The Benefits Obtained After Implementation of a Software Development Maturity Model

Sueli Dantas Bacelar
subacelar@yahoo.com.br
Information Company of the Sergipe Govern

Veruschka Vieira Franca
veruschkafranca@gmail.com
Universidade Federal de Sergipe

João Ricardo Correia Andrade
jricardo_ca@yahoo.com.br Universidade Federal de Sergipe

Abstract:

In the Information Technology Market, the software sector has been consolidating its growth trend. With increasingly strong competition, organizations must improve their market share and primarily their efficiency and efficacy by implementing quality software. Accordingly, this study aims at determining the benefits obtained by organizations after implementation of a software development maturity model referred to as the Brazilian Software Process Model (MPS.BR) and to understand how to achieve value in software development. A thorough revision of the literature was conducted, and questionnaires were applied so that employees of software development companies that had implemented a MPS.BR could describe the benefits obtained. Data were collected from 9 companies and 47 questionnaires were applied. The benefits most cited were "clearer processes" and "improved process quality", while those least mentioned by employees were "shorter development time" and "lower development costs". After statistical analyses the 18 benefits under study were reduced to 4 categories: quality, control, process and team. The benefits of this study were identified in previous research based on international models such as CMM, CMMI and the t-Soft Project. Since all the benefits were recognized in the organizations under study, we suggest that implementing the MPS-BR model has resulted in the same benefits obtained in similar international models. If the practitioners understand the contributions of the software development maturity model, it is possible to create a supportive environment to cultivate key practices and increase the value acquired by the software development.

Keywords: Quality, Maturity, Process, Software.

1. Introduction

Several studies have been conducted to understand how to achieve value in software development. Gallarza, Saura and Holbrook (2011) explained the concept of value through the perceived quality and perceived cost to promote customer satisfaction. This approach provides a comprehensive understanding to correlate quality, cost, value and customer needs.

As stated in the "Brazilian Software Market" report of the Brazilian Association of Software Companies (ABES) in 2016, the retraction of the Brazilian IT market started in 2015 persisted in 2016. However, this market, made up of hardware, software, and IT exports, moved $ 39.6 billion in 2016, accounting for 2.1% of the country's GDP. According to the report, the software and services segments accounted for 48.5% of the total IT market in the country, which ultimately strengthens Brazil's trend towards the world's most mature economies. More specifically in the software sector, there was a modest growth of 0.2% compared to 2015 (ABES, 2017).

To be successful in the IT market, companies need to offer better products or service by improving their processes and focusing on productivity and quality. Developing software is an extremely complex undertaking (Kubota et al., 2008). If there are no structured processes for software engineering, delays, rework, stress and losses may occur. To reduce these problems, companies tend to adopt SPI (Software Process Improvement), a systematic approach to increase efficiency and efficacy in software development organizations, as well as product quality (Unterkalmsteiner, M. et al., 2012), and whose primary objective is standardizing the software development process (Elhag, A.A.M. et al., 2013).

SPI can be implemented by using software development maturity models, such as CMMI (Capability Maturity Model Integration) or MPS.BR (Brazilian Software Process Model); practices that are applied in one or more of the software development phases or tools related to software engineering (Elhag, A.A.M. et al., 2013).

Small businesses account for most software companies both worldwide (Pino, F.J. et al., 2010) and in Brazil (SOFTEX, 2014). However, the high costs involved mean most software development maturity models are implemented in large organizations (Staples, M. et al., 2007). MPS.BR was developed for implementation at a significantly lower cost than that of similar models available on the market but is also adopted by large companies (SOFTEX, 2015).

The growth in the Brazilian software market and rising number of small businesses is also occurring worldwide. Found that implementation of SPI occurs differently according to the country (Niazi, M. et al., 2010). The present study intends to specifically investigate Brazil, recording and following its evolution with a view to helping software development firms undertake such an endeavor and identify the benefits obtained by implementing a MPS.BR (Brazilian Software Process Model).

2. Software Development Maturity Model

The "Research of maturity and success in managing information system projects - 2012" was carried out with 434 Brazilian organizations, showing that 49.7% of software development projects are totally successful; 35.2% partially successful; 15.1% failed, 28% were behind schedule; and 15% were over budget (Archibald and Prado, 2015). This report considers that totally successful projects were completed on time and within budget, their customers were totally satisfied, since the product/service was being used and added value to its operations; partially successful projects were also completed, but even though the software was being used by the customer, there were delays and/or budget overruns and/or customer satisfaction was partial; and failed projects were incomplete and/or are not being used since they do not meet customer expectations.

A software development process is a set of activities, methods, practices and transformations that individuals use to develop and maintain software and associated products (Paulk, M. et al., 2014). Software development methodology involves determining requirements, analysis, a project, implementation, testing, and operation. However, fulfilling these requirements does not guarantee error-free, easy-to-maintain software, with a broad scope, technical team productivity or schedules that are met.

The aim of SPI is to achieve efficiency and efficacy, that is, develop error-free, high- performance software, resulting in faster customer response and reusable source codes. This allows a broadening of functionalities (Garzás, J. et al., 2013) and produces quality software without wasting time and with rational use of technical resources (Unterkalmsteiner, M. et al., 2012).

Browning (2003) suggested that the most important impact on value in a product development process is the way you realize the activities and coordinate them, emphasizing that, in several circumstances, the origin of lack of value is more from doing "value-added" activities following a wrong approach than for doing "non-value-added" activities right.

According to Becker, Knackstedt and Pöppelbuβ (2009), more than one hundred maturity models have been developed to support IT management, with different areas of application, such as business process management and business intelligence. Garzás et al. (2013) report that different software process capacity/maturity models are being used by companies that implemented SPI. The MPS.BR program was launched in December 2003 to improve the Brazilian software process. The MPS.BR model was based on ISO/IEC 12207:2008, ISO/IEC 20000:2011 and ISO/IEC 15504-2 to define components and complemented by the CMMI (SOFTEX, 2014). The MPS.BR model has seven maturity levels, from "G" to "A" combining processes and their capacity. In this context it is useful to realize that the objectives described in the model are cumulative, which means, to be at maturity level "C", the company must have obtained the expected results at levels "G", "F", "E", "D" and "C" (SOFTEX, 2013).
According to SOFTEX (2013), process capacity is the ability of organizations to achieve their current and future business objectives; which is related to meeting process attributes associated to each maturity level. The different process capacity levels are described by nine process attributes (PA), as illustrated in Table 1.

Table 1 - Attributes and Process Description

Process Attributes	Attribute Description
AP 1.1	The process is executed
AP 2.1	The process is managed
AP 2.2	Products are managed
AP 3.1	The process is defined
AP 3.2	The process is implemented
AP 4.1	The process is measured
AP 4.2	The process is controlled
AP 5.1	The process is improved and innovated
AP 5.2	The process is continuously optimized

Source: SOFTEX (2013)

3. Methodological Procedures

This descriptive-exploratory study collects data via a closed questionnaire applied in companies that have implemented MPS.BR. It is exploratory in that it investigated the benefits obtained from the implementation of MPS.BR (Saunders et al., 2009) and descriptive because there is no intention to explain these benefits (Babbie, 2001). Two questionnaires were applied to collect institutional information and identify the benefits achieved after implementing MPS.BR. These questionnaires were addressed to the software development employees, who are directly affected by the consequences of implementing a SPI model. Questions related to the benefits were created based on a comprehensive literature review, Table 2. These benefits may be related to the development process, human resource management and customer perception of quality.

Table 2 – Benefits expected with the implementation of SPI in organizations

Benefits		References
ben1	Better products	Unterkalmsteiner et al. (2012) Ahmed e Capretz (2010) Mezzena e Zwicker (2007) Niazi, Wilson e Zowghi (2006) Saastamoinen e Tukiainen (2004) Stelzer, Mellis e Herzwurm (1996)
ben 2	Lower development costs	Ahmed e Capretz (2010) Niazi, Wilson e Zowghi (2006) Stelzer, Mellis e Herzwurm (1996)
ben 3	Greater return on investment	Unterkalmsteiner et al. (2012) Galin e Avrahami (2006)
ben 4	Better power of response to the current state of the market	Unterkalmsteiner et al. (2012) Paulish e Carleton (1994)
ben 5	Control of development costs	Unterkalmsteiner et al. (2012) Mezzena e Zwicker (2007)
ben 6	More satisfied customers	Unterkalmsteiner et al. (2012)
ben 7	Shorter development time	Ahmed e Capretz (2010) Galin e Avrahami (2006) Niazi, Wilson e Zowghi (2006) Stelzer, Mellis e Herzwurm (1996)
ben 8	More accurate estimation of software size	Unterkalmsteiner et al. (2012) Galin e Avrahami (2006) Paulish e Carleton (1994)

Benefits		References
ben 9	Fewer product delivery delays.	Mezzena e Zwicker (2007) Galin e Avrahami (2006) Saastamoinen e Tukiainen (2004)
ben 10	Clearer processes (transparency)	Stelzer, Mellis e Herzwurm (1996)
ben 11	Improved process quality	Unterkalmsteiner et al. (2012)
ben 12	Fewer flaws	Unterkalmsteiner et al. (2012) Galin e Avrahami (2006) Saastamoinen e Tukiainen (2004) Paulish e Carleton (1994)
ben 13	Improved quality of technical documentation produced	Lavallée e Robillard (2012)
ben 14	Better understanding of requirements	Lavallée e Robillard(2012) Mezzena e Zwicker(2007)
ben 15	Increased productivity	Unterkalmsteiner et al. (2012) Mezzena e Zwicker (2007) Galin e Avrahami (2006) Niazi, Wilson e Zowghi (2006) Stelzer, Mellis e Herzwurm (1996)
ben 16	Fewer internal disputes	Lavallée e Robillard(2012) Mezzena e Zwicker(2007)
ben 17	Superhero developer independence	Niazi, Wilson e Zowghi (2006) Mezzena e Zwicker (2007)
ben 18	Improved team communication	Lavallée e Robillard (2012)

All questions (18 items) were measured on a five-point modified Likert scale. The questionnaires were assessed through a focus group with professionals to correct possible semantic problems or doubts about the questions (Collis and Hussey, 2005), and pilot tested on a service company in Brazil, which had implemented MPS.BR (Freitas, H. et al., 2000). Subsequently, group dynamics in the "focus group" format were conducted to correct semantic problems or clarify doubts on the assertions, with the purpose of improving construct and content validity.

Data treatment and analysis were carried out in four stages using SPSS software. The first stage aimed at determining whether the respondents meet the previously established criteria, that is, who work in the software development area; the second at verifying the existence of unanswered questions, as well as outlier cases and variables, that is, that deviate from the standard of the sample; the third at identifying the benefits obtained from implementing MPS.BR, as evidenced by the mean, median and standard deviation; and the fourth identified the categories of the benefits achieved using exploratory factorial analysis.

The questionnaire was sent by email to 17 randomly selected companies that are recorded in the database of SOFTEX and had implemented software development maturity model.

4. Results

The profile of the responding firms is provided in Table 3. Forty-nine questionnaires about the benefits were received from 9 organizations, but 2 were discarded because “trainee” was entered in the “position” box, resulting in an empirical study with 47 questionnaires to analyze.

Table 3 – Institutional Profile of Organizations

Organization	Level of MPS- BR	Questionnaires completed	Questionnaires discarded
Org1	G	5	1
Org2	G	19	0
Org3	F	2	0
Org4	F	5	0
Org5	F	2	0
Org6	F	2	1
Org7	F	2	0
Org8	C	3	0
Org9	A	9	0

4.1. Descriptive Statistics

Table 4 shows the frequency distribution of responses regarding benefits (5-point Likert scale), mean, median and standard deviation.

Table 4 – Responses regarding benefits

Questions about benefits	Frequency distribution of the Likert scale					Mean	Median	Standard Deviation
	1	2	3	4	5			
Ben1	0	5	12	26	4	3.62	4	0.79
Ben2	8	8	15	12	4	2.91	3	1.21
Ben3	4	8	15	13	7	3.23	3	1.165
Ben4	4	5	15	16	7	3.36	3	1.131
Ben5	3	4	9	22	9	3.64	4	1.093
Ben6	1	6	17	17	6	3.45	3	0.95
Ben7	2	4	22	9	6	3.10	3	1.15
Ben8	0	5	10	17	15	3.89	4	0.98
Ben9	4	4	12	22	5	3.43	4	1.08
Ben10	0	2	4	20	21	4.28	4	0.79
Ben11	0	1	8	21	17	4.15	4	0.78
Ben12	3	7	15	15	7	3.34	3	1.12

Questions about Benefits	Frequency distribution of the Likert scale					Mean	Median	Standard Deviation
Ben13	0	4	12	15	16	3.91	4	0.97
Ben14	1	2	13	18	13	3.85	4	0.95
Ben15	2	7	16	16	6	3.36	3	1.03
Ben16	0	8	10	22	7	3.59	4	0.95
Ben17	5	5	16	15	6	3.26	3	1.15
Ben18	0	4	10	20	13	3.89	4	0.91

The means of perceived benefits from the implementation of MPS-BR show that the most widely perceived was “ben10 – clearer processes” (4.28), followed by benefit “ben1 – improved process quality” (4.15), “ben13 – improved quality of technical documentation produced” (3.91), “ben8 – more accurate estimation of software size” (3.89) and “ben18 – improved team communication” (3.89); the least perceived benefits were “ben3 – greater return on investment” (3.23), “ben7 – shorter development time” (3.11) and “ben2 – lower development cost” (2.91). It was concluded that some of the benefits identified in the literature are little perceived by the employees of the organizations under study.

With respect to the medians found for responses to questions related to perceived benefits from implementing MPS-BR, 10 benefits had a median of 4 and 8 a median of 3. Thus, most of the benefits scored "4 – well perceived" and "5 – very well perceived".

The benefit with the highest standard deviation was "ben2 – lower development cost" (1.21), followed by "ben3 – greater return on investment" (1.16), "ben17 – superhero developer independence" (1.15), "ben7 – lower development time" (1.15) and "ben4 – better power of response to the current state of the market" (1.13); by contrast, the lowest standard deviation was in "ben1 – improved process quality" (0.78). Considering that the higher the standard deviation the lower the response homogeneity, "ben2 – lower development cost" exhibited the highest response distribution, which leads us to conclude that, according to their employees, participating organizations perceive this benefit differently.

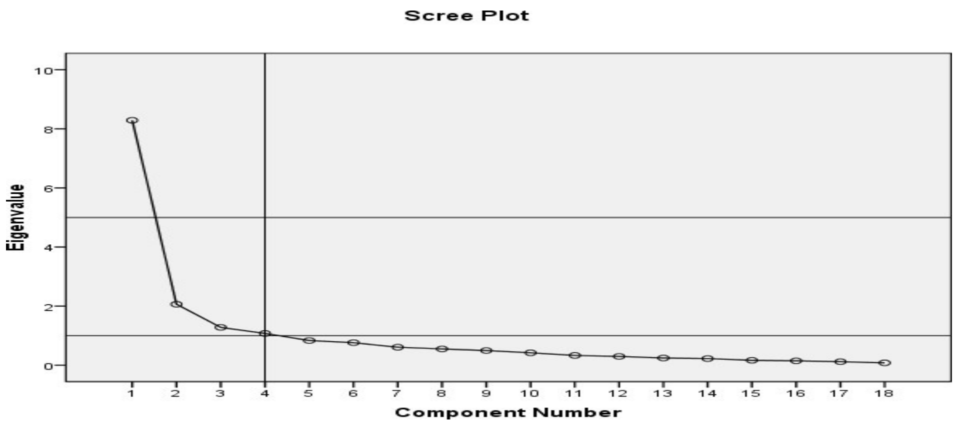
4.2. Factorial Analysis of Benefits

According to Figueiredo and Silva (2010), factorial analysis involves three stages: the first checks the suitability of the database; the second determines the extraction technique and the number of factors to be extracted; and the third selects the type of factor rotation. Bartlett's spherical test was used in the first stage; principal component analysis with the latent root criterion in the second; and VARIMAX in the third.

Bartlett's spherical stage indicated that the data collected here are suitable for factorial analysis, given that the Kaiser Measure of Overall Sampling Adequacy (KMO) was 0.832, higher than 0.8 (Balassiano, 2009). The significance of 0.000 demonstrates that there are no non-null correlations (Hair Jr. et al., 2009).

There was no need to discard any variables from this model because the anti-image correlation matrix presented all Measure Sampling Adequacy (MSA) values greater than 0.500.

Graph 1 shows the scree plot, where the number of factors in model 1 is established. Considering the latent root (eigenvalue)of 1, the intersection of the graph line with this value occurs with a component value of 4. Therefore, in the model we reduced the 18 variables (benefits) to 4 factors (categories).



Source: SPSS version 17.0

Table 5 shows the rotated component matrix (VARIMAX) applied to analyse the perceived benefits.

Table 5 – Rotated Component Matrix (VARIMAX)

Benefits				
	1	2	3	4
Ben1 – Better products	.666	.042	.305	.286
Ben2 – Lower development costs	.620	.244	.018	.579
Ben3 – Greater return on investment	.561	.041	.000	.668
Ben4 – Better power of response to the current state of the market	.534	.118	.240	.608
Ben5 – Control of development costs	-.061	.056	.230	.762
Ben6 – More satisfied customers	.435	-.005	.605	.407
Ben7 – Shorter development time	.677	.191	.142	.322
Ben8 – More accurate estimation of software size	-.041	.809	.209	-.027
Ben9 – Fewer product delivery days	.470	.074	.686	.110
Ben10 – Clearer processes (transparency)	.079	.828	.088	.121
Ben11 – Improved process quality	.406	.477	.524	.069
Ben12 – Fewer flaws	.603	.266	.493	.258

Benefits	Components			
	1	2	3	4
Ben13 – Improved quality of technical documentation produced	-.063	.368	.722	.164
Ben14 – Better understanding of requirements	.343	.669	.121	.134
Ben15 – Increased productivity	.834	.072	.291	.213
Ben16 – Fewer internal disputes	.621	.367	.390	-.065
Ben17 – Superhero developer independence	.879	.029	.094	-.006
Ben18 – Improved team communication	.656	.540	-.003	,067

Extraction Method: Principal Component Analysis. Rotation Method: Varimax. Rotation converges into 8 interactions.

Source: SPSS version 17.0

Table 6 shows the perceived benefits for each factor according to the highest values obtained in table 5 and were named in accordance with the benefit that obtained the highest component value among those that make up the factor (HAIR Jr. et. al, 2009).

Table 6 – Factors of the benefits perceived from implementing MPS-BR

Factor	Factor name	Component value	Benefits
Factor 1	Team	.666	Ben1 – Better products
		.620	Ben2 – Lower development costs
		.677	Ben7 – Shorter development time
		.603	Ben12 – Fewer flaws
		.834	**Ben15 – Increased productivity**
		.621	Ben16 – Fewer disputes between employees or between managers
		.879	**Ben17 – Superhero developer independence**
		.656	Ben18 – Improved team communication
Factor 2	Process	**.809**	**Ben8 – More accurate estimation of software size**
		.828	**Ben10 – Clearer processes**
		.669	Ben14 – Better understanding of requirements
Factor 3	Quality	.605	Ben6 – More satisfied customers
		.686	Ben9 – Fewer product delivery days
		.524	Ben11 – Improved process quality
		.722	**en13 – Improved quality of technical documentation produced**
		.668	Ben3 – Greater return on investment
Factor 4	Control	.608	Ben4 – Better power of response to the current state of the market
		.702	**Ben5 – Control of development costs**

The first factor, called "team" is related to the management of personnel involved in the process. The second factor, which considers technical aspects, was denominated "process". The third factor involves customer expectations and was labeled "quality" while the fourth factor, entitled "control", consists of aspects such as "control during the course of development" and "greater return on investment".

5. Final Considerations

In this study 47 questionnaires were collected from the employees of 9 organizations from 6 Brazilian states, equally divided among small medium and large companies, considering the number of employees. However, 7 of the 9 participating companies were in the initial maturity stages (F and G), in MPS-BR.

The benefits of this study were identified in previous research based on international models such as CMM, CMMI and the t-Soft Project, ISO 9000. Since all the benefits were recognized in the organizations under study, we suggest that implementing the MPS-BR model has resulted in the same benefits obtained in similar international models.

The findings demonstrate that the benefits perceived in the present study are similar to those reported by Stelzer, Mellis and Herzwurm (1996), who studied software development organizations that implemented ISO 9000. In the two studies, most of the benefits perceived by the practitioners focus firstly, in improving the value to "clearer processes" and secondly, in adding value to "better products". But there is a lack of practices to "shorter development time". When interpreting these findings, a discussion about how to achieve value in software development should be considered. This means that the companies that adopted SPI model may not produce gains in development time.

It was possible to reduce the 18 benefits to 4 factors: team, process, quality and control. The team factor condensed 8 benefits, quality 4 and process and control 3 each. This categorization allows future investigations to focus on specific issues, reducing the number of questions, which is a factor in resistance to answering questionnaires.

If the practitioners understand the contributions of the software development maturity model, it is possible to create a supportive environment to cultivate key practices and increase the value acquired by the software development.

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Curriculum Vitae:

Sueli Dantas Bacelar has graduated from Data Processing Technology at Tiradentes University, in Brazil and has a postgraduate degree in Computer Science from the same institution. She received a Master Degree in Business Administration at Sergipe Federal University (UFS), Brazil (2015).

Dra Veruschka Vieira Franca is a Research in the Department of Industrial Engineering in the Sergipe Federal University (UFS), in Brazil since 2005. She received a PhD in Industrial Engineering at São Paulo University (USP), Brazil, in 2005. She has dealt with issues of Quality Management and System Engineering Management in UFS, Brazil and her research interests include: quality management, production and operational management, innovation management, system engineering management.

João Ricardo Correia Andrade is an Industrial Engineering and a student in Master in Business Administration at Sergipe Federal University (UFS), Brazil (2015).

Authors Profiles:

Sueli Dantas Bacelar has graduated from Data Processing Technology at Tiradentes University, in Brazil and has a postgraduate degree in Computer Science from the same institution. She received a Master Degree in Business Administration at Sergipe Federal University (UFS), Brazil (2015).

Veruschka Vieira Franca has received a Ph.D. from the São Paulo University – Brazil, São Paulo in 2005. Is now an Associate Professor at the Production Engineering of the Sergipe Federal University (UFS) - Brazil and a Researcher of the PROPADM/ UFS. Her research interests are in the areas of Quality Management, Quality of Evaluation, Innovation and Quality.

João Ricardo Correia Andrade is an Industrial Engineering and a student in Master in Business Administration at Sergipe Federal University (UFS), Brazil (2015).