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KEY FACTORS OF PROCESS MATURITY IN ENGLISH-SPEAKING CARIBBEAN FIRMS

Fatores-chave do processo de maturidade nas empresas caribenhas de língua inglesa

Factores clave de la madurez procesal en las empresas de habla inglesa del caribe

ABSTRACT

The information system (IS) community has been struggling with the delivery of low quality systems. Software process improvement (SPI) has been accepted as one of the remedies to overcome this problem, with process maturity being a key element. However, most studies on process maturity and the determinants of IS quality have been conducted in large firms in developed countries. This study assessed the key determinants of process maturity in small software development firms in the English-speaking Caribbean (ESC). Using the established practices in the capability maturity model integration (CMMI) as the baseline for the analysis, it was found that project monitoring & control, and verification & validation are key determinants of process maturity in the ESC. These findings can assist IS professionals in their quest to produce higher quality software products, as well as provide a platform for further refinement of the proposed research model by IS researchers.

KEYWORDS | Capability maturity model integration, information systems quality, English-speaking Caribbean firms, process maturity, PLS.

RESUMO

A comunidade de sistemas de informação (SI) tem sofrido com a produção de sistemas de baixa qualidade. A melhoria do processo de softwares (SPI) tem sido aceita como um dos paliativos para superar este problema, sendo a maturidade do processo um elemento-chave; no entanto, a maioria dos estudos sobre a maturidade processual e os determinantes da qualidade IS foram realizados em grandes empresas, em países desenvolvidos. Este estudo avaliou os principais determinantes da maturidade nos processos, em empresas de desenvolvimento de software pequenas, no Caribe, e de língua Inglesa (ESC). Usando as práticas estabelecidas na integração do modelo de maturidade da capacidade (CMMI), como a linha de base para a análise, verificou-se que o monitoramento e controle do projeto, juntamente com a verificação e validação, são os principais determinantes da maturidade processual nas ESC. Essas descobertas podem ajudar os profissionais de IS, em sua busca por produzir produtos de software de qualidade superior, e também fornecem uma plataforma para o refinamento do modelo de pesquisa, proposto por pesquisadores da área de IS.

PALAVRAS-CHAVE | *Integração do modelo de maturidade da capacidade, da qualidade dos sistemas de informação, empresas do Caribe de língua inglesa, processo de maturidade, PLS.*

RESUMEN

La comunidad de sistemas de información (SI) ha sufrido con la producción de sistemas de baja calidad. La mejora del proceso de softwares (SPI) fue aceptada como uno de los paliativos para superar este problema, siendo la madurez del proceso un elemento clave; sin embargo, la mayoría de los estudios sobre la madurez procesal y los determinantes de la calidad IS fueron realizados en grandes empresas, en países desarrollados. Este estudio evaluó los principales determinantes de la madurez en los procesos en pequeñas empresas de desarrollo de software, en el Caribe, de lengua Inglesa (ESC). Usando las prácticas establecidas en la integración del modelo de madurez de la capacidad (CMMI), como la línea base para el análisis, se verificó que el monitoreo y control del proyecto, junto con la verificación y validación, son los principales determinantes de la madurez procesal en las ESC. Estos descubrimientos pueden ayudar a los profesionales de IS, en su búsqueda por producir productos de software de calidad superior, y también proporcionar una plataforma para el refinamiento del modelo de investigación, propuesto por investigadores del área de IS.

PALABRAS CLAVE | *Integración del modelo de madurez de la capacidad, de la calidad de los sistemas de información, empresas del Caribe de habla Inglesa, madurez procesal, PLS.*

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INTRODUCTION

The information system (IS) community has been struggling with the development and delivery of low quality systems (Niazi, Babar, & Verner, 2010), which by extension negatively affects the intended benefits (Barclay, 2008). This condition is more adverse and critical in developing countries which suffers from severe resource constraints (Kimaro, 2006). It is generally felt that the failure rate of IS projects in developing countries is higher than those in developed countries (Heeks, 2002), a condition which keeps small software development 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 failed IS projects (Heeks, 2002; Lawler, 1997).

In an effort to improve the quality of the delivered software and reduce the failure rate of IS projects, it is important that software developers and IS practitioners have a good understanding of the key determinants of 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 & Murthy, 2010). This concept of process maturity can give firms a competitive advantage (Srinivasan & Murthy, 2010). It is posited that high levels of process maturity not only enhance the likelihood of producing higher quality software products, but contribute to reduced developmental cost, improved staff productivity, and improved customer satisfaction (Harter, Slaughter, & Krishnan, 1998; Humphrey, 1989; Krishnan & Keller, 1999; Paulk, Weber, Curtis, & Chrissis, 1995; SEI, 2010).

However, most studies on the determinants of process maturity and the delivery of high 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 (Avgerou, 2008; Horvat, Rozman, & Györkös, 2000; Niazi et al., 2010; Pino, Pardo, Garcia, & Piattini, 2010; Richardson & von Wangenheim, 2007). In addition, it was discovered that there is little research in this domain in the English-speaking Caribbean (Chevers & Duggan, 2007).

An understanding of the key determinants of process maturity can increase the likelihood of delivering higher quality software products, which by extension can enhance the possibility of earning much needed foreign exchange by winning global contracts (Niazi et al., 2010; Sulayman, Urquhart, Mendes, & Seidel, 2012). It is important to note that the ESC is in dire need of foreign exchange for nation building (Chevers & Duggan, 2007). These reasons have motivated this study, in which the research question seeks to ascertain, "what are the key determinants of process maturity in English-speaking Caribbean software development firms?"

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

BACKGROUND

Information systems are integral to the strategic imperatives of many organizations (Bokhari, 2005). As a result, it is important that these systems satisfy the intended benefits after implementation (Barclay, 2008). However, a large percent of IS projects are considered a failure in terms of 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 as suggested by IS scholars is poor quality software products being developed and 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, 2010). However, many scholars believe that careful analysis and design of the IS delivery process is the most influential of all the factors on IS quality (Humphrey, 1989; Paulk et al. 1995). This belief 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). It is for this reason that people and technology were scoped out of this study, and the emphasis was placed on process maturity and its antecedents.

The most popular software process improvement framework is the capability maturity model integration - CMMI (Agrawal & Chari, 2007; Beecham, Hall, & Rainer, 2005; Jiang, Klein, Hwang, Huang, & Hung, 2004), and as such was selected in this study as the baseline for analysis and discussion. The CMMI is

a well-established framework in the area of process maturity. It details a list of prescribed process areas (called practices in this study) from levels 1-5 which can be used to assess a firm's process maturity. If these prescribed practices are understood, followed and institutionalized during the system development cycle, great strides can be achieved towards the likelihood of producing high quality software products (Niazi & Babar, 2009).

The problem of poor quality software being delivered in developing countries needs urgent attention because software development firms in these countries have less capacity to absorb such failures due to their limited finance, human capital, and infrastructure resources (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). This is so because the majority of SPI studies are conducted in developed countries. However, the constraints, norms, and culture in developing countries are different from those in developed countries. For example, there is reference in the literature about:

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 (Thong et al., 1996)
6. Cultural problems such as aversion to change and low productivity (Herrera & Ramírez, 2003).

Based on the above stated constraints, 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 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 form 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, Setchi, & Salmeron, 2007) in this region. Process maturity is defined in this study as the degree to which a process is defined, managed, measured and continuously improved (Dooley, Subra, & Anderson, 2001).

THE RESEARCH MODEL

In an effort to identify the relevant and applicable process maturity practices in the ESC, a series of four focus group sessions using the nominal group technique (NGT) were conducted in four countries - Barbados, Guyana, Jamaica and Trinidad. These four countries are a part of one trading body in the region called the Caribbean Community (CARICOM). It is an organization of fifteen Caribbean nations whose main purpose is to promote economic integration and cooperation among its members. The four countries in this study are the main software development countries in the region and they account for 83% of the English-speaking Caribbean population, which is considered a reasonable representation.

The nominal group technique was used in the four focus group sessions because it enhances greater objectivity in group decision making by reducing emotional attachment to ideas, as well as its ability to fix problems that freely interacting group encounter, like inefficient idea generation, group think and destructive dominance (Delbecq, Van de Ven, & Gustafson, 1986; Duggan & Thachenkary, 2004).

A total of thirty (30) IS professionals – they are 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 focus group sessions (using the NGT technique) 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 constraints, norms, and culture. Only levels 2 and 3 practices 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 embrace in the ESC at this early stage of SPI adoption.

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

TABLE 1. **CMMI level 2 and 3 practices**

Level 2:	Level 3:
Requirements Management (RM)	Requirements Development (RD)
Project Planning (PM)	Technical Solution (TS)
Project Monitoring and Control (PMC)	Product Integration (PI)
Supplier Agreement Management (SAM)	Verification (VER)
Measurement and Analysis (MA)	Validation (VAL)
Process and Product Quality Assurance (PPQA)	Organization Process Focus (OPF)
Configuration Management (CM)	Organization Process Definition (OPD)
	Organizational Training (OT)
	Integrated Project Management (IPM)
	Risk Management (RSKM)
	Decision Analysis and Resolution (DAR)

The definitions of each of the eighteen practices were presented to the participants in the sessions to help guide the discussion. At the end of the four sessions, the top ranked practices were aggregated to derive the top ranked practices among the four countries (see Table 2). Upon completion, the top 10 practices among the four countries in descending order were:

- Risk management
- Technical solution
- Organizational training
- Requirements management + requirements development (merged practices)
- Integrated project management
- Project planning
- Organization process definition
- Organization process focus
- Project monitoring and control
- Verification + validation (merged practices)

The objective of the exercise was to incorporate the top ranked process maturity practices in the proposed research model as indicator variables for the construct – Process Maturity.

TABLE 2. **The top ranked practices in descending order**

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

At the end of the four sessions, the proposed research model had the 10 top ranked practices as key 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

A survey was conducted in an attempt to validate the proposed research model by assessing the strength of each practice on the process maturity construct.

THE SURVEY

In this quantitative study, the main survey approach was online. But face-to-face, telephone calls and postal mailing approaches were also employed. Similar to the focus group sessions, the survey was conducted in the same four ESC countries – 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 (less than two years) 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. The challenges regarding this moderate response rate is the fact that most software development firms in the region rely on commercial-off-the-shelf (COTS) applications (Chevers & Duggan, 2007), in which little or no system development is required. In addition, some executives in these firms tend to be reluctant to share company related information. Of the 128 respondents, 75 were males and 53 were females. Further details regarding the profile of the survey respondents are shown in Table 3.

Figure 1. **The research model**

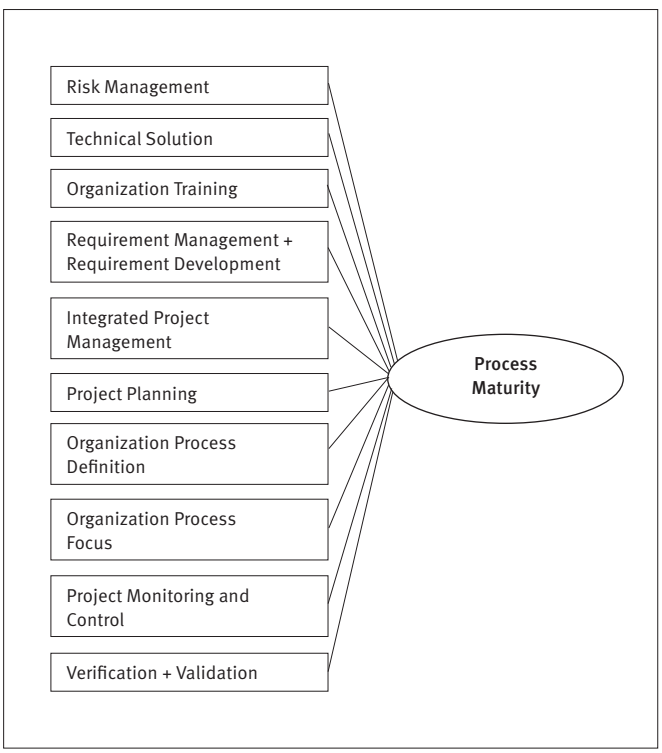

TABLE 3. **Demographic profile of respondents**

Factors	Number	%
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

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 statistical tool because of its ability to assess relatively small sample size, (Chin, 2010) and its ability to evaluate the relationship among a series of independent variables on a single dependent variable (Hair, Black, Babin, Anderson, & Tatham, 2006). It is a multivariate technique that combines factor analysis and multiple regression, and, as such, is a useful technique to determine the predictive power of independent variables on the dependent variable (Chin, 2010).

FINDINGS

The reliability results as shown in Table 4 were 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.

TABLE 4. **Reliability and convergent validity**

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 5. **Research model results**

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

Note: (1) * Significant at 10%
(2) ** Significant at 5%
(3) R^2 for the Process Maturity construct being 0.27

Just two out of the ten practices (project monitoring & control, and verification + validation) were found to be significant vis-à-vis process maturity, which can lead to higher quality systems being delivered (see Table 5). This means that most of the practices that have been embedded and institutionalized in developed countries are not being used and contributing to process maturity 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 that only two practices were found to be significant, it could be argued that the process maturity of firms in the ESC is low – perhaps operating at levels 1 – 2.

The R^2 of the process maturity construct was 0.271, which means that the ten variables explained the 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. From the focus group sessions only the top ten out of eighteen CMMI practices were considered. Perhaps some of the lower ranked practices from the focus group sessions, if incorporated in the research model and assessed could reveal significance in the survey. This is a consideration for future research.

This consideration is strengthened even further from the observation that the two practices that were found to be significant in the survey were ranked ninth and tenth in the focus group sessions. A possible explanation for this disparity is the difference in the objective of the focus group sessions versus the survey. The objective of the focus group 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 the software development and delivery cycle.

DISCUSSION

Both IS researchers and practitioners are keen on the delivery of high quality systems with the requisite functionalities (Livari, 2005). It is believed that high quality systems can lead to greater adoption and usage, and usage can lead to improved firm performance. Unused or underutilized systems can cost firms millions of dollars each year (Markus & Keil, 1994), which is an undesirable state. In an effort to overcome the trend of unused or underutilized systems, it is important that IS project managers and operations managers be knowledgeable about the determinants of process maturity. Such knowledge can positively impact the outcome of IS projects (Anderson et al., 2006; Kamhawi, 2007) and business performance.

The study provides a foundation for maturity determination and process improvement plans for maturity advancement as a precursor to the delivery of higher quality software products. Selecting the practices which can provide the greatest benefits in a reasonable timeframe is critical to IS professionals 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 education and training to increase the awareness and benefits of SPI initiatives. Emphasis should be placed on SPI benefits and a carefully design roadmap should be laid out to incorporated additional practices in the development process, in their pursuit to deliver high quality software and by extension win global contracts. Other determinants

of process maturity like software quality assurance and software configuration management could be assessed in the future. In addition, the research model could be extended to incorporate people and technology as determinants of IS quality; on the basis that people, technology and process maturity are major determinants of IS quality. This study could be explored in other jurisdictions and a comparative analysis could be done.

The study also creates the opportunity for IS researchers to explore other group techniques beyond NGT to provide convergence of the process maturity practices in the first stage of the research. A comparison of these techniques might provide useful insights on their relative worth and value in the desire to find applicable practices in various contexts. In addition, other statistical tools outside of PLS could be used to assess the relative strength of each practices on process maturity.

CONCLUSION

The delivery of low quality systems has negative impact on both individuals (users of the system) and the organization. Low quality systems can cause users not to use or underutilize the delivered system. Unused or underutilized systems can cost firms millions of dollars each year, a resource that is very scarce in the ESC countries. In addition, low quality systems without the requisite features and functionalities can curtail the realization of the intended benefits. As a result, it is important to understanding those factors that enhance process maturity, which by extension can lead to the delivery of high quality and successful IS projects. Project outcomes can be improved, which can lead to better utilization of resources.

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. By extension, this can increase the likelihood of software development firms in the ESC winning global contracts, which can provide needed scare foreign exchange to both firms and the national economy. These chains of events can improve the economic development and prosperity of countries in the English-speaking Caribbean.

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