS projects (Anderson, Birchall, Jessen, & Money, 2006; Peslak, 2006). Process maturity and IS quality are important topics for researchers (Bokhari, 2005), as a result, it is hoped that IS scholars will further refine the research model.

2. Background

Information systems are critical to the strategic imperatives of most organizations (Bokhari, 2005). Hence, it is important that these systems satisfy the intended benefits (Barclay, 2008). However, a large percent of IS projects are considered failure due to budget overruns, time overruns, and abandonment (Bulatovic, 2011; Li, Huang, Luftman, & Sha, 2010; Luftman & Ben-Zvi, 2010; Nauman, Aziz, & Ishaq, 2005; Standish Group, 2009; Thong, Yap, & Raman, 1996). But the main contributor of project failure suggested by scholars is poor quality software products being delivered (Brooks, 1987; Walia & Carver, 2009).

The literature states that people, technology and process maturity are major determinants of IS quality (Iversen & Ngwenyama, 2005; SEI, 2006). However, many scholars believe that careful analysis and design of the IS delivery process is the most impactful of all the factors that influence IS quality (Humphrey, 1989; Paulk et al. 1995). This view is largely responsible for the popularity of software process improvement (SPI) initiatives. Advocates of the process paradigm (SEI, 2005) states that "everyone realizes the importance of having a motivated workforce, quality work force and the latest technology, but even the finest people can't perform at their best when the process is not understood or operating at its best." (p.9). For this reason, people and technology were scoped out of this study and the emphasis is placed on process maturity and its antecedents.

The capability maturity model integration (CMMI) a popular and well established process assessment framework (Agrawal & Chari, 2007; Beecham, Hall, & Rainer, 2005; Jiang, Klein, Hwang, Huang, & Hung, 2004) was selected as the baseline for discussion and analysis. It is a major contributor in the area of process maturity. It details a list of prescribed

practices from levels 1 – 5 which can be used to assess a firm's process maturity. These prescribed practices if understood, followed and institutionalized during the development cycle can increase the likelihood of producing high quality software products.

The issue of poor quality software being delivered in developing countries needs urgent attention because these countries have less capacity to absorb such failures due to their limited resources in finance, human capital and infrastructure (Heeks, 2002; Nauman et al., 2005). In addition, the determinants of IS quality is poorly understood in developing countries because there is relatively little research in this domain (Avgerou, 2008).

The majority of these studies are conducted in developed countries. But the norms and culture in developing countries are different from those in developed countries. For example the literature refers to (1) scarcity of technical experts due to migration (International Monetary Fund, 2006), (2) unavailability of IS specialists (Thong et al., 1996), (3) heavy reliance on imported IT products and solutions (Bhatnagar, 2000), (4) resource poverty in finance, labor, equipment and material (Berisso & de Vries, 2010), (5) highly centralized structures, with the CEO (who might not be an IS personnel) making most of the important IS/IT decisions, and (6) cultural problems such as aversion to change and low productivity (Herrera & Ramirez, 2003).

As a result of the above stated norms and culture, it is reasonable to expect different results in process maturity and IS quality studies in developing countries in contrast to similar studies in developed countries (Kamhawi, 2007). This expectation is equally supported by the discovery in a study conducted in the English-speaking Caribbean (ESC) which found that a large majority of software development firms in the region are not aware of software process improvement (SPI) and its benefits, nor are they using or intend to use any forms of SPI programs in the near future (Chevers & Duggan, 2010). As a result, it is important to identify the process maturity practices which can increase the chances of delivering high quality IS projects (Rodriquez-Repiso, Rossitza, & Salmeron, 2007) in this region. Process maturity is defined as the degree to which a process is defined, managed, measured and continuously improved (Dooley, Subra, & Anderson, 2001).

3. The Research Model

In an attempt to identify the relevant and applicable process maturity practices in the ESC, a series of focus groups sessions using the nominal group technique (NGT) were conducted in four countries - Barbados, Guyana, Jamaica and Trinidad. The nominal group technique was selected because it contributes to greater objectivity by helping to reduce emotional attachment to ideas, as well as its ability to cure problems that freely interacting group encounter like inefficient idea generation, group think and destructive dominance (Delbecq, Van de Ven, & Gustafson, 1975; Duggan & Thachenkary, 2004).

A total of 30 IS professionals (systems analysts, developers and IS managers) participated in the 4 sessions. There were 24 males and 6 females in these sessions, which comprised 7 senior IS managers, 7 senior analysts, and 16 analysts/developers. Five, eight, nine and eight persons participated in the sessions in Barbados, Guyana, Jamaica and Trinidad respectively.
The participants in these NGT sessions were given a list of the 18 established CMMI levels 2 and 3 practices (see Table 1) to select the ones that were most applicable in their countries based on their norms, culture and constraints. Levels 2 and 3 were chosen for the study

because there are no established practices at CMMI level 1 and levels 4 and 5 are advanced practices which might be somewhat difficult to adopt in the ESC at this early stage.

Level 2:	**Level 3:**
1. Requirements Management (RM)	8. Requirements Development (RD)
2. Project Planning (PM)	9. Technical Solution (TS)
3. Project Monitoring and Control (PMC)	10. Product Integration (PI)
4. Supplier Agreement Management (SAM)	11. Verification (VER)
5. Measurement and Analysis (MA)	12. Validation (VAL)
6. Process and Product Quality Assurance (PPQA)	13. Organization Process Focus (OPF)
7. Configuration Management (CM)	14. Organization Process Definition (OPD)
	15. Organizational Training (OT)
	16. Integrated Project Management (IPM)
	17. Risk Management (RSKM)
	18. Decision Analysis and Resolution (DAR)

Table 1: CMMI Level 2 and 3 Practices

The NGT approach taken in these sessions were:

(1) Idea generation - Participants were asked to create new practices or merge existing CMMI practices

(2) Idea recording – Participants were asked to select their top ranked practices

(3) Discussion and clarification – The independent facilitator encouraged discussion on merged practices and the top ranked practices

(4) Ranking of practices – Scores were given to the practices, after which these scores were aggregated to derived the top ranked practices in each country

(5) Decision making on the top practices – The top ranked practices were presented to participants for general agreement and consensus

At the end of these sessions the top ranked practices were aggregated to derive the top ranked practices among the four countries. The definitions of each of the practices are shown in Appendix 1 along with their sources. In fact, these definitions were presented to the participants in the NGT sessions to help guide the discussion. Upon completion, the top 10 practices among the four countries were risk management, technical solution, organizational training, requirements management + requirements development, integrated project management, project planning, organization process definition, organization process focus, project monitoring and control, and verification + validation in descending order (see Table 2). The objective of the exercise was to incorporate the top ranked process maturity practices in the research model as indicator variables for the construct – Process Maturity.

At the end of the four sessions the research model had the 10 top ranked practices as determinants of IS quality in ESC software development firms (as shown in Figure 1). As a result the study consisted of 10 hypotheses. These are:

H1: Risk management will have a positive impact on IS quality

H2: Technical solution will have a positive impact on IS quality

H3: Organizational training will have a positive impact on IS quality

H4: Requirements management + Requirements development will have a positive impact on IS quality

H5: Integrated project management will have a positive impact on IS quality

H6: Project planning will have a positive impact on IS quality
H7: Organization process definition will have a positive impact on IS quality
H8: Organization process focus will have a positive impact on IS quality
H9: Project monitoring and control will have a positive impact on IS quality
H10: Verification + Validation will have a positive impact on IS quality

Rank	Process Maturity Practice	Description	Total Score
1	RSKM	Risk Management	41
2	TS	Technical Solution	36
3	OT	Organizational Training	33
4	RM+RD	Requirements Management & Requirements Development	24
5	IPM	Integrated Project Management	22
6	PP	Project Planning	19
7	OPD	Organization Process Definition	19
8	OPF	Organization Process Focus	19
9	PMC	Project Monitoring & Control	13
10	VER+VAL	Verification & Validation	13

Table 2: The Top Ranked Practices in Descending Order

A survey was conducted in an attempt to validate the research model, as well as assess the strength of each practice on the process maturity construct.

4. The Survey

The main survey method was on-line but face-to-face, telephone calls and postal mailing methods were employed. Like the NGT sessions, the survey was conducted in the same four ESC – Barbados, Guyana, Jamaica and Trinidad. The unit of analysis was IS projects and the targeted respondents were project managers and developers of a recently deployed system in these countries. A total of 360 questionnaires were distributed and 136 were collected. However, 8 were incomplete and had to be discarded, resulting in a 36% response rate. Of the 128 respondents, 75 were males and 53 were females. Further details regarding the demography of the respondents are shown in Table 3.

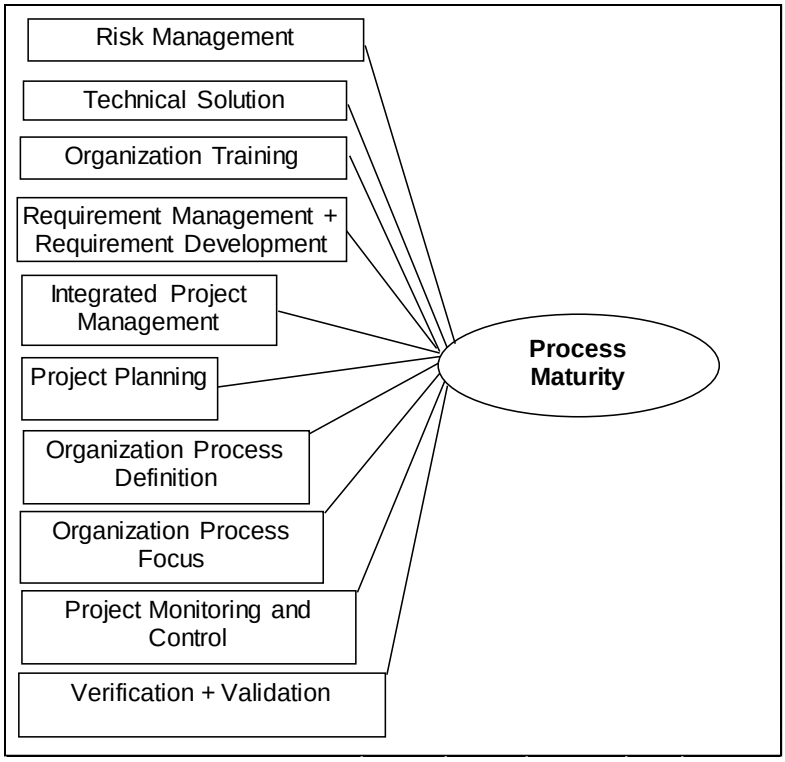

Figure 1: The Research Model

Factors	Number	Percent
Countries survey was conducted:		
Barbados	9	7
Guyana	9	7
Jamaica	86	67.2
Trinidad	24	18.8
Industry Type:		
Communications	12	10.2
Education	24	20.3
Finance	7	5.9
Government	19	16.1
Health	1	0.8
Hotel & Hospitality	2	1.7
Technology	30	25.4
Insurance	5	4.2
Manufacturing	5	4.2
Transportation	6	5.1
Utilities	7	5.9

Table 3: Demographic Profile of Respondents

The bootstrap re-sampling method (using PLS-Graph and 200 samples) was used to test the significance of the paths. PLS-Graph 3.0 was chosen as the analytical tool because of its ability to assess relatively small sample size (Chin, 1998) and evaluates the relationship among a series of independent variables on a single dependent variable (Hair, Black, Babin,

Anderson, & Tatham, 2006). In other words this technique is useful to determine the predictive power of independent variables on the dependent variable (Chin, 1998).

5. Findings

Reliability tests as shown in Table 4 came out in the range of 0.833 – 0.932, which is above the acceptable threshold of 0.70 (Gefen, Straub, & Boudreau, 2000). This indicates that reliability existed in the variables. Likewise, convergent validity existed in all variables as evident in the average variance explained (AVE) being above 0.50 (Fornell & Larcker, 1981). All AVE readings in Table 4 are above 0.50, with the lowest being 0.558.

Variable	**Composite Reliability**	**AVE**
RSKM	0.906	0.709
TS	0.835	0.628
OT	0.866	0.687
RM+RD	0.833	0.558
IPM	0.872	0.697
PP	0.874	0.583
OPD	0.890	0.731
OPF	0.909	0.772
PMC	0.840	0.574
V+V	0.932	0.774

Table 4: Reliability and Convergent Validity

Only two out of ten practices (project monitoring and control, and verification + validation) were found to be significant vis-à-vis IS quality (see Table 5). This means that most of the practices that have been embedded and institutionalized in developed countries are not being used in the development of systems in the ESC countries. This finding is consistent with (Chevers & Duggan, 2010) study in which it was found that the majority of software development firms in the ESC were not aware of nor using any form of SPI programs. Based on the finding of only two practices being significant it could be argued that the process maturity of firms in the ESC is low – perhaps operating at levels 1 – 2.

Variable	Weights	T-Statistics	Hypotheses	Findings
RSKM	-0.241	1.002	H1	Not supported
TS	0.037	0.138	H2	Not supported
OT	0.069	0.268	H3	Not supported
RM+RD	0.169	0.609	H4	Not supported
IPM	0.022	0.076	H5	Not supported
PP	0.166	0.669	H6	Not supported
OPD	-0.018	0.065	H7	Not supported
OPF	-0.287	0.896	H8	Not supported
PMC	0.674	1.982**	H9	Supported
V+V	0.396	1.737*	H10	Supported

Table 5: Research Model Results

Note: (1) Significant at $p \leq 0.10$
(2) Significant at $p \leq 0.05$
(3) R^2 for the Process Maturity construct being 0.271

In addition, the R^2 of the process maturity construct was 0.271 which means that the ten variables explain 0.271 of the variance in the dependent variable – process maturity. This means that there are other factors that contribute to process maturity in the ESC.

Interestingly, the two practices that were found to be significant in the survey, were ranked ninth and tenth in the NGT sessions. A possible explanation for this disparity is the difference in the objective of the NGT sessions versus the survey. The objective of the NGT sessions were normative, in which participants discussed and agreed on what ought to be (the ideal), whereas the survey was more descriptive in which respondents were reported on what existed in their organization during software development.

6. Discussion

Both IS researchers and practitioners are keen on the delivery of high quality systems (Livari, 2005), because unused or underutilized systems can cost firms millions of dollars each year (Markus & Keil, 1994). The performance of IS project managers and operations managers can improve if they are knowledgeable about the determinants of IS quality. Such knowledge can positively impact the outcome of IS projects (Anderson et al., 2006; Kamhawi, 2007).

The study provides guidance for the adoption and institutionalization of process maturity practices as a precursor to deliver higher quality software products. Selecting the practices which can provide the greatest benefits in a reasonable timeframe is critical to IS practitioners (chief information officers, project managers and developers) in the ESC, especially against the background of limited resources.

Based on the fact that only two practices were found to be significant, it is reasonable to suggest that software development firms in the ESC should begin to focus on SPI education and training. Focus should be placed on SPI benefits and a concerted effort should be made to incorporated additional practices in the development process, in their pursuit to deliver high quality software and by extension win global contracts.

The study also creates the opportunity for researchers to explore other group technique beyond NGT to provide convergence of the process maturity practices in the first stage of the research. A comparison of techniques might provide useful insights in their relative effectiveness. In addition, other analytical tools rather than PLS could be used to assess the relative strength of each practices on process maturity.

7. Conclusion

Unused or underutilized systems can cost firms millions of dollars each year, a resource that is very scarce in the ESC countries. Hence, it is important to understanding those factors that enhance the delivery of high quality and successful IS projects. Project outcomes can be improved which can lead to better utilization of resources (Thomas & Fernandez, 2008).

It is hoped that the findings of this study will provide useful insights for both IS researchers and practitioners in their desire to produce higher quality software. This by extension can increase the likelihood of winning global contracts which can provide scare foreign

exchange. These chains of events can increase the economic development and prosperity of countries in the English-speaking Caribbean.

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Appendix 1: Definition of Practices and Sources

Construct/Measures	Source/Ref.
Process Maturity	
Risk Management (RSKM) is about identifying potential problems before they occur so that risk management activities can be planned and put into action as needed	Zubrow et al., 1994
Technical Solution (TS) is about designing, developing and implementing solutions to user requirements	Zubrow et al., 1994
Organization Training (OT) is about developing the skills and knowledge of project personnel so they can perform their roles effectively and efficiently	Zubrow et al., 1994
Requirements Management + Requirements Development (RM+RD) are about analysing and producing the system requirements and managing customer requirements	Zubrow et al., 1994
Integrated Project Management (IPM) is about managing the project in a manner that brings team members together in a coordinated manner	Zubrow et al., 1994
Project Planning (PP) establishes and maintains the plans that define project activities	Zubrow et al., 1994
Organization Process Definition (OPD) establishes and maintains a usable set of software development procedures and standards	Zubrow et al., 1994

Organization Process Focus (OPF) plans, implements and deploys process improvements based on a thorough understanding of the strengths and weaknesses of the organization's software development processes	Zubrow et al., 1994
Project Monitoring and Control (PMC) provides an understanding of the project's progress so that appropriate corrective actions can be taken when the project's performance deviates significantly from the plan	Zubrow et al., 1994
Verification + Validation (VV) describes the steps taken to ensure that the activities are performed in compliance with processes such as reviews, audits and software quality assurance, as well as checking that the software process produces the intended results such as formal walkthroughs and inspections	Zubrow et al., 1994