iMPS 2012

Evidence on Performance of Organizations that Adopted the MPS-SW Model since 2008

Guilherme Horta Travassos

Marcos Kalinowski

Translation

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SOFTEX
EXCELLENCE IN SOFTWARE

mps Br Melhoria de Processo do Software Brasileiro

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SOFTEX - Association for Promoting the Brazilian Software Excellence

Created at the end of 1996, the SOFTEX Association, is a Civil Society Organization of Public Interest headquartered in Campinas, SP, Brazil.

SOFTEX is responsible for managing the Informatics Priority Program of the Federal Government for Promoting the Brazilian Software Excellence, the SOFTEX Program.

SOFTEX Mission

To expand the competitiveness of Brazilian Software and Service Companies in the domestic and overseas markets and promoting the development in Brazil

The SOFTEX System has national scope. Its Management Structure is formed by SOFTEX and its regional agents, to which more than 2,000 companies with activities in software and IT services are bound.

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Among the activities of SOFTEX in the context of Quality Management, due to results achieved since December 2003, the MPS.BR Program – Brazilian Software Process Improvement – is one of the highlights.

MPS.BR Program – Brazilian Software Process Improvement

Kival Chaves Weber – Executive Coordinator

Summary

Preface

The MPS.BR program – Brazilian Software Process Improvement – was created in December 2003, under the coordination of SOFTEX – Association for Promoting the Brazilian Software Excellence. Since then, the MPS model has been adopted by small and medium sized enterprises (SME) – about 70% of the published MPS assessments, as well as by large organizations – about 30%. MPS assessments in organizations have validity of three years: the 1st was accomplished in 2005; assessment number 100 happened in 2008; number 200 in 2009; number 300 in 2011, and number 400 in 2012. Further information on the MPS.BR program and the MPS model can be found in <*www.softex.br/mpsbr*>.

In 2008, SOFTEX hired the Experimental Software Engineering Group of COPPE/UFRJ – Federal University of Rio de Janeiro, to model the iMPS project – "*Information to Monitor and Provide Evidence Regarding Performance Variation of Software Organizations that Adopted the MPS Model*", and to conduct of yearly iMPS trials. The main iMPS goal was to plan a survey, following the principles of Experimental Software Engineering, and to execute it periodically to monitor and provide evidence of performance results of organizations that adopted the MPS model. [Kalinowski, M., Weber, K. C., and Travassos, G. H. (2008). "*iMPS: An Experimentation Based Investigation of a Nationwide Software Development Reference Model*". ACM/IEEE 2nd International Symposium on Empirical Software Engineering and Measurement (ESEM). October, 9-10. Kaiserslautern. Germany].

The iMPS 2008 survey results, which included 123 questionnaires from different organizations, indicated that organizations that adopted the MPS show greater customer satisfaction, greater productivity and capacity to develop larger projects, when compared to organizations that were starting the MPS model implementation. More than 80% of them reported to be satisfied with the MPS model. [Travassos, G. H. and Kalinowski, M. "*iMPS: Resultados de Desempenho de Organizações que Adotaram o Modelo MPS*" – in portuguese. SOFTEX, 2008].

The iMPS 2009 survey results, which included 135 questionnaires from different organizations, showed a notorious satisfaction of the organizations with the MPS model, with over 98% of them reporting to be partially or fully satisfied. Additionally, organizations reported to obtain return on investment (ROI) and, for those organizations that have evolved or internalized the MPS in their processes, it was possible to observe improvement tendency regarding cost, project duration, productivity, and quality. [Travassos, G. H. and Kalinowski, M. "*iMPS 2009 – Characterization and Performance Variation of Software Organizations that Adopted the MPS Model*" – available in English. SOFTEX, 2009].

The iMPS 2010 survey results, which featured electronic questionnaires answered by 156 different organizations, showed that the satisfaction of the organizations was again evident, with over 92% reporting to be partially or totally satisfied with the MPS model. The characterization allowed observing that organizations that adopted the MPS have higher customer satisfaction, handle larger projects, are more accurate in their schedule estimates, and are more productive, when compared to organizations that are starting the MPS model implementation. The performance variation analysis allowed to identify that organizations tend to obtain the expected benefits of applying software engineering principles to their development efforts, regarding cost, schedule, quality and productivity. [Travassos, G. H. e Kalinowski, M. "*iMPS2010: Performance of Software Organizations that Adopted the MPS Model from 2008 to 2010*" – available in English. SOFTEX, 2011].

The iMPS 2011 research results, which featured electronic questionnaires answered by 133 different companies, showed that in 2011 the satisfaction of the organizations with the model was again evident, with approximately 97% of them reporting to be totally or partially satisfied with the MPS model. The characterization has observed positive correlations between the maturity of organizations in the MPS model and the number of projects (both, in Brazil and abroad). In the performance variation analysis, it was possible to identify that organizations that remain persistent in the use of software engineering practices represented by the MPS maturity levels have more customers, develop more projects, have a greater number of employees, deal with larger projects and show higher estimation accuracy, despite a slight increase caused in the average time spent on their projects. [Travassos, G. H. and Kalinowski, M. "*iMPS 2011: Performance Results of Software Organizations that Adopted the MPS Model from 2008 to 2011*" – available in English. SOFTEX, 2012].

The iMPS 2012 survey, presented in this publication, featured electronic questionnaires answered by 132 companies involved with the MPS model for Software (MPS-SW), making the historical iMPS basis contain 743 questionnaires referring to 298 organizations that participated in the iMPS trials from 2008 to 2012. Satisfaction with the MPS model remains high (> 95%). In 2012, the characterization showed similar behavior to previous results, reinforcing the indication that higher maturity levels tend to have better performance regarding productivity, quality and estimation accuracy. The global analysis since 2008, in a sample consisting of 226 separate organizations, supports the results of the characterization and highlighted the importance of seeking higher maturity levels for the sake of productivity, quality and estimation accuracy. [Travassos, G. H. e Kalinowski, M. "*iMPS 2012: Evidence on Performance of Organizations that Adopted the MPS-SW Model since 2008*" – available in English. SOFTEX, 2013].

As this study is unique in the world, it is expected that the objective evidence presented as results of this fifth trial of the annual iMPS survey will be useful to stakeholders of the Academy, Government and mainly in Industry (Triple Helix) in order to improve software processes and increase the competitiveness of software companies.

Kival Chaves Weber **Nelson Henrique Franco de Oliveira**

iMPS 2012: Evidence on Performance of Organizations that Adopted the MPS-SW Model since 2008

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Resumo

Context: *The MPS-SW model reached the milestone of 400 assessments of software development organizations in 2012. The performance of these organizations has been monitored by the iMPS project and their results published since 2008.*

Objective: *To present the characterization and performance of organizations using MPS-SW based on the data provided in the year 2012 and describe the results of a global analysis involving the aggregation of data from organizations that participated in the iMPS trials from 2008 to 2012.*

Method: *Run the iMPS survey to collect data from 2012 and incorporate them into the iMPS historical basis. Perform the characterization and performance observation through the iMPS indicators of organizations that responded to the survey. From the set of historical data, identify organizations that have responded to the questionnaires at least four times, taking use of the last survey of each organization for the global analysis of iMPS indicators.*

Results: *132 organizations involved with the MPS-SW (15 starting implementation, 37 in assessment process, 47 assessed level G, 19 assessed at level F and 14 assessed levels E-A) responded to the survey in 2012, making the iMPS historical basis contain 743 questionnaires relating to 298 organizations that participated in the iMPS trials from 2008 to 2012. The characterization showed similar behaviors of previous results, reinforcing the indication that higher maturity levels improve the performance regarding productivity, quality and estimation accuracy. The satisfaction with the model remains high (> 95%). The global analysis on a sample of 226 distinct organizations reinforces the characterization results and highlights the importance of seeking higher maturity levels in order to improve productivity, quality and estimation accuracy. The focus of the organizations has been in developing conventional systems.*

Conclusions: *Organizations in different MPS-SW maturity levels have different performance. Generally it was observed, as expected, that the higher the level, the better the performance. However, regardless of the maturity level, organizations still need to improve their measuring and quality assurance processes, given the inconsistency and possible volatility of the measures presented. The participation of the organizations in projects abroad is still low; however, apparently the Brazilian market demands every effort available in the organizations. Embedded systems, despite its importance for the country's technological development, have not been much considered by the organizations that adopted the MPS-SW.*

1. Introdução

The MPS.BR program is an initiative to improve the software development capability in Brazilian organizations. Its main objective is to develop and disseminate process improvement models that suit the needs of the Brazilian Software and IT Services Industry (now the family of models consists of the MPS-SW and MPS-SV reference models regarding Software and IT Services, respectively), aiming to establish an economically feasible way for organizations, including small and medium sized enterprises, to achieve the benefits of process improvement and of using software engineering and IT services best practices, within a reasonable time frame.

As the MPS-SV reference model for IT services is still very new (the first assessment was conducted in September 2012), this publication focuses on MPS-SW for Software and covers organizations that use this model to improve their engineering practice applied to software development.

The MPS-SW model was developed considering internationally recognized standards and models, best software engineering practices and the business needs of the Brazilian software industry. The adoption timeline of the MPS-SW model by organizations highlights the dynamics of its use:

- September 13, 2005: 1st MPS-SW Assessment;
- May 16, 2008: 100th MPS-SW Assessment;
- November 26, 2009: 200th MPS-SW Assessment;
- September 15, 2011: 300th MPS-SW Assessment;
- September 17, 2012: 400th MPS-SW Assessment.

The results of these assessments of more than 400 organizations of the software industry are available in the Assessments section of *www.softex.br/mpsbr*. This dynamic has been obtained thanks to the active collaboration of the triple helix formed by a synergistic action between academia, industry and government, that even with the limited financial resources available over the years[1], managed to involve additional voluntary effort and accomplished both, an accelerated spread of the MPS-SW knowledge to the software organizations, and training specialized personnel involved (implementers and appraisers) with the implementation and maintenance of the model.

The widespread adoption of the MPS-SW model by Brazilian organizations promotes interest in understanding qualitatively the performance results obtained by these organizations in their projects, referring to variables such as time, productivity, cost and quality. With this objective, the iMPS project (information to monitor and provide evidence regarding performance variation of software organizations that adopted the MPS model) was initiated in 2007 with the Experimental Software Engineering Group of COPPE/UFRJ (http://ese.cos.ufrj.br).

The iMPS project is presented in the form of surveys, sustained by the scientific method and applying the principles of Experimental Software Engineering [Wohlin et al., 2000], periodically performed to monitor and show the performance results in the software organizations that have adopted the MPS model. The details on the survey plan, the capture of information moments, the threats to validity

1) Data SOFTEX: U.S. $ 14,000,000.00 from 2006 to 2012. Sources of funding: MCTI / SEPIN, FINEP, IDB / MIF and SEBRAE.

and the mitigation forms can be found in [Kalinowski et al., 2008]. The first trial of the iMPS in 2008 (baseline) provided initial evidence about possible software organizations behaviors [Kalinowski and Travassos, 2008], which were annually strengthened with new findings obtained in later iMPS trials, allowing even more robust benchmarking.

Thus, this publication presents the results of the fifth iMPS research trial and complements the initial publication of the results presented at the VIII MPS.BR Annual Workshop [Kalinowski and Travassos, 2012b]. As in the previous two iMPS trials, the questionnaires were filled in an electronic format, which collaborated with the quality of the reported data. The results will be presented through two perspectives: 2012 characterization and a global analysis, using data from the last questionnaire sent by the organizations that provided at least 4 iMPS questionnaires in the last 5 years (2008, 2009, 2010, 2011 and 2012).

The purpose of the characterization is to outline the performance of organizations that adopted the MPS in 2012. The perspective related to the global analysis grouping, on the other hand, is to be able to compare the possible effects on the indicators regarding the organizations permanency in using the MPS-SW model and its maturity levels. The grouping was instantiated with 226 organizations (last sent questionnaire) from the historical iMPS basis. Thus, each of these organizations contributed with their latest questionnaire. Consequently, the questionnaires from trial 1 (2008) were not considered. This grouping allowed an increased confidence in the results concerning the effects produced by the adoption of the model.

The rest of this publication is organized as follows. In section 2 a current overview of the iMPS project is provided. Section 3 describes how the survey application was conducted and the preparation of the initial trial data for 2012. Section 4 provides the 2012 characterization results and its analysis. In section 5, the overall results of the analysis regarding the organization prevailing the use of MPS-SW model over the years are presented. Finally, Section 6 contains the concluding remarks.

2. The iMPS Project: Performance of Organizations that Adopted the MPS Model

The iMPS project aims at periodically monitoring performance results of software organizations that adopted the MPS model. This monitoring is based on a survey, which allows the periodic characterization of organizations that adopted the MPS model in order to understand their performance variation. The choice of an experimental strategy to assess the performance variation of organizations due to the adoption of the MPS model helps to ensure the validity of the study and enables the appropriate consolidation of data.

Following the GQM paradigm [Basili et al., 1994] and in order to prevent possible threats to validity [Kalinowski et al., 2008], follow-up questionnaires were developed for application at the following moments: (i) when organizations are starting the implementation of the MPS model, (ii) when organizations are in assessment process, and (iii) periodically for organizations with unexpired assessments published on the SOFTEX website. These instruments were evaluated in 2008 in a pilot study and showed themselves adequate to capture the basic information contained in the survey plan in order to support understanding the organizations' performance variation. Additionally, for the first

trial in 2008, a retrospective application for the organizations that had already been evaluated before the start of the survey was conducted. The series of publications on the performance results, available at the SOFTEX portal (http://www.softex.br/mpsbr/EN/_livros/resultado_desempenho.asp), allows us to observe the evolution of the research [Kalinowski and Travassos, 2008], [Kalinowski and Travassos, 2009], [Kalinowski and Travassos, 2011] and [Kalinowski and Travassos, 2012a].

Collected suggestions until 2011 allowed to evolve the questionnaires regarding the clarity and consistency of the questions for the 2012 trial without, however, changing the information that should be collected. The following subsections describe the dynamics of the survey application at the organizations and the scenarios that were considered for data collection:

a) Organizations Starting to Implement the MPS Model

For organizations in this situation, once SOFTEX is notified of the beginning of an MPS implementation, it provides a link to the organization through which it can access and complete the following electronic forms: Consent Form; Characterization Form of an organization that is starting to implement the MPS model, and; Performance Questionnaire of an organization that is starting to implement the MPS model.

b) During Official MPS Assessment Procedures

This refers to organizations that were approved in an official MPS assessment. For organizations in this situation the link provided by SOFTEX during the assessment procedures (right after the final assessment) provides the following electronic forms: Consent Form, Characterization Form of an organization that is in the process of assessing the MPS model, and; Performance Questionnaire of an organization that is in the process of assessing the MPS model.

c) Periodically for Organizations with Unexpired Assessments

This situation reflects the periodic (annual) survey application for organizations with unexpired MPS assessments. For organizations in this situation, SOFTEX yearly provides a link containing the following electronic forms: Consent Form; Characterization Form of an organization that was assessed according to the MPS model, and; Performance Questionnaire of an organization that was assessed according to the MPS model.

Having provided a current overview of the iMPS project, the following section describes how the survey application was carried out and the initial data preparation for the 2012 trial.

3. Survey Application and Initial Data Preparation: 2012 Trial

The sets of electronic questionnaires were distributed to the participants (representatives of organizations that adopted the MPS) through the iMPS management system by the MPS.BR Operations Management. Filling out the electronic questionnaires resulted in automatic transference of the data to the iMPS repository. The electronic questionnaires allowed the standardization of responses and an initial data validation of the data already by the time of the filing.

In the performance questionnaires it was not mandatory that organizations fulfill all the data, since not all organizations have all the data requested in the survey. Some additional information for the characterization of organizations, such as the MPS maturity level, were obtained directly from existing SOFTEX databases.

In this fifth trial (2012) questionnaires were received from 132 organizations (15 starting implementation, 37 in the assessment process, 47 assessed at MPS level G, 19 assessed at MPS level F and 14 assessed at MPS levels E-A), which filled out the information from 08/01/2011 to 07/31/2012. As the organizations have different data, it is natural that the measures are presented with a high standard deviation. Thus, to ensure consistency with the previous trials and to present the most appropriate information, the use of the median (central value for each measure) will be maintained in this trial.

During the data preparation, values of measures with more than three standard deviations from the average (outliers) were discarded until the final data set contained no further values in this situation. In this way, it was possible to use most responses, while not influencing the results with data which may eventually be distorted. During this process it was possible to identify that the majority of outliers was in organizations starting to implement either at level G, where the standard deviation of the measurements also showed higher. This may be related to the fact that the measurement process is required in the MPS maturity level F, which leads us to believe that the organizations' measures are more reliable from this level up.

The next two sections describe the results of the 2012 iMPS trial, contemplating the 2012 characterization and global analysis with data from the last years.

4. iMPS 2012 Results: Characterization

The characterization aims at outlining the performance of organizations that adopted the MPS in 2012. Given the concentration of most participating organizations still in the initial maturity levels (15 starting implementation, 37 in the assessment process, 47 assessed MPS level G, 19 assessed MPS level F, and 14 assessed MPS levels E-A), we decided to divide the data set in the following 5 categories: Organizations Starting Implementation, Organizations in Assessment Process, Organizations Assessed at Maturity Level G, Organizations Assessed at Maturity Level F and Organizations Assessed at Maturity Levels E-A. Furthermore, data is observed with focus on three different perspectives treated by the questionnaire, concerning the organizations, their projects and the MPS model itself.

The measures in the survey plan, for each of the perspectives (Organization, Projects and MPS Model) and their interpretation are presented in the following subsections, along with the values that could be obtained, considering the number of organizations that participated in this trial of the study. For each metric, in addition to the basic aggregated information found (median or percentage), the number of responses obtained is presented and, when relevant, a textual interpretation with additional information is provided.

After presenting the metrics for each of the perspectives and their values, a characterization analysis, highlighting some behaviors possibly related to the adoption of the model, concludes this section.

4.1. ORGANIZATION Perspective

An organization represents the entity being studied. In general, the concept is associated to a software development organization. However, it is possible for a certain organization to have different organizational units dealing with software development and that make use of the MPS-SW model. Table 4.1 presents the interpretation that was given to collect values for measures related to this perspective.

TABLE 4.1 - Measures used in the perspective Organization

MEASURE	INTERPRETATION
Number of customers in Brazil	Represents the number of customers the organization has in Brazil
Number of customers abroad	Represents the number of customers the organization has abroad
Number of projects in Brasil	Represents the number of projects the organization has in the country
Number of projects abroad	Represents the number of projects the organization has abroad
Total number of employees	Staff involved in software development

The tables 4.2 to 4.6 present values (median and percentages) that could be obtained for the measures of the organization perspective. For some tables, additional explanations were added to facilitate the understanding of the values extracted from the collected data.

TABLE 4.2 - Number of customers inside de country (Brazil)

Grouping	Number of Customers	Number of Answers
Organizations starting implementation	55	14
Organizations in assessment process	80	35
Level G Organizations	65	45
Level F Organizations	18	12
Level E-A Organizations	14	13
All organizations	55	119

For the measure referring the number of customers abroad, only 24.24% of the organizations participating in the study indicated to have customers abroad and the median (midpoint) for the analysis of all groups is zero. Thus, we consider more convenient to present, for each of the groups, the percentage of organizations with customers abroad, regardless of how many customers they have.

TABLE 4.3 - Percentage of Organizations that have customers Abroad

Grouping	% that have Customers Abroad	Number of Answers
Organizations starting implementation	20.00%	15
Organizations in assessment process	27.03%	37
Level G Organizations	17.02%	47
Level F Organizations	31.58%	19
Level E-A Organizations	35.71%	14
All organizations	24.24%	132

TABLE 4.4 - Number of Projects inside the Country

Grouping	Number of Projects	Number of Answers
Organizations starting implementation	5	9
Organizations in assessment process	7.5	30
Level G Organizations	9	39
Level F Organizations	7	15
Level E-A Organizations	11.5	10
All organizations	8	103

For the measure referring to the number of projects abroad, only 16.67% of the organizations participating in the study indicate owning overseas projects and the median (midpoint) for the analysis of all groups is zero. Thus, we consider more convenient to present, for each of the groups, the percentage of organizations that have indicated overseas projects, regardless of the number of projects they have.

TABLE 4.5 - Percentage of Organizations with Projects Abroad

Grouping	% having Projects Abroad	Number of Answers
Organizations starting implementation	13.33%	15
Organizations in assessment process	21.62%	37
Level G Organizations	10.64%	47
Level F Organizations	26.32%	19
Level E-A Organizations	14.29%	14
All organizations	16.67%	132

TABLE 4.6 - Number of Employees

Grouping	Number of Employees	Number of Answers
Organizations starting implementation	36	14
Organizations in assessment process	28	33
Level G Organizations	31.5	42
Level F Organizations	38.5	14
Level E-A Organizations	40	7
All organizations	33	110

4.2. PROJECTS Perspective

In the MPS.BR context, a project is related to effort undertaken to create a product or to provide a service. In this perspective, only projects that were completed within the last 12 months or that are still in progress should be considered. Table 4.7 presents the interpretation that was given to collect the values for the measures related to this perspective.

TABLE 4.7 - Measures used in the perspective Projects

MEASURE	INTERPRETATION
Average project cost	Measured in terms of percentage of net sales in the last 12 months.
Average project size	Average project size in the last 12 months, measured in the unit used by the organization. Examples: function points, use case points, lines of code, man-hours.
Average project effort	Average project effort in the last 12 months, measured in hours. This measure was included in the 2012 trial, aiming at facilitating the comprehension of other indicators.
Average project duration	Duration, measured in months, considering the projects completed within the last 12 months.
Average estimated project duration	Estimated duration, measured in months, considering projects that were completed or are in progress within the last 12 months.
Estimation accuracy	*Given the average estimated project duration within the last 12 months and the average project duration within the last 12 months, different than 0, calculate:* Estimation accuracy = 1 - | ((average project duration within the last 12 months - average estimated project duration within the last 12 months) / average estimated project duration within the last 12 months) |
Productivity	*Given an average project duration within the last 12 months, different than 0, calculate:* Productivity = Average project size within the last 12 months / average duration of projects within the last 12 months.

The Tables 4.8 to 4.13 present values (medians and percentages) that could be obtained for the projects perspective measures.

Regarding the average cost of the projects, the survey plan specifies that this should be obtained as a function of percentage from the net sales, therefore, values are relative and incomparable between different organizations. Thus, although this measure has not been used in the characterization analysis, it can be used to examine the performance variation of an organization over the years.

Considering the average size of projects, between the various units of the size used, the one used by most organizations is Function Points (36 organizations). Other units of measurement are quite used, such as Hours of Work (28 organizations, although this measure, according to the technical literature is not appropriate to capture the size of software projects) and Use Case Points (5 organizations). Among the organizations in levels E-A (14), 6 use Function Points. The values in Table 4.8 consider only the data provided by participants which use Function Points.

TABLE 4.8 - Average Project Size (in Function Points)

Grouping	Average Size in FP	Number of Answers
Organizations starting implementation	190	6
Organizations in assessment process	150	8
Level G Organizations	125	9
Level F Organizations	400	6
Level E-A Organizations	300	6
All organizations	180	36

The measure of the effort was introduced in the research in 2011 and was also collected in the iMPS trial 2012 in order to provide additional evidence for understanding the behavior of other indicators. The medians of the average effort undertaken in the projects are shown in Table 4.9.

TABLE 4.9 - Average Project Effort (Hours)

Grouping	Average Effort	Number of Answers
Organizations starting implementation	400	13
Organizations in assessment process	620	34
Level G Organizations	631	40
Level F Organizations	640	17
Level E-A Organizations	1228	12
All organizations	640	116

TABLE 4.10 - Average Project Duration (in months)

Grouping	Average Duration in Months	Number of Answers
Organizations starting implementation	2	11
Organizations in assessment process	2	32
Level G Organizations	2	41
Level F Organizations	3	19
Level E-A Organizations	5	11
All organizations	3	114

TABLE 4.11 - Average Estimated Duration of Projects (in months)

Grouping	Average Estimated Duration	Number of Answers
Organizations starting implementation	2.5	12
Organizations in assessment process	2	33
Level G Organizations	2	40
Level F Organizations	3	19
Level E-A Organizations	4.4	11
All organizations	3	115

Regarding the estimation accuracy, it is important to observe that many organizations reported the estimated and the actual duration of their projects to be the same (estimation accuracy 1), which is not consistent with the reality of most software projects, according to technical literature and our management experience. For this reason the table below, beyond presenting the median, shows the variation ranges in each of the analyzed groups. More details on the estimation accuracy are discussed ahead.

TABLE 4.12 - Estimation Accuracy (Relation Between Estimated Duration and Real Duration)

Grouping	Estimation Accuracy	Number of Answers
Organizations starting implementation	1 (range from 0 to 1)	10
Organizations in assessment process	1 (range from 0.08 to 1)	32
Level G Organizations	1 (range from 0.20 to 1)	39
Level F Organizations	1 (range from 0.38 to 1)	19
Level E-A Organizations	0.88 (range from 0.70 to 1)	11
All organizations	1 (range from 0.08 to 1)	111

Regarding productivity, following to the metric defined in Table 4.7, it was measured in Function Points/Month, representing the organization's production capacity in their projects, regardless of the number of employees involved.

TABLE 4.13 - Productivity (in Function Points per Month)

Grouping	Productivity	Number of Answers
Organizations starting implementation	50.00	5
Organizations in assessment process	50.00	7
Level G Organizations	43.75	8
Level F Organizations	66.67	5
Level E-A Organizations	66.67	5
All organizations	50	30

4.3. MPS MODEL Perspective

Represents the model itself and tries to capture the features effectively and directly related to the MPS-SW Model, independent of organization and project. The Table 4.14 presents the interpretation of the measures related to this perspective.

Tables 15-18 present values (median and percentages) that could be obtained for the measures from the MPS model perspective.

TABLE 4.14 - Measures used by the perspective MPS-SW Model

MEASURE	INTERPRETATION
Implementation Time	Average time spent by organizations to implement the MPS model. This measure takes into account only the organizations that were evaluated during the current year.
Implementation Investment	Percentage of net sales obtained by software development invested in the implementation of the MPS model, measured by the following formula: *Given the organizations net sales over the past 12 months, other than 0, calculate:* Implementation Investment = (value invested in MPS implementation / net sales over the last 12 months) * 100.
Assessment Investment	Percentage of net sales obtained by software development and invested in the MPS assessment, measured by the following formula: *Given the organizations net sales over the past 12 months, other than 0, calculate:* Assessment Investment = (Amount invested in evaluating MPS / value of the net sales over the last 12 months from the organization) * 100.
Satisfaction with the Model	Indicates the organization's satisfaction with the MPS model (Fully Satisfied, Partially Satisfied, Not Satisfied).

TABLE 4.15 - MPS-SW Implementation Time (in months)

Grouping	Implementation Time	Number of Answers
Organizations in assessment process	15.5	36

TABLE 4.16 - MPS-SW Implementation Investment (Percentage of Net Sales)

Grouping	Implementation Investment	Number of Answers
Organizations in assessment process	4.5%	27

TABLE 4.17 - MPS-SW Assessment Investment (Percentage of Net Sales)

Grouping	Spent with the assessment	Number of Answers
Organizations in assessment process	1%	26

It can be seen that, the implementation time and the investments are suitable and consistent with the positive changes that can be triggered in the software development context.

TABLE 4.18 - Satisfaction with MPS -SW Model

Grouping	Results	
Organizations starting implementation	Fully Satisfied	46.67%
	Partially Satisfied	40.00%
	Not Satisfied	0.00%
	Unknown satisfaction	13.33%
Organizations in assessment process	Fully Satisfied	67.57%
	Partially Satisfied	27.03%
	Not Satisfied	0.00%
	Unknown satisfaction	5.41%
Level G Organizations	Fully Satisfied	65.96%
	Partially Satisfied	29.79%
	Not Satisfied	0.00%
	Unknown satisfaction	4.26%
Level F Organizations	Fully Satisfied	73.68%
	Partially Satisfied	26.32%
	Not Satisfied	0.00%
	Unknown satisfaction	0.00%
Level E-A Organizations	Fully Satisfied	35.71%
	Partially Satisfied	64.29%
	Not Satisfied	0.00%
	Unknown satisfaction	0.00%
All organizations (including those in assessment process)	Fully Satisfied	62.12%
	Partially Satisfied	33.33%
	Not Satisfied	0.00%
	Unknown satisfaction	4.55%

4.4. 2012 Characterization Analysis

The data presented in the previous section allow different interpretations and may possibly be associated with confounding factors and even the political and economic factors in the years 2011 and 2012. However, some behaviors possibly related to the adoption of the model can be observed. An initial analysis of these behaviors was provided in [Kalinowski and Travassos, 2012b].

It is a fact that some of the organizations that participated in this study also use other reference models to guide the actions concerning their software processes. This may in itself represent a confounding factor influencing the results. However, most organizations focus effectively on the MPS-SW model, which we believe is an influential factor in behaviors that can be observed at this point. For a description of these behaviors we are, where relevant, showing some correlation coefficients obtained between the measurements and the different groups (with weights 1 - Starting Implementation, 2 - in Assessment process, 3 - Level G, 4 - Level F and 5 - Levels E-A).

The following subsections provide the description of the observed behavior for some of the metrics used in the study directly related to the performance of the organizations that adopted the MPS-SW Model.

4.4.1. Size of the Projects

Regarding the size of the projects, from the 132 organizations considered in the iMPS 2012 trial, 36 (27.27%) mentioned to measure the size of their projects in Function Points. Other measures of size used were Hours, used by 28 organizations (although this measure is not indicated as an interesting measure for project size, being confused by the concept of effort, considering the different interpretations and measurement approaches that can be applied) and Use Case Points, used by 5 organizations.

Figure 4.1 shows the median of the average project size of organizations that use Function Points for each group used in the study.

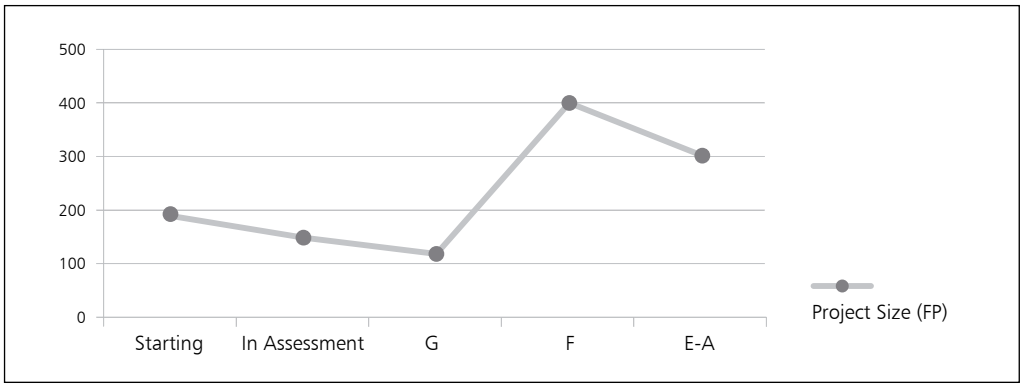


Figure 4.1. Median project size (for projects measured in Function Points)

It is possible to observe that, while the median size for organizations under assessment is 150 Function Points, the median for organizations of levels E-A is 300. There is a positive correlation between the increase of the median and the increase of the MPS-SW maturity level of +0.65. A similar behavior was observed in the 2011 trial [Kalinowski and Travassos, 2012a]. It is also important to note that the project size variation may reflect the project requests received by an organization, so this should be evaluated together with the organization's number of projects, shown below.

4.4.2. Number of Projects in the Country

This number is higher for organizations in higher maturity levels (E-A), which had an average of 11.5 projects in the country. The median number of projects in the country can be seen in Figure 4.2. There is a positive correlation between the number of projects in the country and the maturity level increase of +0.82.

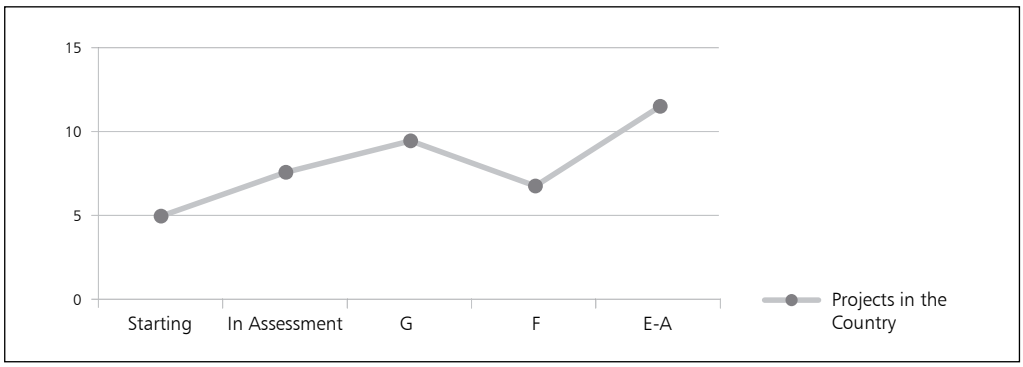


Figure 4.2. Median number of projects in the country

It is possible to see unexpected behavior in organizations of level F. However, when comparing to Figure 4.1, we can see an inverse behavior. Although we have no evidence to support the claim, we believe that this behavior (increased size, reduced number of projects) is associated with the confidence gained by the organization with the arrangement of activities provided by level F. The inclusion of more elaborated practices, regarding processes inserted at level F, makes the organization feel able to work with larger projects without even adequate notion of saturation levels of their development teams and all the risks involved when dealing with larger projects.

Organizations with higher maturity levels, on the other hand, apparently organize their demands in projects with a size that facilitates its control and reduces risk, considering the acquired experience, the internalized processes and practices and the number of employees involved.

4.4.3. Percentage of Organizations that Export

To obtain this information, the number of overseas customers was considered. As the organizations that export are among the minority that provided data for the research, at this point it was decided to raise the percentage of organizations (which have one or more overseas customers) that export for each group, as shown in Figure 4.3. It is possible to notice that among the organizations of higher maturity levels the percentage that export is considerably higher. There is a positive correlation between the percentage of organizations that exports and the maturity level increase of +0.73.

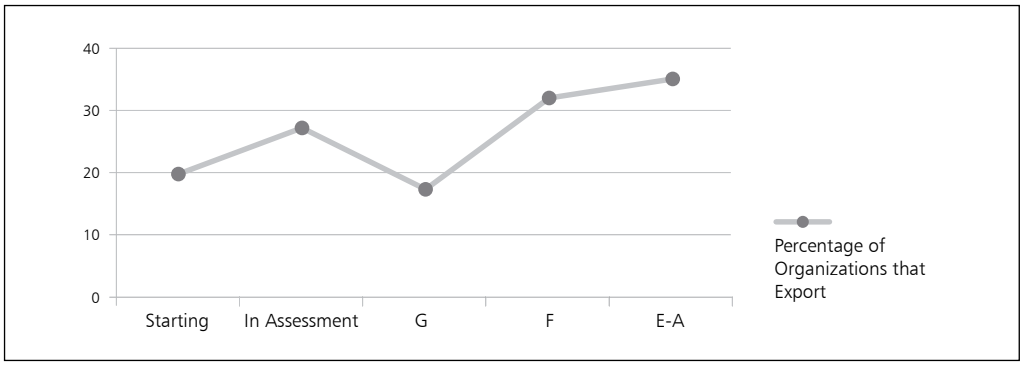


Figure 4.3. Percentage of Organizations that Export

By looking at the graphs we must consider that organizations that are starting to implement or are in assessment process may be preparing themselves for any maturity level and, thus, are possibly bigger than many organizations that are at level G, which in the MPS-SW model has as main purpose providing access to process improvement for small businesses.

4.4.4. Estimation Accuracy

As many organizations reported that the average time spent on projects is equal to the deadline of the project (i.e., estimate accuracy 1), we believe that this variable is best observed by looking at the variation within each group of organizations. Figure 4.4 illustrates this variation through a boxplot, which outlines the minimum, maximum and median.

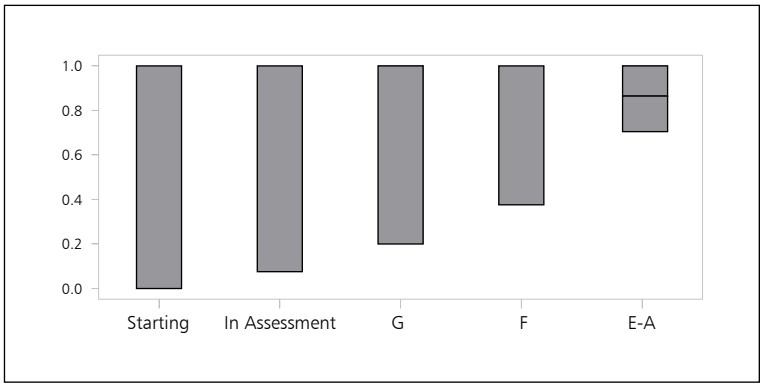


Figure 4.4. Boxplot of Estimation Accuracy

In this picture you can see that the organizations at maturity levels F and E-A showed less variation and higher minimum estimation accuracy (ranging respectively between 0.38 and 1 and between 0.70 and 1) compared to organizations in maturity level G (ranging between 0.2 and 1), in assessment process (between 0.08 and 1) and initiating the implementation (between 0 - corresponding to an error estimation greater than or equal to 100% - and 1). Therefore, as in the characterization of 2011, according to the information collected, the organizations with higher maturity levels achieved higher precision in their estimates.

4.4.5. Productivity

Regarding productivity we emphasize that it is being observed in an isolated form. It is important to remember that productivity is shown naturally different according to the type of project and that this measure should be observed taking into account other characteristics, such as quality and cost. Additionally, the productivity calculation takes into account other base measures that appear to be more reliable for organzations from level F up, which required to have an institutionalized measurement process.

Having these considerations in mind, productivity is positively correlated with the MPS-SW maturity level increase (+0.75). The highest median was of organizations at level F and organizations at levels E-A (both groups had production capacity of 66.67 function points per month in their projects).

Figure 4.5 shows the median productivity of organizations using function points for each group used in the study (after the outlier analysis in the size and project duration measures, the group of organizations in assessment process had 7 organizations, the group of level G had 8 organizations and each of the other groups had 5 organizations).

The behavior related to productivity is very similar to the one obtained in the previous iMPS trials, considering different groups of organizations each year.

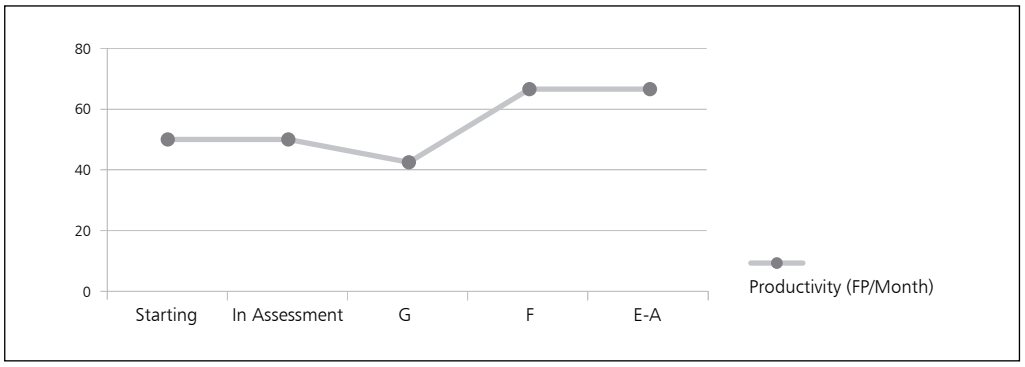


Figure 4.5. Median Productivity (in FP/Month)

4.4.6. Quality

The quality was measured in terms of defects found after the delivery of the project. For this measure the organizations were asked to report the number of defects per unit of size of the project. The unit most used again was Function Points (25 organizations). Considering these definitions, the quality increase (fewer defects) was positively correlated with the MPS-SW maturity level increase (+0.87).

Figure 4.6 shows the average number of defects per function point, for each group used in the study (after outliers analysis, the groups starting implementation and in assessment process had 5 organizations each, the level G group had 7 organizations and the levels F and E-A groups had 4 organizations each).

This was the first year that each group contained a minimum of 4 organizations, allowing such analysis. We believe that the permanence of organizations in MPS-SW over time has contributed in obtaining more accurate and consistent information. While these statements cannot be made based on evidence, we believe that the presence of configuration management and quality assurance processes at level F, the verification and validation processes at level D and the defect causal analysis practices at higher maturity levels contribute to the profile of decreasing defects with the increase of maturity. Our expectation is that the increased maturity leads organizations to refocus from defects correction to defects prevention, preventing the introduction and spread of defects, thereby reducing rework [Kalinowski et al., 2012].

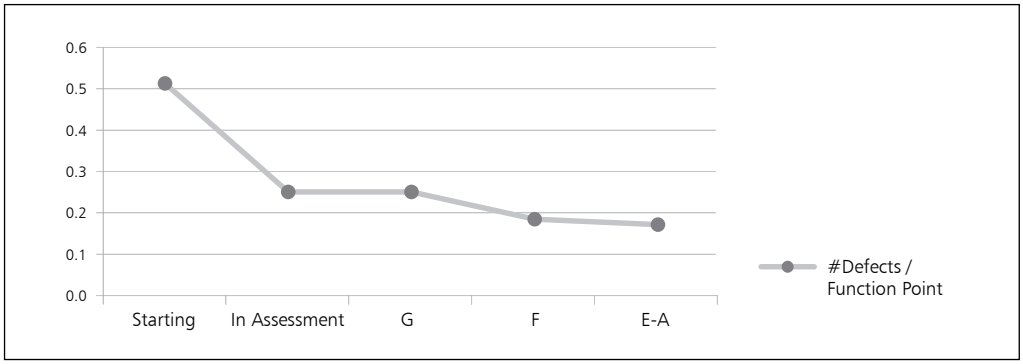


Figure 4.6. Median Number of Defects per Function Point

4.4.7. Satisfaction with the MPS-SW Model

Referring to the satisfaction of the 132 organizations with the MPS-SW model, 62.12% (82 organizations) reported being completely satisfied with the model and 33.33% reported being partially satisfied. No organization reported being unsatisfied and 4.55% (6 organizations) reported not knowing their level of satisfaction with the model. This result indicates that the majority of organizations (95.45%) is fully or partially satisfied with the MPS-SW model.

In general, the characterization data allowed to observe that, for organizations that responded to the questionnaires in 2012, those with higher maturity handled more projects in the country, had a greater presence abroad, performed deliveries closer to the estimated deadlines, had a greater productive capacity (FP/Month) and delivered products of higher quality (fewer defects), with consequent reduction of rework. Comparing these results with the characterizations made in the previous iMPS trials allows observing behavioral similarities, increasing the confidence in the results.

Having presented the 2012 characterization results of the organizations that adopted the MPS-SW model, the following section describes the overall analysis that aims to compare the possible effects on indicators given the permanency of organizations in using the MPS-SW model and its maturity levels.

5. Global Analysis: Organizations that have Internalized the MPS-SW in their Development Activities

The iMPS historical basis has 743 questionnaires regarding 298 organizations that participated in the iMPS trials from 2008 to 2012. Thus, it is possible to observe the market trend of these organizations over this period with respect to Services Categories, Applications Domains and Product Categories, as can be seen in the following sections.

5.1. General Indicators

5.1.1. Service Categories

In this category it is possible to note a number of organizations consistently offering Consulting and Project services over the years (no change), with growth in Distribution and Publishing services. Since 2010, a reduction in Outsourcing services and a slight reduction in Training and Technical Assistance services can also be observed. Table 5.1 shows the distribution of data over the years. Note that a single organization can inform to offer more than one class of service, affecting the total of responses. Figure 5.1 shows a graphic aiming to offer a different perspective of viewing the data.

TABLE 5.1 - Service Categories Offered by Organizations that adopt MPS-SW

Service Category	2008	2009	2010	2011	2012	Variation
Outsourcing	47	48	62	46	35	-0.43
Training	47	51	67	44	41	-0.29
Software Technical Assistance	40	46	68	40	41	-0.05
Consulting and Project	94	115	136	101	101	0.00
Distribution and Publishing	6	8	13	10	41	0.79

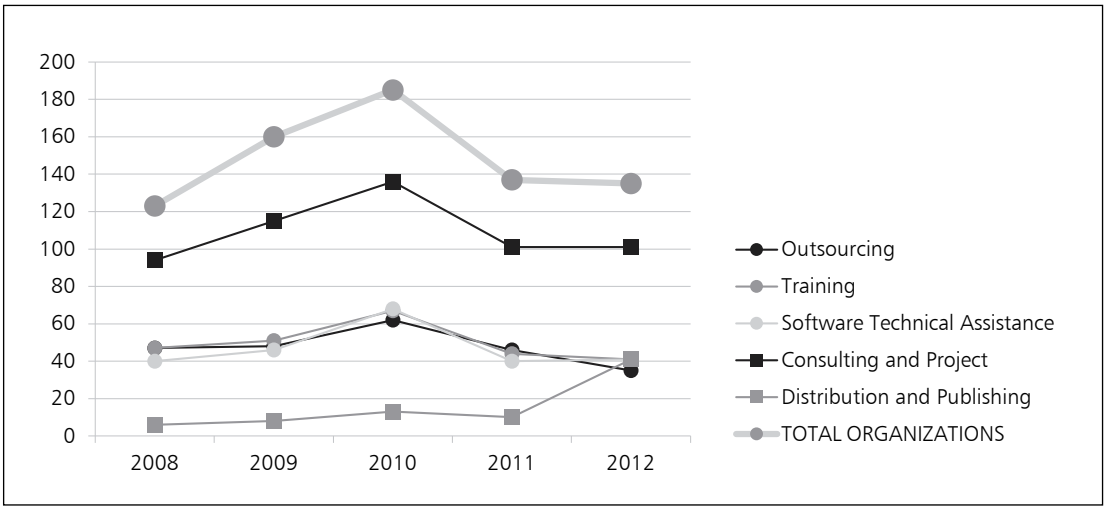


Figure 5.1. Service Categories Offered by Organizations that Adopted the MPS-SW

5.1.2. Application Domains

Different application domains have been considered over the years. However, we can see a reduction in the treatment of different Application Domains, such as Banking Automation. On the other hand, a few areas presented growth in their treatment, such as Integrated Management Systems - ERP, which again has increased attention from 2011 on, and Messaging Services, which began to appear for some organizations involved with MPS-SW. It is also interesting to note that some domains were not listed as being treated by the organizations in 2012 (Electronic Commerce, Administration Services and Computer Graphics).

TABLE 5.2 - Application domains addressed by organizations that adopt MPS-SW

Application Domain	2008	2009	2010	2011	2012	Variation
Banking Automation	24	22	24	15	15	-0.85
Human Resource Management	31	33	24	23	24	-0.82
E-Business	26	27	29	15	14	-0.80
Data Comunication	26	20	23	11	16	-0.78
Tool / SW Development Environment	25	30	27	14	16	-0.77
Electronic Commerce	26	28	39	16	0	-0.69
Manager Database	15	16	20	7	7	-0.68
School Administration	17	22	19	17	10	-0.68
Content Management	30	23	37	10	12	-0.67
Quality Management	21	16	25	10	10	-0.67
Services Administration	34	39	54	24	0	-0.65
Customer Relationship Management	32	28	45	21	15	-0.57
Webpages	60	66	79	45	46	-0.54
Knowledge Management	21	26	25	23	16	-0.52
Geoprocessing	11	9	19	9	3	-0.44
Legal Administration	12	9	15	9	10	-0.25
Business Automation	25	36	44	22	27	-0.17
Document Management	17	19	38	11	17	-0.12
Computer Graphics	1	0	3	4	0	0.17
Administration - Other	36	37	41	45	36	0.32
Distance Education	36	37	41	45	36	0.32
Automation - Other	17	12	22	22	17	0.38
Integrated - ERP	34	44	69	37	55	0.39
Messaging Services	0	0	0	0	7	0.71

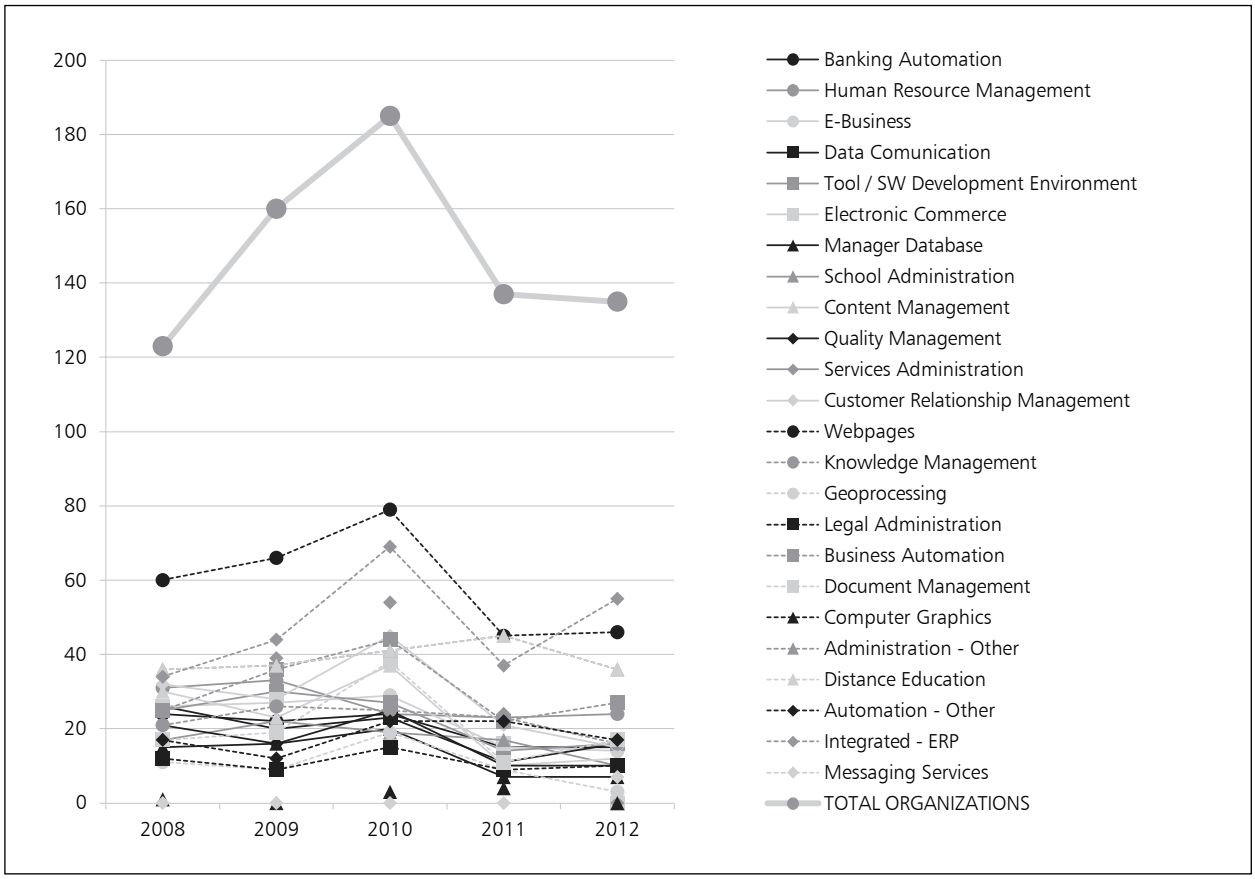


Figure 5.2. Application domains addressed by the Organizations that adopt MPS-SW

5.1.3. Product Categories

In the product categories, customization appears to be the main focus, despite the importance of other categories, such as embedded systems, which indicate to suffer a strong reduction of interest. At a time when the technological development of the country demands the integration of software systems and devices, this behavior draws attention. Embedded systems are extremely important and need specific technologies and practices involving software and hardware.

We believe that the practices suggested by maturity models are more focused on conventional software development (with or without agility) and may not be directly applicable to development requirements of embedded and ubiquitous computing systems. Despite not having data to support a more elaborated investigation, we consider it necessary to understand this phenomenon in order to provide opportunities for organizations working with this product category to also assure the quality of their products and processes in the MPS context.

TABLE 5.3 - Product Categories Offered by Organizations that adopt MPS-SW

Product Category	2008	2009	2010	2011	2012	Variation
Embedded	13	14	9	10	4	-0.88
Package	68	87	94	65	69	-0.24
Custom	93	111	136	108	103	0.17

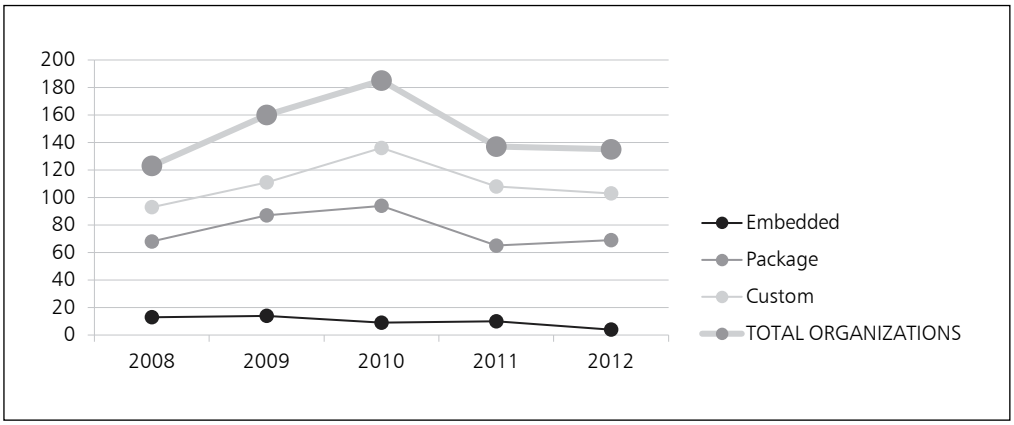


Figure 5.3. Product Categories Offered by Organizations that adopt MPS-SW

5.2. Performance Indicators

In the iMPS historical data a subset consisting of 226 organizations was found that, over the years, provided at least 4 questionnaires with information related to its performance with the implementation, assessment and use of MPS SW from 2008 to 2012. This criterion was used in order to obtain a representative sample of organizations that have already effectively internalized MPS-SW in their software processes.

For this subset, only the last questionnaire provided by the organization was used. Therefore, no questionnaire provided in the 2008 trial was considered and each organization contributed only once to the distribution of organizations by Year and MPS-SW Level, which can be seen in Table 5.4. Therefore, as expected, the latest iMPS trials contributed to the analysis with more data.

Organizations at levels F and G are the most frequent, observing an increase in the number of organizations at the highest levels over the years. Although this growth is expected, it can be noticed that the organizations, especially for those who contributed with data for the years 2011 and 2012, tended to remain at the maturity level achieved in the first MPS-SW assessment, either G or F. Considering the positive results that have been presented over the years with the use of MPS-SW, it would be interesting to extend the research to understand the reasons that might have led a few organizations to stop using MPS-SW or to not participating in the recent iMPS trials.

TABLE 5.4 - Distribution of Organizations per Year and MPS-SW Level

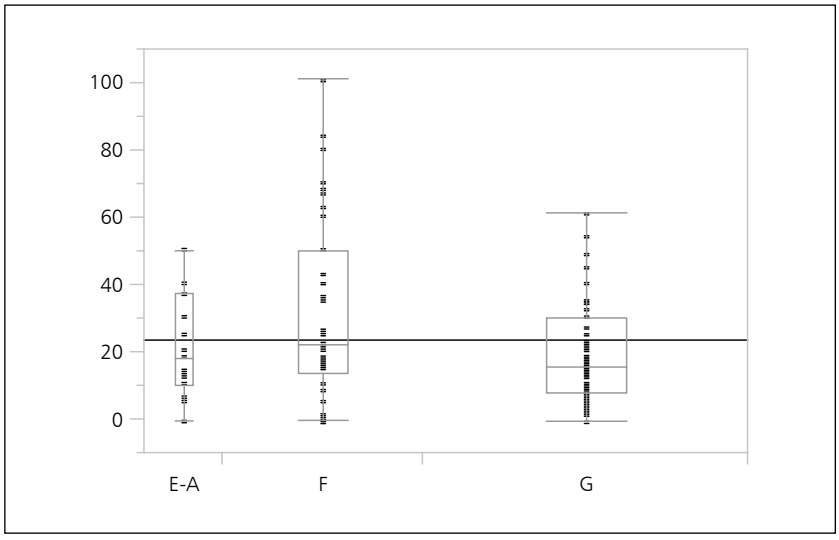
Level	2009	2010	2011	2012
G	10	48	29	47
F	6	14	21	23
E-A	2	3	8	15

Different perspectives of observation were used fot the data, according to the expectations previewed in the iMPS study. However, with the diversity and independence of data, some indicators could not be completely treated. To avoid misinterpretations, some overly positive and others negative, only those indicators that showed stability and sufficient quality for analysis will be presented. Similarly, indicators that showed no statistical evidence (alpha = 5%) in nonparametric tests (Wilcoxon / Kruskal-Wallis 1-way Test, ChiSquare approximation) are not presented in order to avoid discussion without any factual basis. Exceptions were made for indicators that showed results at the borderline with p-values very close to the limit, for which some analysis was performed in order to avoid losing the observation opportunity, considering the risks associated with the results.

For each indicator (treated independently) an outlier analysis was performed, removing the extremes by visualizing the distribution through boxplots. The use of statistical tests with higher power (parametric) was discarded because the treatment of the distributions in order to obtain normality and homoscedasticity led to samples with few organizations and therefore with low representativeness for the population.

5.2.1. Number of Customers in Brazil

The indicator Number of Customers in Brazil can be seen in the context of 145 organizations, after the removal of 81 outliers. As shown in Figure 5.4, the organizations of higher maturity levels tend to have more customers, with a slight advantage for organizations in level F (p-value = 0.0254).



Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
E-A	19	1348.00	1387.00	70.9474	-0.226
F	48	4136.50	3504.00	86.1771	2.658
G	78	5100.50	5694.00	65.3910	-2.354

1-way Test, ChiSquare Approximation

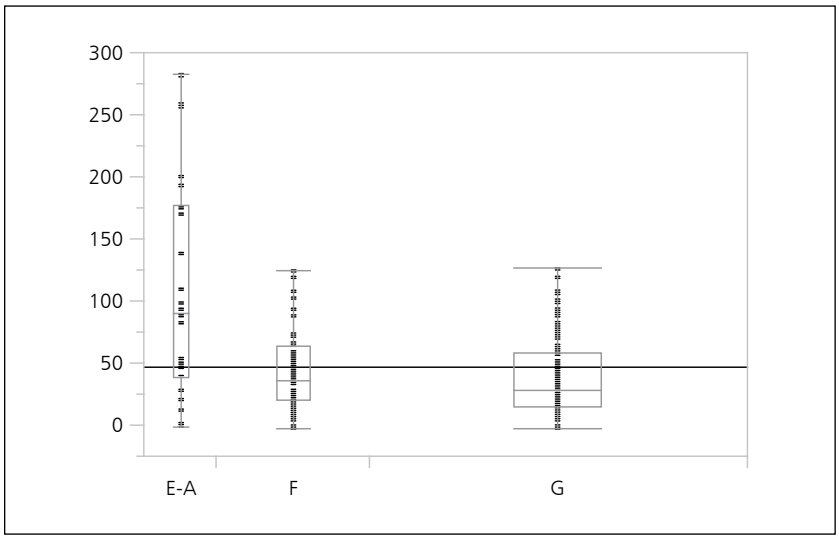
ChiSquare	DF	Prob>ChiSq
7.3439	2	0.0254

Figure 5.4. Numbers of Customers in Brazil per MPS-SW Level

5.2.2. Number of Employees

For this indicator 40 outliers were identified, having 186 organizations contributing to the result. As shown in Figure 5.5, the number of employees increases as the maturity level increases (p-value = 0.0006).

This behavior is expected because higher maturity levels imply more activities, thus requiring additional effort. On one hand, this behavior can lead to a negative interpretation by organizations, given the apparent increased investment needed, on the other hand, it shows the potential progress that the maturity level increase can bring. In fact, it is important to observe the behavior of this indicator in conjunction with the increase of the number of projects and customers, which rationally justifies the increase of employees to attend more business demands.



Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
E-A	22	2933.00	2057.00	133.318	3.693
F	47	4487.00	4394.50	95.468	0.288
G	117	9971.00	10939.5	85.222	-2.730

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
14.8667	2	0.0006

Figure 5.5. Number of Employees per MPS-SW Level

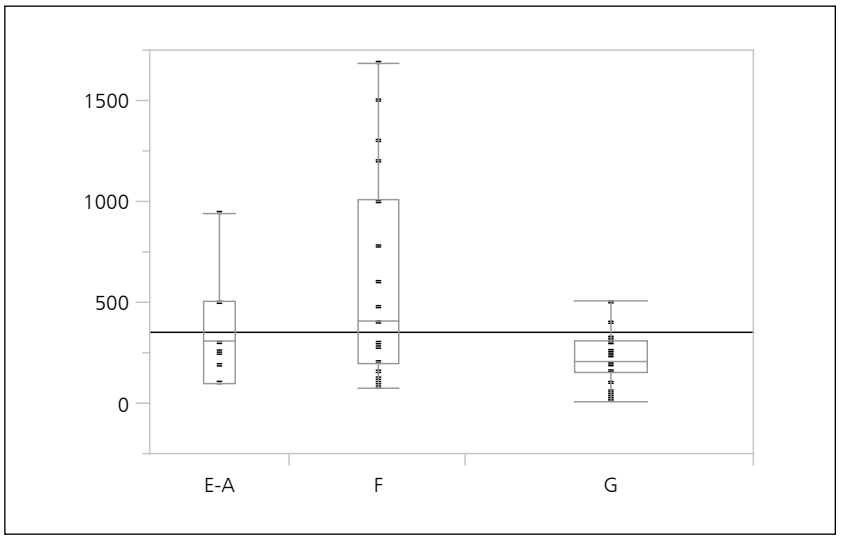
5.2.3. Average Project Size

This indicator apparently is not yet well understood by many organizations. It is observed that several measures are used without a consensus on which measure should be effectively used. In fact, there is still some conceptual mistake that needs to be treated in the field, because organizations have conducted measurements of size in time, screens, number of use cases, among others, that are not appropriate measures for this characteristic. Moreover, it is possible to see, for the same organization, some volatility related to the measures used over the years, avoiding a more elaborated evaluation on the organization's performance variation, since in these cases it is not possible to perform a temporal comparison of the results.

However, a subset of organizations informed to measure the size of their projects in Function Points. Despite of using the same unit, it is possible that the reported values are not directly comparable because of the way in which each organization counts the function points related to their projects. Therefore, the results presented below must be received considering this possible confounding factor.

From the 226 organizations, only 76 use Function Points as the size measure of their projects, 11 of which had to be eliminated (outlier). As can be seen in Figure 5.6, the average project size tends to increase for organizations with higher maturity levels (p-value = 0.0201).

It is understood that the greater the size of the project, the greater the need for management and control. Therefore, this result is expected and corroborates the behavior observed for the Number of Employees indicator (section 5.2.2). Although there is no statistical evidence, similar behavior can be graphically displayed for the organizations that measure their project size in Use Case Points.



Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
E-A	15	508.500	495.000	33.9000	0.203
F	19	802.000	627.000	42.2105	2.527
G	31	834.500	1023.00	26.9194	-2.479

1-way Test, ChiSquare Approximation

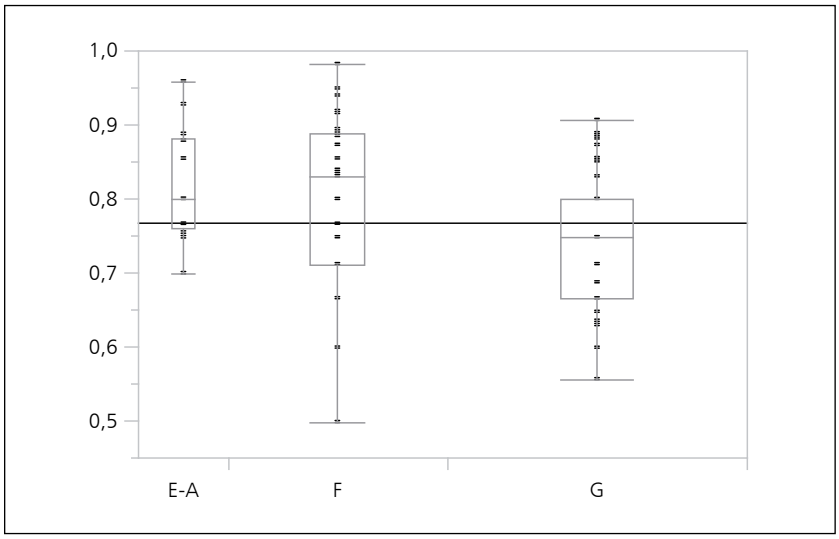
ChiSquare	DF	Prob>ChiSq
7.8113	2	0.0201

Figure 5.6. Average Project Size per MPS-SW Level

5.2.4. Estimation Accuracy

The expected behavior for this indicator is of increased accuracy for increased organizational maturity levels. This indicator is derived, as defined in the iMPS plan, from the project's average duration estimate and the average time spent on a project.

Of the 226 organizations, 139 were eliminated (outliers), causing 87 organizations to contribute with data that allows us to observe the estimation accuracy at different MPS-SW maturity levels. Figure 5.7 shows that organizations with a higher maturity levels have a higher estimation accuracy (p-value = 0.0034).



Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
E-A	13	740.000	572.000	56.9231	2.006
F	31	1582.00	1364.00	51.0323	1.939
G	43	1506.00	1892.00	35.0233	-3.291

1-way Test, ChiSquare Approximation

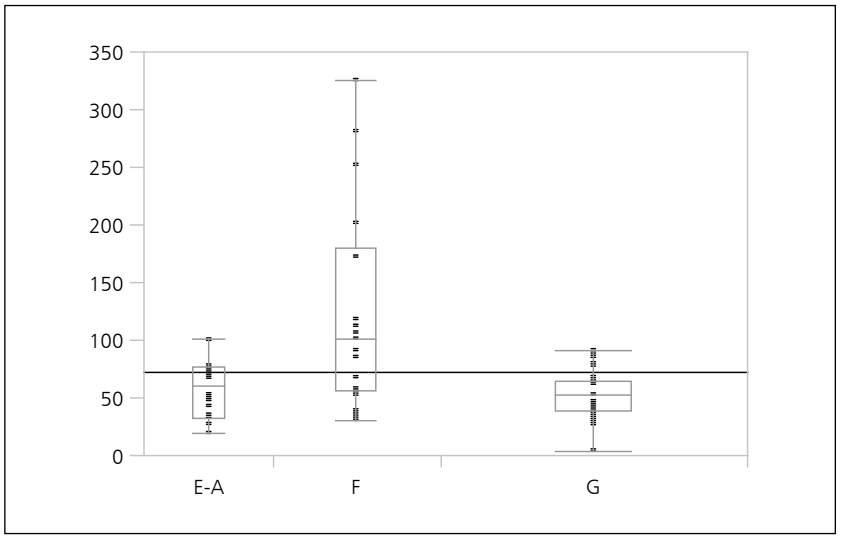
ChiSquare	DF	Prob>ChiSq
11.3649	2	0.0034

Figure 5.7. Estimation Accuracy per MPS-SW Level

5.2.5. Productivity

Productivity, according to the iMPS study plan, is treated according to the perspective of software. That is, productivity is considered here as being the amount of software produced (measured, for example, in Function Points) by the average project duration. As observed, productivity is a derived indicator, which depends directly on the size and duration of the project. In particular (Section 5.2.3) the indicator Average Project Size presents limitations of treatment that, consequently, limits the note about productivity.

Considering the organizations that presented the Average Project Size in Function Points, it was possible to use the data from 65 organizations (11 outliers removed), indicating that productivity increases as the maturity level increases, with a slight advantage for organizations at level F (p-value = 0.0010) as seen in Figure 5.8.



Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
E-A	14	421.500	462.000	30.1071	-0.639
F	18	844.500	594.000	46.9167	3.671
G	33	879.000	1089.00	26.6364	-2.754

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
13.8645	2	0.0010

Figure 5.8. Software Productivity per MPS-SW Level

Productivity and Estimation Accuracy can be considered essential to establish reliable parameters regarding project planning. Although it is not possible to establish a linear relationship between them, reducing their variation may represent an important business advantage that should be pursued by organizations.

To support this argument, we provide the results of the analysis of the relationship between productivity and the number of projects and also between productivity and defect density. It is understood that, in theory, organizations that keep their software processes adhering to the best software engineering practices should maintain their productivity levels regardless of the number of projects and that the impact of rework, due to defects, would be reduced. To support this argument, and considering that using only the data of the organizations shown in Figure 5.7 would introduce a limiting bias into the sample, a log transformation was applied to the distribution of the productivity, in view of the definition of the indicator. Thus, all valid measures (Project Size / Project Duration and Number of Defects / Unit of Size) were transformed using a natural logarithm, a practice commonly used when processing conceptually equivalent scales.

As can be seen in Figure 5.9, there is a strong inverse relationship between productivity and the number of projects, notably more intense (leaning of the line) for organizations at level F (p-value = 0.0049). That is, the larger the number of projects, the greater the reduction in productivity. The organizations at level G also showed similar (p-value = 0.0061), but less intense, behavior.

As for organizations in the higher maturity levels, there is an inversion (p-value = 0.0006), which means, the increase in the number of projects does not present a trend of reduced productivity, on the contrary, there is an increasing trend. This behavior conforms with the expectations of software engineering, considering the presence of additional management and control practices.

Levels G and F, despite their importance, are initial levels of adjustment and should not be considered as the ultimate goals of software organizations that demand the management of their software processes and that develop large-scale or lot of systems. Particularly, the reuse of artifacts between projects may be helping this positive relationship in organizations at a higher maturity level. However, we do not have enough data to extend the observation, and further investigations are needed to support such claim.

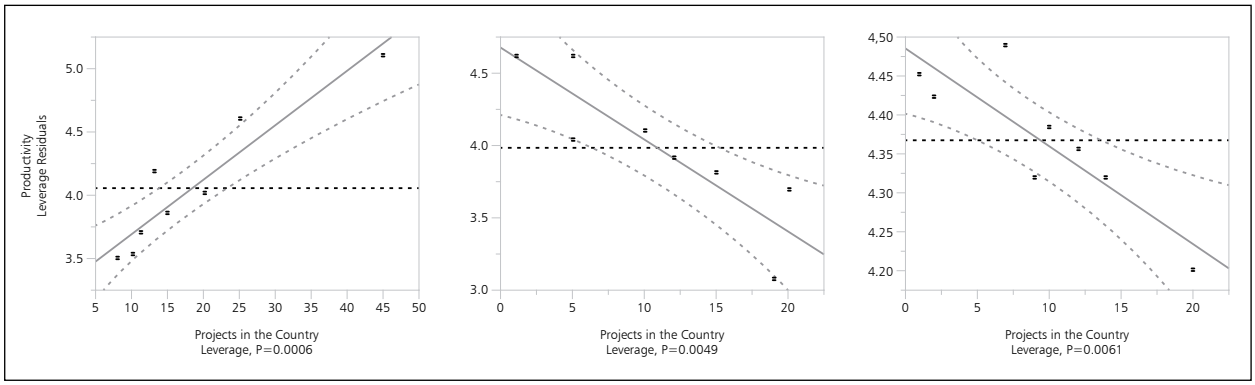


Figure 5.9. Productivity X Number of Projects in MPS-SW Level (E-A, F, G)

Similarly, as can be seen in Figure 5.10, there is a strong inverse relationship between productivity and defect density for the organizations at levels G and F (p-value <0.0001). Although the graph indicates a similar relationship, it is less intense for organizations at levels E-A, there is no statistical evidence to support this statement. In fact, based on the technical literature, we expect a negative relationship between defect density and productivity, since the existence of defects indicates the need for rework. However, there is an expectation that this impact is effectively smaller in organizations at a higher maturity level considering the different processes and established practices, especially those inherent to traceability, testing, inspection, risk management and causal analysis.

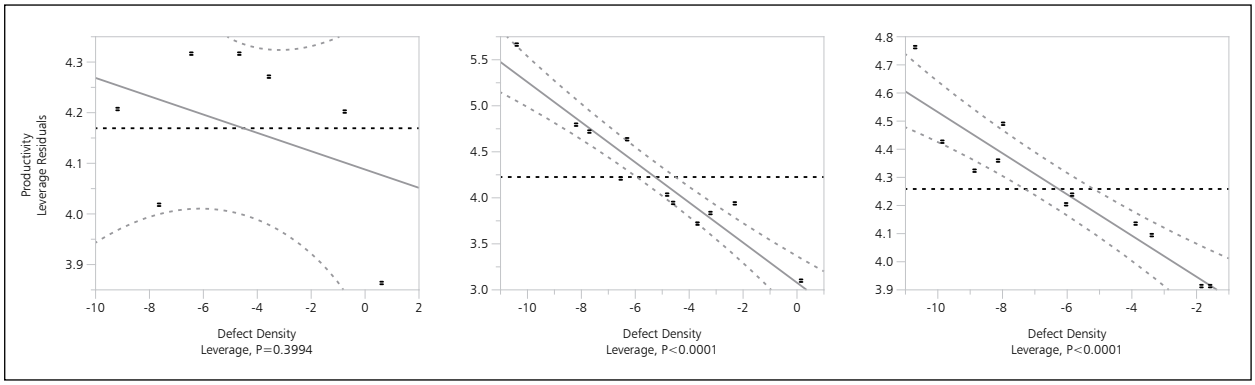


Figure 5.10. Productivity X Defect Density in MPS-SW Level (E-A, F, G)

6. Concluding Remarks

In 2012 the MPS-SW model has passed the milestone of 400 assesments in software development organizations. This publication presents the results of the 2012 iMPS project trial, which aims to monitor the performance of these organizations.

This year, 132 organizations (15 starting implementation, 37 in assesment process, 47 assessed at MPS-SW maturity level G, 19 assessed at MPS-SW maturity level F and 14 assessed at MPS-SW maturity levels E-A) responded to the survey, making the historical base contain 743 questionnaires relating to 298 organizations that participated in iMPS trials from 2008 to 2012.

To allow describing the behavior of these organizations, the results were presented in two different observation scenarios: (i) present the characterization of the organizations based on the data provided in the year 2012 and (ii) present results of a global analysis involving the aggregated data of the organizations that participated in the iMPS trials from 2008 to 2012.

The characterization showed similar behavior to previous results, reinforcing the indication that higher maturity levels improve the performance results for variables such as productivity, quality and estimation accuracy. A positive correlation between the percentage of organizations that export and the increase of the maturity level could also be observed. The satisfaction of the organizations with the model in 2012 remained high (greater than 95%).

Regarding the overall analysis, on the other hand, this time the volume of information of the iMPS project already allowed to obtain more explicit statements about the effects of the MPS-SW model on the organizations that use it. In the fourth trial of the iMPS research (iMPS 2011) [Kalinowski and Travassos, 2012] it was already possible to observe that as organizations acquire maturity the number of customers, the number of projects, the number of employees, and the size of projects also increases and the estimation accuracy improves. The overall analysis of this year, after the fifth trial (iMPS 2012), in a sample composed of 226 separate organizations, reinforces these findings and also the findings of the 2012 characterization, highlighting the importance of seeking higher maturity levels for the sake of productivity, quality and estimation accuracy.

Additionally, the relationship between productivity and the number of projects presented evidence that organizations with higher maturity levels are able to handle a larger number of projects without sacrificing productivity of each individual project. This way the research presents evidence that the adoption of the MPS-SW maturity model and seeking for higher maturity levels helps in structuring the organization to be able to attend a larger volume of business demands, absorbing a larger number of employees without sacrificing its performance related to productivity and quality.

Despite of the data quality, it is still possible to see that the organizations have some inconsistency in the measurement and monitoring of their projects. It is important to emphasize the importance of establishing policies for robust project management, regardless of the adopted development strategy (traditional or agile) and in this case, it may be interesting to discuss the completion of additional training in the organizations to strengthen these technical aspects.

It is also evident that there are strong indicator variations among organizations of the same group, which can be noticed based on the large number of outliers removed in each analysis. Some organizations have indicators that are far below their peers, while others, on the other hand, outweigh

the existing expectation for the group in question. These cases need to be investigated, because they may present improvement opportunities to the practices usually instantiated in organizations that may serve to evolve the MPS-SW itself, incorporating concrete recommendations on activities and software technologies (based on evidence) that can support the improvement of the software processes of these organizations. However, this investigation is beyond the scope of the current iMPS project.

There is general tendency of organizations to focus on activities related to conventional software projects. This may show the existence of high demand in this specific market, while, on the other, points out that some other areas, particularly with regard to organizations that adopted the MPS-SW, have not been considered by these organizations, as the case of Embedded Systems. These systems involve different computational characteristics combining hardware and software, and usually deal with the composition of systems of systems, technological trend for the coming years. This way, there is an opportunity to move towards providing the model with processes and software practices that address software for this specific domain.

It is important to notice that some context variables that may be influencing these results and represent threats to the validity of the study (such as economic factors, and others) were not considered or not identified. All possible efforts were made to make this analysis as consistent, fair and explicit as possible. However, some risks of misinterpretation can naturally exist. We believe that the observed behaviors may serve to motivate organizations already using MPS-SW to continue their improvement activities and to support the decision of those organizations wishing to start to adopt the MPS-SW in a near future.

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iMPS 2012: Evidence on Performance of Organizations that Adopted the MPS-SW Model since 2008

The iMPS 2012 survey featured electronic questionnaires answered by 132 companies involved with the MPS model for Software (MPS-SW), making the historical iMPS basis contain 743 questionnaires referring to 298 organizations that participated in the iMPS trials from 2008 to 2012.

The satisfaction with the MPS model remains high (> 95%).

In 2012, the characterization showed similar behavior to previous results, reinforcing the indication that higher maturity levels tend to have better performance regarding productivity, quality and estimation accuracy.

The global analysis since 2008, in a sample consisting of 226 separate organizations, supports the results of the characterization and highlighted the importance of seeking higher maturity levels for the sake of productivity, quality and estimation accuracy.

As this study is unique in the world, it is expected that the objective evidence presented as results of this fifth trial of the annual iMPS survey will be useful to stakeholders of the Academy, Government and mainly in Industry (Triple Helix) in order to improve software processes and increase the competitiveness of software companies.

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