Results of 10 Years of Software Process Improvement in Brazil Based on the MPS-SW Model

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Abstract—[Context] In December 2003 the MPS.BR Program was launched aiming at establishing and disseminating a software process reference model – the MPS-SW – allowing both micro, small and medium-sized enterprises and large organizations to achieve the benefits of process improvement. Nowadays, ten years later, the achieved results exceed MPS.BR’s predefined benchmarks in several ways. [Objective] This paper aims at providing an overview on the MPS-SW model and presenting these results, describing its nationwide adoption in Brazil (more than 500 assessments spread across the country) and outcomes of two recent surveys concerning the impact of such adoption in the software industry. [Method] We planned surveys to capture the impact from two different and complementary points of view: the qualitative perception of the customers (sponsors of MPS-SW adopting organizations) and the performance results of organizations that adopted the model (e.g., concerning productivity, quality and estimation accuracy). [Results] Results of the qualitative survey indicated that the adoption was motivated by both business and technical reasons and that most sponsors are satisfied with the obtained improvements and would recommend the MPS-SW model. Results of the survey on performance results indicated higher productivity, quality and estimation accuracy for organizations assessed in higher maturity levels.

Keywords—Software Process Improvement; Software Process Reference Model; MPS.BR Program; MPS-SW Model; Customer Satisfaction Survey; Performance Result Survey.

I. INTRODUCTION

Software is working both explicitly and behind the scenes in virtually all aspects of our lives, including critical systems that affect our health and well-being. Therefore, quality-focused software engineering is more important than ever [1]. Additionally, the information technology industry faces intense competition. Thus, besides developing high quality software products, software organizations must also deliver them on time and at low cost. A well-known strategy to handle these quality, time and cost restrictions is defining a software process and continuously improving its capability [2].

Reference models, as the CMMI-Dev [3], have been developed to guide such efforts. However, improvement based on such models is usually obtained in the long term and may involve large investments [4]. These obstacles can become impeding for some organizations, especially for micro, small and medium-sized enterprises (mSME) that operate under strict financial constraints [5]. In Brazil over 70% of the software industry is constituted of mSME1 [6], demanding particular attention to this scenario.

MPS.BR is the Brazilian Software Process Improvement Program, coordinated by Softex (Association for Promoting the Brazilian Software Excellence). It aims at both, establishing reference models and disseminating them in the marketplace. Currently the family of MPS reference models consists of two: MPS-SW (MPS for Software) and MPS-SV (MPS for Services). The MPS-SW, focus of this paper, is [7]: i) in compliance with international standards ISO/IEC 12207 [8] and ISO/IEC 15504 [9]; ii) fully compatible with the CMMI-Dev [3]; iii) based on software engineering best practices; and iv) focused primarily on mSME.

The MPS.BR program and its software reference model were launched in December 2003, being the general strategy officially announced 10 years ago during QUATIC 2004 [10]. Currently the MPS.BR program is recognized as a success case of the Triple Helix cooperation (Academia, Government and Industry) in Brazil [11][12][13]. In September 2013, the MPS-SW surpassed the emblematic milestone of 500 assessments in software organizations, mainly in mSME.

This paper presents results of 10 years of software process improvement (SPI) in Brazil based on the MPS-SW model. The results are presented by describing its adoption in Brazil and outcomes of two surveys concerning the impact of such adoption in the software industry. The surveys capture the

1 mSME parameters in this paper consider the Brazilian Development Bank annual gross revenues criteria: micro-sized companies (less or equal to US$ 1 million); small-sized companies (between US$ 1 million and US$ 6.7 million); medium-sized companies (between US$ 6.7 million and US$ 37.5 million); medium to large-sized companies (between US$ 37.5 million and US$ 125 million); and large-sized companies (greater than US$ 125 million).
impact from two different and complementary points of view: the qualitative perception of the customers (sponsors of MPS-SW adopting organizations) and the actual performance results of organizations that adopted the model (e.g. concerning productivity, quality and estimation accuracy).

The remainder of this paper is organized as follows. Section II describes the background of the MPS.BR program and the MPS-SW model. Section III provides an overview on the main achieved results. Sections IV and V provide insights into the impact of the MPS-SW model on the Brazilian software industry based on results of the two surveys. Section VI presents the concluding remarks of this paper.

II. BACKGROUND

Over 70% of the Brazilian software industry is constituted of mSME and until 2004 few Brazilian organizations had adopted reference models [6]. It is a general belief that the use of reference models may improve the performance of organizations [4]. However, some authors recognize the need in reducing process assessment costs and the amount of time necessary to make the SPI benefits visible [14][15] and also that SPI approaches should focus on mSME [5].

In the early years, starting from December 2003, many activities and actions were accomplished to establish and sustain the MPS.BR program and its community of practitioners [16]. This constituted the MPS.BR Implementation Phase (2004-2007). The Consolidation Phase (2008-2011) aimed to consolidate the MPS.BR program structure, to improve the MPS-SW model, and disseminate them in Brazil. The current Expansion Phase (2012-2015) aims at increasing the MPS.BR program sustainability, continually improving the MPS-SW and creating the MPS-SV models, and spreading the use of the MPS-SW model both in Brazil and in other countries with similar software sector characteristics.

In order to manage the MPS.BR program, the following organizational structure was defined [7]: (i) MPS.BR Management Program Team: responsible to manage the program activities; (ii) MPS Model Technical Team: responsible to develop and continually improve the MPS reference models, and to prepare and execute MPS model trainings; and (iii) MPS Accreditation Forum: responsible to accredit organizations to provide MPS model-based implementation and assessments services, to evaluate and control implementation and assessment results, and to ensure that these accredited organizations execute their activities within expected ethical and quality limits.

The MPS.BR program is constituted of three main components [7]: MPS Reference Models (MPS-SW and MPS-SV); MPS Assessment Method (MA-MPS); and MPS Business Model (MN-MPS).

Concerning the first component, the MPS-SW reference model for software is documented in the form of three guides (available at www.softex.br/mpsbr). The MPS-SW General Guide provides a general definition of the MPS-SW model and common definitions to all other guides. The MPS-SW Implementation Guide provides technical guidance for implementing the MPS-SW by describing the theoretical foundations on the processes defined in the MPS-SW maturity levels and on how to implement their expected outcomes, as a non-prescriptive rule, reducing risks of misunderstanding implementation issues. Finally, the MPS Acquisition Guide describes an acquisition process for software and related services.

Three additional MPS-SW Implementation Guides cover topics such as the use of MPS-SW model by organizations that do not develop software but acquire their development, by software factories and by software test factories. Furthermore, there are three guides (also available at www.softex.br/mpsbr) discussing the compatibility between MPS-SW and: CMMI-Dev v1.3 [3], ISO/IEC 29110-4-1:2011 [17], and the MoProSoft model [18].

Over the years the MPS-SW reference model has been extended and improved aiming at (i) providing a better process profile, considering software engineering best-practices (including the definition of processes not present on CMMI-Dev [3] but defined on ISO/IEC 12207 [8] such as Reuse Management, Development for Reuse, Human Resources Management and Project Portfolio Management); and (ii) reflecting the evolution of CMMI-Dev and new additions of ISO/IEC 15504 [9].

Still regarding the first component, the MPS-SV reference model for services, is documented in the form of two guides (also available at www.softex.br/mpsbr). The MPS-SV General Guide provides a general definition of the MPS-SV model and common definitions specific to services context. The MPS-SV Implementation Guide provides technical guidance for implementing the MPS-SV by describing the theoretical foundations on the processes defined in the MPS-SV maturity levels and on how to implement their expected outcomes, as a non-prescriptive rule.

Concerning the MPS-SW reference model for software, focus of this paper, Table I shows the structure of its maturity levels. Based on the requirements of ISO/IEC 15504, it is defined in two dimensions: process dimension and process capability dimension (process attributes). At all, there are seven maturity levels, ranging from level G (initial) to A (highest), enabling stepwise software process improvement. The depicted process attributes are: 1.1 – the process is executed; 2.1 – the process is managed; 2.2 – the process work products are managed; 3.1 – the process is defined; 3.2 – the process is implemented; 4.1 – the process is measured; 4.2 – the process is controlled; 5.1 – the process is subject to incremental improvements and innovation; and 5.2 – the process is continuously optimized.
The initial maturity level G is constituted of two of the most critical software processes to mSME: Requirements Management and Project Management. Level A, on the other extreme, is the highest MPS-SW maturity level focusing on continuous process improvement.

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<thead>
<tr>
<th>ML</th>
<th>Processes</th>
<th>Process Attributes</th>
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<tr>
<td>A</td>
<td>(no new processes are added)</td>
<td>1.1, 2.1, 2.2, 3.1, 3.2, 4.1*, 4.2*, 5.1*, 5.2*</td>
</tr>
<tr>
<td>B</td>
<td>Project Management (new outcomes)</td>
<td>1.1, 2.1, 2.2, 3.1, 3.2, 4.1*, 4.2*</td>
</tr>
<tr>
<td>C</td>
<td>Decision Management, Risk Management, and Development for Reuse</td>
<td>1.1, 2.1, 2.2, 3.1, 3.2</td>
</tr>
<tr>
<td>D</td>
<td>Requirements Development, Product Design and Construction, Product Integration, Verification, and Validation</td>
<td>1.1, 2.1, 2.2, 3.1</td>
</tr>
<tr>
<td>E</td>
<td>Human Resources Management, Process Establishment, Process Assessment and Improvement, Project Management (new outcomes), and Reuse Management</td>
<td>1.1, 2.1, 2.2, 3.1</td>
</tr>
<tr>
<td>F</td>
<td>Measurement, Configuration Management, Acquisition, Quality Assurance, and Project Portfolio Management</td>
<td>1.1, 2.1, 2.2</td>
</tr>
<tr>
<td>G</td>
<td>Requirements Management and Project Management</td>
<td>1.1, 2.1</td>
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* These Process Attributes (PAs) are applicable only on selected processes. The others PAs must be applied on all processes.

The second component is the MPS Assessment Model (MA-MPS), described in the MPS Assessment Guide, which goal is to verify the maturity of an organizational unit in the execution of its processes. It also describes the requirements for accreditation of organizations to provide MPS assessment services (MPS Assessment Institutions), MPS Competent and Provisional Assessors, and the assessment process defined to support the application of the MA-MPS method.

In order to guarantee the MPS model success, it is essential that organizations can effectively adopt it and obtain benefits from implementing software process improvement. Therefore, the third MPS model main component (MPS Business Model; MN-MPS) was defined and has a very important role in the MPS.BR program management, describing all business rules. It aims at improving commitment of all MN-MPS participants to continuously foster the program success by supporting the relation defined as triangle of services [11] among the Enterprise (the MPS.BR program itself), the Front Line Collaborators (such as those responsible to organize groups of enterprises or to support the MPS implementations or to conduct the MPS assessments, and the MPS instructors), and Customers (organizations that adopted the MPS model).

The adaptation of ISO/IEC 15504 and ISO/IEC 12207 profiles and reference model is important to build a body of knowledge on how Brazilian companies deal with SPI initiatives. It allowed shaping MPS requirements both to their needs and software engineering best practices, aiming at aligning the state of practice to the state of art. In the business perspective the MN-MPS allows Softex to act proactively to promote the model adoption, grant money to foster SPI adoption in Brazilian mSME, and create a community of SPI practitioners, assessors and consultants throughout the country. In a strategic perspective the set of undertaken actions to manage the MPS.BR program allowed to forge formal and informal alliances among the Government, Industry and University (Triple Helix) that are responsible for its success. An overview of the obtained results follows.

III. MPS.BR: RESULTS AFTER 10 YEARS

The MPS.BR program was launched in December 2003, initially aiming at establishing and disseminating a software process reference model to allow both mSME and large organizations to achieve the benefits of process improvement.

The MPS.BR baseline strategy to software process improvement in Brazilian companies was announced during QUATIC 2004 [10]. According to this initial publication: “Studies on quality in the Brazilian software sector show a need of a significant effort to enable improving the maturity of software processes in the companies. The MPS.BR program is an initiative joining universities, industry and government, coordinated by Softex. The program aims at creating and disseminating a process reference model, a process assessment model, and a business model. The novelty is in the implementation strategy tailored to the Brazilian reality. The business model has great potential of replication in Brazil and in other countries with similar software sector characteristics”.

Nowadays, the MPS.BR program is a recognized success case of the Triple Helix (Academia, Government and Industry) in Brazil [11][12][13]. The “10 Years of the MPS.BR program” were celebrated in December 2013 and the achieved results exceed MPS.BR’s predefined benchmarks. Hereafter we highlight the SPI results obtained in Brazil based on the MPS-SW model, concerning official Assessments, Guides and Knowledge Sharing, Training, the establishment of a Collaboration Network, and Impact Monitoring.

SPI Assessments. Over 500 MPS-SW assessments have been conducted in all five Brazilian regions (center-west, north, northeast, south, and southeast) and in maturity levels ranging from G to A, from 2005 to 2013: mainly in mSME, but also in large organizations, evidencing that the MPS-SW is suitable for all-sized organizations. Therefore, we believe that micro and small-sized companies can adopt the model and use it as basis to grow until becoming a large corporation. From 2011 to 2013, the adoption of MPS-SW has been increasing at a rate of 100 assessments per year as can be seen in Table II.

There is a three-year period of validity for MPS-SW assessments. Softex notifies an organization of the age of their assessment at the two-year point. This practice alerts organizations in time for planning a new assessment before the older assessment results expire.
TABLE II. MPS-SW ASSESSMENTS FROM 2005 TO 2013.

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<tbody>
<tr>
<td>MPS-SW Assessments</td>
<td>1</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
</tr>
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Furthermore, as mentioned in the background Section, a technical mapping shows compatibility between the MPS-SW and CMMI-Dev models in the following maturity levels: MPS-F is compatible with CMMI-2, MPS-C is compatible with CMMI-3, and MPS-B/A are compatible with CMMI-4/5. Therefore, it is possible to conduct synergic MPS-CMMI assessments in two ways:

- Complementary – faster MPS assessment in compatible levels.
- Jointly – with the MPS assessment and CMMI appraisal teams working together. Such experiences are reported elsewhere [19].

Figure 1 shows the cumulative total of MPS-SW assessments and CMMI (SCAMPI A) appraisals from 2004 to 2013 in Brazil, evidencing the predominance of the MPS-SW model in the country.

**SPI Guides and Knowledge Sharing.** Many MPS-SW Guides and reports on lessons learned have been produced and are publicly available for download in Portuguese and Spanish (at www.softex.br/mpsbr), such as the MPS-SW General Guide, the MPS-SW Implementation Guides (one for each maturity level), the MPS Assessment Guide, and the MPS for Acquisition Guide.

**SPI Training.** Almost 6,000 people have attended official MPS-SW training courses such as C1 – MPS-SW Introduction, C2 – MPS-SW Implementation, C3 – MPS Assessment, and C4 – MPS for Acquisition.

**SPI Collaboration Network.** The MPS business model enables building a comprehensive network of frontline collaborators, including:

- **Implementation Institutions.** 19 accredited organizations to provide MPS-SW implementation consultancy services, with over 150 trained and authorized implementation consultants.
- **Enterprise Group Organizer Institutions.** 8 active organizations accredited to organize and provide simultaneous implementation services to groups of companies interested in implementing and assessing the MPS-SW model.
- **Assessment Institutions.** 13 accredited organizations to provide MPS-SW assessment services, with over 70 trained and authorized assessors.
- **Acquisition Consultancy Institutions.** 2 accredited organizations to provide consultancy services concerning the acquisition of software and related services.
- **MPS-SW Instructors.** 35 MPS-SW trained and authorized instructors.

**SPI Impact Monitoring and Results.** Surveys are being conducted to provide further understanding into the overall results and the impact of the MPS-SW model on the Brazilian software industry. In the context of this publication we highlight the following:

- **‘MPS Wants to Hear You!’ Survey.** This qualitative survey, conducted in the first semester of 2014, was focused on customer satisfaction, based on answers from sponsors of MPS-SW adopting organizations concerning all 544 MPS-SW assessments, from September 2005 to February 2014 (see Section IV).
- **‘iMPS’ Performance Results Survey.** This survey is conducted on a yearly basis. ‘iMPS’ stands for ‘information on the MPS models’, concerning information related to its performance impact on the software industry. The iMPS survey has been conducted since 2008. The most recent trial captures data gathered in 2013 (see Section V).

These recent surveys shed new light on the achieved results from an industry perspective considering two complementary and important points of view: customer satisfaction and actual performance results. Therefore, details on the survey outcomes extend the understanding on MPS.BR’s results during its 10 years and are provided hereafter.

**IV. ‘MPS WANTS TO HEAR YOU!’ SURVEY**

In order to celebrate both the achievement of the 500th MPS-SW assessment in September 2013 and the ten years of the MPS.BR program in December 2013, the moment was...
considered opportune to communicate [20] and carry out the first customer satisfaction survey.

Objective. To present the results of the qualitative customer satisfaction survey ‘MPS wants to hear you!’ answered by the customer software organization sponsors of MPS-SW assessments (all published at www.softex.br/mpsbr), including both the updated MPS assessments, within the period of validity (1st assessment and renewals), and those that were not renewed.

From September 2005 to February 2014, 544 MPS-SW assessments where accomplished (in 425 different organizations), out of these 250 (59%) are updated and 175 (41%) are not renewed assessments.

The 119 (namely, 544 - 425) not considered assessments are included in the 425 assessed organizations because they were performed in the MPS-SW loyal customer base that renewed their assessments to maintain or evolve their maturity levels, being assessed more than once (103 two times, 13 three times and 3 four times), so the sponsors of those companies needed to send only one answer related to the most recent assessment.

It was also verified that 10 organizations that adopted the MPS-SW model (2 with updated assessments and 8 that did not renew) are not active anymore due to business reasons that exceed our monitoring possibilities. Furthermore, another 12 organizations that did not renew their assessments did not have valid sponsor e-mails registered at Softex anymore, reducing the overall population size from 425 to 403.

Method. The SurveyMonkey Gold survey tool (www.surveymonkey.com) was used to create an online questionnaire, to share it with the MPS assessment sponsors, and to analyze their answers. The questions were planned to capture basic characterization and customer satisfaction. Concerning customer satisfaction questions to sponsors focused on how likely they would recommend the MPS-SW model, why they adopted it (or why they did not renew their assessment if this was the case) and what are, in their opinion, the main reasons to adopt it (or for not renewing). Considering the target population of MPS-SW sponsors (mainly directors of assessed companies) the questionnaires were elaborated so that answering would require no longer than 20 minutes.

Softex sent the online questionnaire by e-mail to the MPS-SW assessment sponsors of all 403 (still reachable) assessed organizations, 248 (62%) with updated assessments and 155 (38%) with not renewed assessments, requesting their honest feedback as income to continually improve the MPS-SW model.

Characterization. The responding organizations were characterized according to their annual gross operational revenues, MPS maturity levels and geographic location. Related to gross revenues, there are companies in five zones (Brazilian Development Bank criteria’): 36% micro-sized companies; 42% small-sized companies; 18% medium-sized companies; 2% medium to large-sized companies; and 2% large-sized companies, as shown in Figure 2.

![Figure 2. Size distribution of enterprises that answered the ‘MPS Wants to Hear You!’ survey.](image)

Referring to their MPS maturity levels: 84% are in the levels G-F (base of the pyramid); 15% are in the levels E-D-C (middle of the pyramid); and 1% are in the levels B-A (top of the pyramid).

Concerning the geographic location of the organizations that answered this survey: 50% are in the country’s southeast; 30% are in the south; 11% are in the northeast; 7% are in the center-west; and 2% are in the north.

Results. The results, obtained from February 28th to June 26th, include answers from 193 sponsors, 3 partially and 190 totally answered: 151 (78%) from organizations with updated (valid) assessments (confidence level 96%) and 42 (22%) from organizations that did not renew their assessments (confidence level 86%).

The observed results concerned if the sponsors would recommend the MPS-SW model as a model for the elevation of organizational performance (rating scale question from 1 to 10, 10 being the highest), why they adopted it / did not renew (multiple choice question, with options brainstormed by eight experts on the MPS-SW model) and what are, in their point of view, the main reasons for doing so (open question). We separate the results by organizations with updated (valid) assessments and organizations that did not renew their assessments.

For organizations with updated MPS-SW assessments, the results indicated that:

- **MPS-SW Recommendation.** Sponsors of these organizations are very likely to recommend the MPS-SW as a model for the elevation of organizational performance to a friend or colleague. 64% of the participants responded with ratings 9 or 10 while only 7% provided a 6 or below. Figure 3 shows the cloud view of the text analysis on the main reason for the given rate to this question, showing the most important
words and phrases, highlighting: Model (30%, 44 mentions); Improvement (26%, 39 mentions); Organization (19%, 28 mentions); Our Processes; Quality and Software (17%, 24 mentions).

**Why Sponsors Adopted the MPS-SW.** Main sponsor answers, with percentage higher than 50%, are: i) Business reasons: ‘Process improvement – a strategic decision aiming to enhance business performance and competitiveness’ (73%, 107 answers), ‘Company sustained and organized growth – the current growth requires improvement’ (67%, 98 answers) and ‘Company organizational and management improvement’ (58%, 86 answers); ii) Technical reasons: ‘Process improvement – a technical decision aiming to assure software quality’ (64%, 94 answers); iii) The percentage of financial reasons was less than 25%. Figure 4 shows the cloud view of the text analysis of the open question on the main reason for adopting the MPS-SW, showing the most important words and phrases, highlighting: Process Improvement (35%, 51 mentions); Enterprise (22%, 33 mentions); Performance Results, Software Productivity, Return on Investment and Customer Satisfaction (18%, 26 mentions).

**Sponsors of organizations that did not renew their MPS-SW assessment,** on the other hand, show a similar but less intensely favorable attitude towards the model:

- **MPS-SW Recommendation.** It is still likely for those sponsors to recommend the MPS-SW as a model for the elevation of organizational performance, 35% of the participants responded with ratings 9 or 10 while 23% ratings 6 or below. Figure 5 shows the cloud view of the text analysis on the main reason for the given rate to this question, showing the most important words and phrases, highlighting: Process (35%, 15 mentions); Enterprise (30%, 13 mentions); Model (21%, 9 mentions).

**Why Sponsors did not Renew their MPS-SW Assessment.** Answers were more evenly distributed among the options, the only sponsor answers with percentage higher than 25% were the following two business reasons: ‘Internal reasons – e. g. other priorities; a change in the organizational culture’ (49%, 21 answers) and ‘Customers do not require the model – we didn’t achieve more customers with it’ (47%, 20 answers). Figure 6 shows the cloud view of the text analysis of the open question on the main reason given for not renewing MPS-SW assessments, showing the 9 most important words and phrases, highlighting: No and Enterprise (37%, 16 mentions); MPS Model (16%, 7 mentions); Strategic Repositioning (9%, 4 mentions); Internal Reasons and Cost (7%, 3 mentions).

**Conclusions.** As expected, the results of the qualitative survey ‘MPS wants to hear you!’ show that the customer satisfaction is different in the two cases. It is very high (93% rating recommendation from 7 to 10) and well defined for the great number of answers from sponsors of assessments that are within the period of validity, mainly due to business and
technical reasons. It is lower, although still relatively high (77% rating recommendation from 7 to 10), and diffused for the small number of answers from sponsors that did not renew the assessment.

It is noteworthy that it was not our goal to gather information from the software development organization’s customers on their satisfaction with the provided services. This would have been difficult due to the absence of a direct contact to such customers and the strong bias observed when collecting such data indirectly from the development organizations.

V. ‘iMPS’ PERFORMANCE RESULT SURVEY

The adoption of the MPS-SW model by Brazilian organizations led to the interest of understanding the benefits brought to industry, measuring performance results obtained by these organizations, regarding cost, schedule, productivity, and quality, among others. Given this interest, the iMPS project was launched in 2007.

Main goal of the iMPS project was planning a survey, following Experimental Software Engineering principles, and periodically executing trials of it to monitor performance results of software organizations that adopted the MPS-SW. Information about the research plan and the treatment given to its threats to validity can be found in [21]. The 2008 (baseline), 2009, 2010, 2011 and 2012 iMPS trials provided initial evidence [22]-[26], to be supplemented annually by new iMPS trials, allowing comparative analyses. A summary of the results obtained in the iMPS2013 trial follows. Detailed results are being published separately [27].

The iMPS2013 survey featured 181 questionnaires answered by 148 different organizations. Including this data, the historical iMPS database contains 923 questionnaires from 364 different organizations that participated in iMPS trials since 2008. Given the amount of data, two different analysis could be performed: 2013 characterization and a global analysis considering data since 2008.

2013 Characterization. The characterization of the latest survey trial reinforce indications of previous years that the higher the maturity level the better the performance, quality and estimation accuracy. Trend interpolation results, obtained after discarding outliers by the quartile method, concerning project size (for organizations measuring size in function points), productivity (average project function point production per month) and quality (number of defects found during customer acceptance tests per function point) per maturity level are shown in Figures 7, 8, and 9 respectively. The decision to group levels C-A, and E-D was taken because currently there are less organizations in higher maturity levels.

As can be seen in Figure 7, for organizations participating in the iMPS2013 survey, and measuring their project size in function points (the most used size unit, with valid, i.e. not outlying data points, informed by 38 organizations), the ones of higher maturity levels reported having larger projects.

Concerning Figures 8 and 9, it is possible to observe, for the iMPS2013 data set, a slight trend towards improved productivity and quality (less defects) with the increase of the maturity level. The small amount of data points in these figures is justified by the large amount of discarded outliers and because both graphs refer to derived metrics (more than one base metric had to be informed properly to allow their calculation), related to organizations who informed measuring their software in function points.
However, despite the small amount of data points, the trend is similar to the one observed in previous iMPS trials [22]-[26], with independent (although surely overlapping) sets of organizations answering each year. We believe that an increase in productivity and quality may be obtained due to the required adoption, in higher maturity levels, of software engineering best practices that have already proven their effectiveness, such as peer reviews [28] (at level D) and defect causal analysis [29] (at level A). It is noteworthy though that this data does not allow any validity inferences nor enable further explanations into the observed behaviors. In fact, the results should not be interpreted in an isolated way. More complete results are available in [27].

Finally, concerning estimation accuracy, shown in Figure 10, it is important to observe that many organizations informed the estimate and duration to be equal (estimation accuracy = 1, i.e., 100%), which according to DeMarco and Lister [30] does not reflect the reality of most software projects. Therefore, the boxplot shown in Figure 10 presents the variation in each of the analyzed groups. Also, precision accuracy results under 50%, present in groups G and F were not considered, because in these cases lack of quality in the provided base metrics (estimate and duration) was assumed. It can be observed that, for the iMPS2013 data set, the organizations in higher maturity levels presented less variation and a higher minimum estimation accuracy.

Another observed difference was that among the higher maturity level companies the exporting activities showed more intense (more of them reported to have customers and projects abroad). Furthermore, organizations (81%) reported to perceive the MPS-SW model as a process innovation driver. As in previous years, the overall satisfaction with the MPS-SW remained high (95%) – differently from the ‘iMPS Wants to Hear You!’ survey, in the iMPS survey data is mainly provided by project managers.

**Global Analysis.** The global analysis considering data from the several years, allows to observe that as organizations acquire maturity they also increase their average project size and their number of customers, projects and employees [27]. Given the larger data set, the global analysis allowed to obtain some statistically significant indications. Aiming at analyzing such statistical significant differences and given the small amount of organizations assessed in higher maturity levels, for the global analysis data points of maturity levels E-A were grouped.

For instance, the global analysis results for the average project size of organizations that reported measuring their size in function points is shown in Figure 11. Assuming the risk of considering that the size measures for those organizations are equivalent (which we are aware might not the case, since different organizations potentially count function points differently), organizations of group E-A consistently informed to develop larger projects than organizations in maturity level G (p-value= 0.0119 – non parametric Wilcoxon test).

The global analysis for productivity (average project function point production per month) is shown in Figure 12. Therein it can be seen that, among the organizations that answered the iMPS surveys, organizations of maturity levels E-A and F present almost similar productivity, and consistently higher than the productivity of organizations at level G (although this result is not statistically significant, considering alpha value 0.05). However, as mentioned before, the indicators should not be interpreted in an isolated way, for instance, according to Figure 11, we saw that organizations in levels E-A usually handle bigger projects.

As for project size and productivity, the global analysis allowed conducting stronger analyses for several indicators on benefits of the MPS-SW model for software organizations,
providing evidence on the importance of seeking higher maturity levels, especially for organizations growing in size and evolving their project profiles. However, the initial description of the iMPS2013 results in this paper aim at providing an overview on performance results to extend the understanding on the MPS-SW overall results during its 10 years. Thus, more complete results of the iMPS2013 survey and the in depth global analysis are published as a separate book [27].

Regarding the adoption, by the end of 2013, after 10 years, the MPS-SW surpassed the emblematic milestone of 500 assessments in companies located in Brazil’s five regions, including mainly micro, small and medium-sized enterprises. As described in Section III, besides the number of assessments, results include the creation of publicly available MPS guides, providing process improvement training to about 6,000 people, establishing a collaboration network, and monitoring the impact of MPS-SW based process improvement in the industry. Currently the MPS model is recognized in Brazil as a success case of the Triple Helix (Academia, Government and Industry).

Concerning the surveys, they present additional new results from an industry perspective considering two complementary and important points of view: customer satisfaction and performance results. The conducted ‘MPS Wants to Hear You!’ survey showed that, according to their annual gross operational revenues, 96% of the MPS-SW model customers are micro, small and medium-sized enterprises (mSME). Mainly, this survey indicated high customer satisfaction especially for sponsors of organizations with valid MPS-SW assessments (the majority of sponsors would recommend the MPS-SW for the elevation of organizational performance). The iMPS2013 survey trial, on the other hand, reinforces indications of previous years that the higher the maturity level the better the performance, quality and estimation accuracy. Higher maturity level companies also showed more intense exporting activities. Furthermore, organizations mentioned to perceive the MPS-SW model as a process innovation driver.

Given MPS-SW adoption by micro, small and medium-sized companies, we believe that the MPS.BR program has been successful in its main goal of bringing benefits of software process improvements to those companies.

As future work, the MPS.BR program’s main next steps are: (i) to improve the MPS.BR program and the MPS model based on recommendations of a working group of experts, representatives of the Academia, Government and Industry (Triple Helix), listening to both, MPS Front Line Collaborators (II, IA, IOGE, ICA, and instructors) and MPS customers; (ii) to develop an holistic approach of the MPS models, comprising MPS-SW (MPS for Software), MPS-SV (MPS for Services) created in 2012, and the MPS-RH (MPS for People Management) to be created in 2014; and (iii) to disseminate the MPS models abroad in a global initiative, beginning in 2014 with pilot MPS-SW assessments in several countries.

VI. CONCLUDING REMARKS

This paper presented results of 10 years of software process improvement in Brazil based on the MPS-SW model. Results were presented by describing its adoption in Brazil and outcomes of two surveys concerning the impact of such adoption in the software industry.

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