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MEASUREMENT PROCESS OF SOFTWARE DEVELOPMENT PROJECTS FOR SUPPORTING STRATEGIC BUSINESS OBJECTIVES IN SOFTWARE DEVELOPING COMPANIES

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ABSTRACT

Software developing companies work in a competitive market and are often challenged to make business decisions with impact on competitiveness. Models accessing maturity for software development processes quality, such as CMMI and MPS-BR, comprise process measurements systems (PMS). However, these models are not necessarily suitable to support business decisions, neither to achieve strategic goals. The objective of this work is to analyze how the PMS of software development projects could support business strategies for software developing companies. Results taken from this work show that PMS results from maturity models for software processes can be suited to help evaluating operating capabilities and supporting strategic business decisions.

Keywords: Measurements for Software Development Processes; Quality Assessment for Software Development Process, Strategic Management of Software Developing Companies

1. INTRODUCTION

Software products currently play an important role in many areas of the world economy. For instance, for a company that manufactures high-tech printers, today would be easy to copy the pieces of metal, glass and plastic used to build this product. However, the software embedded for operating these printers is the key factor that differentiates them from illegal copies. Software also plays an important role for managing companies' activities, as its effective application is a key factor for supporting strategic business decisions and improving market competitiveness.

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Professionals and companies working in the software development market are also responsible for developing applications that are capable of adding business value to the companies that hire them. Contractors of software development services return to contracting suppliers when satisfied with the value added to their business from the acquired software. Therefore, the satisfaction of customers who hire software development services relates to the development process as well as from the software's ability to improve contractors' business activities.

Software developing companies face challenges to remain competitive in their business market, and that depends, amongst other issues, on their commitment to satisfy customers. Software companies are also demanded for continuous improvements in their working processes to remain competitive and the adoption of established models to ensure maturity in their software development processes is seen as a way to get market recognition for the quality of their work (SOFTEX, 2012B).

The adoption of models for quality certification of software processes involves the use of measurements that are not directly related to the business management of software developing companies. Maturity models such as CMMI and MPS.BR are adopted as a differentiating factor and also as facilitators to improve software process quality. These models describe software processes with established best practices and focusing on continuous improvement, aiming at operational excellence. They also have measuring practices for analyzing development processes that can work for improving flexibility and quality in the business processes of software developing companies (SEI, 2010). These models do not advocate that the measurement process should be aligned with the business objectives of the software developing company (SOFTEX, 2012a; SEI, 2010). Therefore, it is important to explore software processes measurements concerning their role for supporting strategic business objectives of software developing companies.

The objective of this work is to analyze the software development measuring processes for supporting strategic business objectives in software developing companies. Given the importance of strategic business management and the adoption of certification models for software process maturity, the analysis in this work aims at showing the benefits for aligning software process measurements with business strategic objectives. To cope with this objective, this work presents in section 2 the literature review on issues as software measuring processes and management of software developing companies. Section 3 presents the methodology used to conduct the research. Section 4 shows the analysis of the results found in the research work. Section 5 presents the conclusions of this research work regarding its objectives.

2. LITERATURE REVIEW

This chapter presents a literature review that guides the research work, with emphasis on issues of business strategic planning and management, organizational performance, business process management, management of software development processes and management of software developing companies. Further details on process management are presented in the following section.

2.1 Process Management

The internal structure of a company and its strategies to approach the market are related to its values, mission and business objectives, which are driven by their Strategic Planning (SP). The SP of a company should clarify essential business processes, long

and short-term objectives, as well as performance measurements for business management (Pessanha, Prochnik, 2004). The process management entails the understanding and results analysis of a company business processes, aiming to improve performance and delivering benefits for stakeholders, including customers, suppliers and shareholders (FNQ, 2009).

According to the principles of excellence from the evaluation system from the Brazilian Award for Quality Management and Productivity (Prêmio de Gestão da Qualidade e Produtividade - PGQP), companies work as a sum of processes, which consume resources, subject to continuous improvement, and customer perception plays an important role for achieving competitive advantages (FNQ, 2009). Process management implies predictability of results and assists as a foundation for innovation and improvement (FNQ, 2009). Therefore, it is necessary to map and understand the business processes and customer requirements for driving improvements and delivering benefits to company's business. Process management is also driven by repetition and resources optimization, thus considering the final customers' perception of added value to products and/or services (Gonçalves, 2000). It also comprises a systemic view of the organization, assisting the allocation of resources to the most relevant business objectives defined by the company's SP (Lamb, Dalla Valentina, Possomai, 2001).

Some company's business processes may produce results that are not perceived by the final customers, though they are essential for business management and strategies. It mainly occurs with service providing organizations, such as software developing companies (Pessanha, Prochnik, 2004). For those companies it is highlighted the use of the Balanced ScoreCard (BSC), as it deals with an analysis based on different perspectives that must be considered together for representing business management from a systemic viewpoint (Lamb, Dalla Valentina, Possomai, 2001). The Internal Process perspective in BSC is the one that indicates the fundamental processes and factors defined as priorities to achieve business objectives (Kaplan, 2006). Moreover, business management requires the use of measurements that are capable of tracking companies' performance, and it also applies to software developing companies.

2.2. Strategic Management in Software Developing Companies

Until the early 1990s most of the software development projects and related activities were conducted within the company and by their own employees (Rocha, 2001). From the 90s onwards, companies started becoming more complex with their internal and external working activities, and thus requiring more specialized services. This led to an increase in hiring specialized third parties for delivering services, as well as a growth of companies working as services providers (Kubota; Nogueira, 2007).

Software development services have undergone a major transformation in the late twentieth century, as they have become more focused on hiring professionals with programming skills from independent software developing companies. They allow contractors to focus on their strategic business activities, thus reducing direct costs, though having to manage third parts contracts (Rocha, 2001). As of the moment the number of independent software development projects started to be hired from independent companies, there has been a growing number of software developing companies, with their own dynamics, processes and business objectives (Roselino, 2006). These transformations have led to a higher degree of specialization in software production, favoring the expansion of software developing companies (Rocha, 2001).

According to the of Brazilian Association for Companies of Information Technology Systems and Internet (ASSESPRO) there is a great market opportunity for software services companies to work in Brazil as well as for exporting (ASSESPRO, 2008). IT now plays an important role in the country's technological development, offering both economic and social benefits (SOFTEX, 2012B; ASSESPRO, 2008). The use of IT in enterprises should be evaluated considering its impact on the corporate structure as a whole, focusing on achieving expected results in regard to the business objectives defined in the SP (Brodbeck, 2001).

In spite of the opportunities thatsoftware developing companies have to grow their business, there are still management challenges that have to be faced (Petit, Janssen, Pereira 2007). Managing the growth for this type of company is a difficult task due to several factors that are specific to the sector. For instance, one of these factors is that 93.4% of the software developing companies in Brazil are micro (43.8%) and small (49.6%) sized (ABES, 2012). Another factor is that software developing companies are usually managed by professionals with a technical background, and not business experts. Business management for software developing companies requires different knowledge and skills from those offered by computer science schools (Cusumano, 2004). Furthermore, software development is an activity surrounded by uncertainties that could affect project outcomes, since the result is an intangible product that takes mostly the intellectual effort from developers with no business background. The expertise for managing human resources, business process development, quality of products, as well as the use of structured systems development models are key to the success of software developing companies (Kubota, Nogueira, 2007).

2.3. Process Management of Software Development

Management for software processes requires knowledge and tools for measuring all working activities involved. In spite of the benefits that could be gained from models for certifying software processes, cost and complexity are factors that must be considered by software developing companies willing to adopt them (Wiegers, 2003).

Knowledge and techniques for measuring software processes have been evolving in the software engineering domain (Pressman, 2006). According to Kubota and Nogueira (2007), to manage a software developing company requires continuously improving staff and conditions that leverage working processes performance. It is notseldom to find software developing companies considering process measurements as an additional and difficult activity. However, PMS have been adopted as a proactive approach by software developing companies willing to improve software quality from a viewpoint of development processes (Salviano et al., 2004).

Maturity models have been designated as references to help identify which metrics should be collected to properly manage software development projects. For instance, the Capability Maturity Model Integration (CMMI) provides elements for software processes management (Salviano et al, 2004). Though maturity scales are well known for measuring software process quality, they are mostly based on the concepts developed by Crosby (1979), Deming (1986), Juran (1995) and Humphrey (1990), whose aim was to evaluate quality for general business processes.

This research work considers only the PMS present in MPS.BR and CMMI, both used for assessing quality of software development processes. Maturity models application implies that, as far as the process maturity grows, companies' policies, standards and organizational structures become more institutionalized within the whole organization. As the maturity level grows, the amount of collected data and process

analysis develop a more meaningful role, thus following the approaches indicated by the different maturity models (SOFTEX, 2012a). The metrics are essential to achieve an objective and to improve communication correctness to software development personnel. Therefore, it is essential for measurements to be based on quantitative and accurate data collected from software development process (Rock, Maldonado, Weber, 2001).

To implement a measurement process, it is first necessary to define what the company needs to know, and then identify the right measurements to be collected from the right processes. A common mistake is to decide for a measurement process without evaluating its actual value for the company (Rummler, Brache, 2007). Another common mistake is having professionals that lack specific expertise on process management, as it is necessary to assign responsibilities to people who know about the concepts involved in measuring, data collection, information analysis and reporting for decision support (Softex, 2012a). According to Kulpa and Johnson (2003), for a measurement process to be successful it is necessary to:

- be closely linked to the business objectives;
- have a systematic and spread use to justify its cost and effort;
- be well-defined to allow understanding and comparison, and;
- be communicated impartially and thoughtfully.

Once defined the objectives of a PMS, it is necessary to define the management processes, covering such aspects as (Kulpa, Johnson, 2003):

- measurement objectives should indicate its definition, purpose and scope;
- metrics must be related to the company's business objectives, goals and strategies;
- considering a systemic view of the software project as a whole;
- setting a clear and thorough definition of technical aspects for the metrics and measurements;
- involving all professionals in the organization;
- defining ways to use, storage and communicate results;
- defining roles and responsibilities about the measurement process and metrics, and;
- developing policies for safe communication and the actions to take with the metrics results.

The measurement process present in maturity models for software processes can function as the foundation for structuring a PMS with metrics for supporting business decisions at software developing companies (Johnson, 2004). The demand for measurements is associated with the maturity levels, as required for meeting the objectives of each maturity level (SOFTEX, 2012a; Sei, 2010). The continuous analysis of measurements acquired from different software projects and processes can provide information to support business decisions, corrective actions for projects and for promoting competitive advantage. Considering this whole scenario for software process management, this research work analyzes the software development measuring processes for supporting strategic business objectives in software developing

companies, thus developing relationships between strategic business objectives and metrics from software development processes.

2.3.1. CMMI and Software Processes Measurement

CMMI has a process area specifically dedicated to project metrics, which is referred to as Measurement and Analysis, and it is at level 2 (Sei, 2010). The CMMI presupposes standards applied for generating metrics that truly represent the software projects under evaluation (Sei, 2010). However, this reality is not present in some companies, especially for those applying CMMI only aiming for certification, neither as an opportunity for improving business management nor for software development process and projects (Kulpa, Johnson, 2003).

All CMMI metrics are related to activities of a Process Area (PA). For instance, one could measure (Sei, 2010):

- the time taken to perform the planning task for the Project Planning PA;
- if the supplying plan is delivered as planned in the Supplier Agreement Management PA;
- the time taken to create the quality assurance plan in the Quality Assurance PA; and
- if the costs of the company's projects are delivered as budgeted and planned in the Quantitative Project Management PA.

The Measurement and Analysis PA describes essential characteristics to determine the maturity of the measurement process in an organization. As part of the CMMI, it contemplates what should be done to achieve a maturity measurement for the software development process (Sei, 2010). The purpose of the metrics in CMMI is not to provide guidelines for project development, but for allowing results obtained from measurements to assist the project performance analysis, including comparisons among different projects. If projects results are not as expected, they allow identifying the place and cause of failures. As time goes on, the understanding of CMMI metrics and companies results allows eliminating causes of similar problems affecting projects performance, thus helping to ensure that business objectives are achieved (Mcgarry et al., 2002).

2.3.2. MPS.BR and Software Process Measurement

Measurements in MPS.BR have the main goal of supporting decision making for software projects, which are based on the management of processes development, and meeting business objectives of software developing companies (SOFTEX, 2012a).

Measurements in MPS.BR start at level F and go up to A, and must be aligned with business objectives and needs for strategic information of software developing companies, thus providing quantitative performance pointer for projects and working activities (SOFTEX, 2012a .) The measurement process goes through all MPS.BR maturity levels (F to A) and is represented by the 4th Process Attribute Result (RAP 4). For instance, in level F it aims to identify whether measures are planned and collected for monitoring the implementation process, and for helping making adjustments (SOFTEX, 2012a). The achievement of RAP 4 is what makes the measurement applicable, both for projects and for processes, thus generating the data required by the organization. RAP 21 is another example and it is mandatory from level E. It defines the

measures to be collected and analyzed, thus providing a basis for understanding process behavior and allowing continuous improvement.

The measuring activity requires time, effort and financial investments. It is also important to identify metrics that are associated with measurement process that are the most strategic to the organization, regardless of the reference model used (Mcgarry et al. 2002).

3. RESEARCH METHOD

This work was conducted as a multiple case study of an exploratory research, since it seeks to develop a general theory to represent the phenomena under study (Tracy, 2010). According to Yin (2005), case study is an empirical investigation that seeks to understand the context of a phenomenon in a clearly defined situation. Case study research as a whole is applied for building analogies and comparisons with previously modelled phenomena of for generating new models for explaining a research problem (Campomar, 1991), thus allowing the creation of new ideas and theories that may arise from the research work.

This work carried out a multiple case study developed through a qualitative and cross-sectional research. The qualitative aspect allows the in-depth analysis from the experts' perceptions about the researched elements (Tracy, 2010; Bansal, Corley, 2011). According to Mattar (1996), this type of research offers the possibility to obtain extensive knowledge about the issue in focus, fostering understanding of concepts and peculiarities about the behavior of a phenomenon. The analysis depth and results of such research depend primarily on the researcher's effort to deepen the interviews and dig out for relevant results (Bansal, Corley, 2011). The cross-sectional characteristic indicates that the data was collected only once in each company, and at a similar time interlude. Cross-sectional surveys are especially applied in cases with limited time and resources, as well as in situations whose aim is to evaluate a research objective in a specific time frame (Collis, Hussey, 2005).

The interviews in this work were conducted based on a semi-structured research instrument and carried out as focused and informal. This type of interview allows the respondent to freely make comments about situations and challenges that seem to be related to the research issues, thus focusing on the issues related to the research problem (Malhotra, 2006). In this research, the focus was the analysis of software development measuring processes for supporting strategic business objectives on software developing companies. Multiple case studies can be applied for comparing results from different companies (selected cases for study), based on a unique criteria to examine similarities and differences between the investigated cases (Tachizawa, 2002).

The cases analyzed in this research were software developing companies that comply with the following selection criteria:

- having adopted models for maturity assessment to software development processes; and
- being evaluated from level 2 or above with CMMI (Sei, 2010) or from level G or above in MPS.BR (SOFTEX, 2012a).

The selection of case studies was also characterized by criteria such as the companies' role in the software developing market, willingness to contribute with

knowledge on the research issues, allowing access to business managers and software process experts, and by the interest of respondents with the research objectives.

3.1. Structure of the Research Instrument

Research instruments are used to represent and provide understanding about the reality of a well-defined research topic (Hoppen, Lapointe, Moreau, 1996). The research instrument used in this study was developed based on the recommendations indicated by Cooper and Schindler (2003) and it has types three of measurements:

• Demographic Measurement: aims to collect demographic data to identify respondents' profile as well as to set the interviewing procedures and promoting a closer relationship between the parts involved (researchers and respondents).

• Classification Measurement: for gathering information about the alignment between the SP and the software process measurement, regarding the support for achieving business objectives.

• Directing Measurement: analyzes the company's profile and maturity level to analyze the attributes that might be influencing the relationship between software process performance measures and company's endeavor for achieving business objectives.

More information about the analysis carried out in this work to assess the alignment between the software development measuring processes in relation to strategic business objectives of software developing companies is presented below.

3.1.1 Contents of the Research Instrument

The structure and contents of the semi structured research instrument used in this work, to analyze the software development measuring processes for supporting strategic business objectives of software developing companies, were based on the literature review. The review included issues related to the ways of assessing business processes results as to offer a deeper understanding about the use of maturity scales.

As a result of the literature review, the instrument was built with three Dimensions of Analysis (DA), each one represented by Analysis Factors (AF), i.e., questions to be answered qualitatively by the respondents to show their opinion about the issues in the research instrument. The AFs and DAs in the research instrument are described as follow.

DA01 - Strategic Management Dimension: aims to explore if the SP process and the deployment of the company's strategic objectives have the requirement for establishing a business measurement process. The AFs used to represent this DA and details about its applicability are described below:

• AF01 - Strategic Objectives: aim to verify how business objectives are created and their importance within the organization, and are evaluated by asking questions about:

i) the existence of a formal process for its characterization;

ii) if the role and responsibilities for personal are indicated;

iii) if the allocation of resources for achieving objectives is tracked, and;

iv) who the participants in the SP meetings for defining the business objectives are.

- AF02 - Measuring Performance: aims to analyze how organizational performance is monitored and if it is associated with the organization's strategic objectives. It is evaluated through four questions:

  i) if there are measurements and targets linked to strategic objectives and how they are designed and communicated,

  ii) which criteria are used for measuring performance (cost, technological leadership, market leadership, business leadership, customer satisfaction, product quality, or any other criterion adopted by the company);

  iii) how performance measurements are used within the organization; and

  vi) presence of metrics for a continuous evaluation of strategic objectives on aspects such as definition, collection, analysis and communication.

DA02 - Process Management Dimension: evaluates if the strategic processes are managed with metrics that are identified, prioritized, and monitored. It also aims to verify the viewpoint of the managers who participate in the SP about the importance of software processes measurement, and of the process manager about the SP. Details about the AFs used to represent this DA are the following:

- AF03 - Process Planning: checks how processes are defined, prioritized, resourced and assigned to a skilled person in charge, questioning about:

  i) how the processes considered strategic for the organization are identified;

  ii) if there are efforts for processes prioritization;

  iii) if the processes are assigned with resources and a manager in charge;

  iv) how the processes are institutionalized and communicated in the company; and

  v) how the process are linked to the strategic business objectives.

- AF04 - Process Performance Measurement: analyzes how processes performance are measured and monitored, and it considers four questions about:

  i) how targets for process are defined,

  ii) how process results are evaluated;

  iii) what the role and importance of processes measurements results for managing activities are; and

  iv) how the process results are communicated throughout the company.

DA03 - Software Process Measurement Dimension: examines if it supports the setting of strategic business goals and the relationships between software processes and business metrics. The AFs present in this dimension are:

- AF05 - Software Process Measurement Planning: evaluates if the process measurement is defined, prioritized, resourced and assigned to a manager (or leader), and it involves three questions about:

  i) the identification of responsibilities in the measurement process

  ii) the prioritization of the processes to be measured; and

iii) approaches to support the creation of measurement processes (such as PSM - Practical Software Measurement, GQM - Goal Question Measurement, and others).

- AF06 - Software Process Performance Measurement: concerns how software process performance is monitored and it presents three questions about:

  i) how software processes are monitored (tools, frequency and alignment with strategic business objectives),

  ii) how results are used (corrective actions, problem mitigation, contingencies and decision support); and

  iii) which the current problems with the process measurement are.

- AF07 - Relationship Between Metrics for Business and Software Process: this factor analyzes the coverage of the relationship between strategic business objectives and software processes measurements, considering four questions about:

  i) by whom and how the relationship between strategic and process metrics is validated;

  ii) what the coverage of process measurements for business objectives is;

  iii) to whom the results are communicated; and

  iv) how business and process results are used as a whole within the company.

These dimensions, factors and questions were put together for interviewing business and software process managers in four software developing companies. Details about the interviewing process and the results analysis are shown in the following section.

3.2. Data Collection

Data collection was performed by semi-structured and in-depth interviews driven by the research instrument described in the previous sections. The interviews' contents were recorded and fully transcribed for further analysis. As a complement for the data collection, some companies' documents were also analyzed to help understand and confirm the answers. Process and business managers from the software developing companies selected for the interviews were firstly contacted by phone. Once they agreed with the research work, an email was sent to formalize the invitation and to set the date for interview. Along with the email, the research instrument with the questions was sent as an attached file. At the beginning of each interview, the respondents were informed about the research objectives and terms of confidentiality for respondents and companies involved in the research. Altogether, 10 interviews were carried out for understanding mostly about three company's issues, which were: i) business management, ii) software process management; and iii) software process measurement. All interviews were conducted by the researchers with each manager individually. The researchers also conducted the transcription and reviewing of the interviews' contents. The interviews took about one hour, with 15 minutes for the explaination about their purpose, and 45 minutes for answering the questions.

Shortly after the interviews, the companies' documents were reviewed. It was carried out with the supervision of the companies' quality managers, and though it was not a formal interview, it allowed deepening the understanding of companies'

procedures. Documents reviewing lasted for about 1 hour and 30 minutes in each one of the 4 companies studied, involving records related to: (i) software process measurements, (ii) metrics for software processes, (iii) business performance process measurement (iv) business performance metrics; and (v) strategic planning (SP). Interviews' contents were analyzed in-depth and the extensive experience of the researchers in the field was an advantage for analyzing results (Tracy, 2010; Bansal, Corley, 2011), as showed in the following section.

4. RESEARCH RESULTS

This section presents an analysis of the results from the interviews, as well as from the companies' documents. The studied companies are referred to in this work as A, B, C and D and the data analysis was first carried out within each company individually, comparing its documents with the interviews' contents. Further analysis involved commonalities and complementarities among the documents and the interviewing contents from all four companies. The studied companies showed a similar profile, as they are small and medium sized, and mostly focused on doing business in Brazil. They also adopted the maturity assessment model quite recently (2 to 3 years) and all four companies worked together in an effort for developing a software factory methodology in the state of Rio Grande do Sul - Brazil). This effort was part of a group of software developing companies coordinated by a business representative entity called SOFTSUL. These companies have also joined efforts in a partnership to attract clients from abroad and to promote the MPS-BR model internationally, in a cooperative effort called UNACORP. Moreover, all companies have formal software processes and development life cycle based on the Rational Unified Process (RUP). The companies' size was defined using the criteria developed by the Brazilian Institute of Geography and Statistics (IBGE), which considers the number of employees and owners, along with the business sector. Therefore, the companies studied in this work were indicated as service providers and categorized according to the following scale: (i) Micro: up to 9 employees, (ii) Small: 10-49 employees, (ii) Medium: 50-99 employees (iii) Large: 100 or more employees (SEBRAE, 2007). Companies' profile is summarized in Table 1.

Company	Size	Business Sector	Market	Company Age	Maturity Model	Model Adopted
A	Medium	Products + Services	National + International	16 years	MPS.BR - F	3 years
B	Small	Products + Services	National	18 years	MPS.BR - F	3 years
C	Medium	Services	National	9 years	CMMI - 3	2 years
D	Small	Products + Services	National	13 years	MPS.BR – F + CMMI -2	2 years

Table 1 – Companies' profile.
Source: authors.

4.1 Strategic Management

Regarding the AF01 (Strategic Objectives), respondents from the four companies indicated the existence of strategic planning (SP) in their companies and of procedures for aligning business objectives with the software development process. Companies A, C and D adopted the BSC and its perspectives associated with the software process metrics. Company B is already on its way for adopting the BSC. Regarding the FA02 (Performance Measurement), the aim was to verify how organizational performance is monitored and if it is aligned with the strategic business objectives of the organization. Oliveira (2005) mentions that it is necessary a constant monitoring for process results to successfully evaluate the achievement of business strategies. Therefore, the Performance Measurement System (PMS) conception and use were reviewed in the four companies and results are summarized in Table 2.

Dimensions	Analysis Factor	A	B	C	D
DA01 – Strategic Management	AF01 – Strategic Business Objectives	yes	yes	yes	Yes
	AF02 – Organization PMS defined	yes	yes	yes	No
	AF02 – BSC adoption	yes	ongoing	yes	Yes
	AF02 – PMS Results Supporting Business Strategies	yes	no	no	No

Table 2 – Companies' results for the AF01 and AF02.
Source: Interviews and document analysis.

Companies A, B, C and D highlighted that results from business metrics are used in their companies and that they help to improve the speed for strategic decision-making. Company B pointed out that business results are used with different purposes, according to the company sector and hierarchy, thus offering benefits throughout the company. However, company D only uses results from software development activities for monitoring operational performance. Among the difficulties for accomplishing a PMS in the companies studied, it was noticed that companies A and D have struggled for maintaining the alignment with business strategies. This fact was corroborated by Attadia and Martins (2003) as common to companies in the early stages of a PMS adoption. In Company B the major difficulty was related to the fact that the software measurement process was not considered as strategic, thus facing difficulties for allocating resources for its execution. For company C the major difficulty pointed out was about linking PMS results from software projects life cycle with business results, as they are evaluated in a different time frame and purposes.

The analysis of DA01 identified some red flags for companies to be aware of, such as:

i) difficulties communicating goals and criteria used to define metrics (A, B),

ii) PMS is not considered strategic and used only for operational purposes (B); and

iii) PMS is used properly to help make process decisions, but it still has not been used for supporting strategic business decisions (C, D).

Strengths taken from the analysis of DA01 are that the four companies have well defined business objectives that are used for supporting the design and goal present in the PMS. Therefore, the main differences are mainly related to the use of PMS results.

4.2 Software Process Management

The analysis of DA02 shows that all companies perform the planning process (AF03) based on formal and well known models for maturity assessment, which have been pointed out as suitable to excellence in process management (Rock, Maldonado, Weber, 2001). The identification of which processes are considered strategic for all four companies was carried out in the SP and based on business objectives. Though all four companies reported the BSC as a reference model for process management, company B is still implementing its practices. The other three companies are already using the BSC and considering its all four perspectives for mapping process priorities and driving the alignment between business and operational metrics (Pessanha, Prochnik, 2004).

According to FNQ (2009), it is necessary for a company to be able to control its process for achieving predictability and assertiveness in results. SOFTEX (2012a) quotes that knowledge about lead times and maximum production capacity for software development are also provided by process management practices. The literature highlights the importance of alignment between strategic business objectives and software processes metrics to obtain a suitable PMS (Rummler, 2007). As part of this work it was also investigated the foundation for conceiving the software process metrics, and the four companies indicated the SP as the main reference (GOETHERT, 2001).

For FA04 (Performance Measurement Processes) the four companies are adopting formal software maturity models for establishing the measurement procedures, which is compliant with the project planning PA from CMMI. Regarding the use of results obtained by the performance measurement process, there was a common issue in the four companies, which is the fact that all evaluation of results comes from the organization responsible for the software development. It means that all evaluation objectives rely on monitoring operations within the software developing company. Table 3 presents a summary of the analysis, design and use of performance measurement processes within the companies studied.

Although all companies have faced difficulties implementing an organizational PMS for the strategic management dimension (DA01), only Company B reported difficulties in process management. As pointed out by respondents from company B, data collection and analysis of software processes results should be more frequent, and process measurements should be taken to SP meetings and used for supporting strategic business decisions. Furthermore, communication of results should be carried out more effectively and spread throughout the company, and not used only for project management meetings. Companies A and D stated that a challenge for the PMS is of keeping the alignment between organizational performance objectives and metrics, as it affects the definition of objectives for process measurements. This problem of disassociated objectives between business and software processes is a major challenge for companies willing to establish a PMS (Henderson, 1996). Another difficulty quoted

by respondents from companies A and C regards the need for improving communications of processes measurements in alignment with organizational business objectives, as is it not just about spreading process results, but also about the impact on companies results and market performance (Kulpa, Johnson, 2003).

Dimensions	Analysis Factor	A	B	C	D
DA02 – Process Management	AF03 – Process orientation	yes	yes	yes	yes
	AF03 – Process priorities	yes	yes	yes	yes
	AF03 – Type of Operation	Projects	Software Factory	Software Factory	Products
	AF04 – PMS results	Operation capacity	Operation capacity	Operation capacity	Operation capacity

Table 3 – Comparison of comapies' results for AFA03 e AF04.
Source: Interviews and document analysis.

Companies A, C and D indicated difficulties for data collection and analysis of organizational measurements. According to Goethert (2001), this is a common problem on PMS, which can produce metrics that are misinterpreted or not significant to help managing software processes (Travassos, Kalinowski, 2009). This difficulty is associated with three PMS glitches cited in the literature (WIEGERS, 2003), that are: poorly defined processes; ineffective metrics; and lack of organizational culture. Respondents from companies C and D indicated that ineffective metrics and lack of organizational culture are issues that are still to be improved in their organizations. However, respondents agree with the literature review by pointing that a culture for evaluating operational process results is an important step towards achieving a successful PMS, and aligned with strategic business objectives (Travassos, Kalinowski, 2009).

Strengths related to DA02 are that company C as a software factory has a strong culture for reporting process results frequently, and it has provided a positive influence on results. In contrast, respondents from company C also commented that this is one of the organizational deficiencies related to its business PMS. Another issue that is common to the four companies is that they all have well defined and institutionalized processes that are used as guidelines for the PMS operation. Additionally, all four companies are monitoring processes results and recognizing that it could work as an important asset for the management of organizational results (Lamb, Dalla Valentina, Possomai, 2001).

4.3 Software Measurement Process

The literature review shows that the measurement process is an activity that requires resources and may be costly for companies, thus making it necessary to plan its

implementation for adhering to company's business reality. Moreover, the successful design and implementation of process measurement can help organizations' management (SEI, 2010). The processes measurement in the companies studied was based on the software process maturity models presented in this work (CMMI and MPS-BR). Companies A and B used the MPS.BR as the foundation for the AF05 (Software Process Measurement Planning). Company C was based on CMMI and D used both CMMI and MPS-BR.

It was also noticed that all four companies highlighted the importance of using a well-known model for developing the design and planning for measuring activities. In addition, company B highlighted the importance of formal processes to keep knowledge in the organization, which was defined as an important company's asset. Company C also stressed the importance of using a standard, formal and institutional PMS for handling knowledge about the software factory performance. Process maturity models describe that software measurement processes must have their own objectives, thus stemming from strategic business objectives. Software measurement procedures should also be adhering to company cultural context and providing information that is helpful to business management, as well as communicated and used for supporting stakeholders decisions (SOFTEX, 2012a). The analysis showed that all four companies have process metrics built from the software development processes (standard processes), with upper and lower limits well defined. However, all respondents agreed that software processes objectives should be defined at the SP and considering business objectives, and then associated with software processes. Only Company B mentioned that adjustments to software process values are made at operational level.

Regarding the AF06 (Software Process Performance Measurement), the four companies mentioned its importance to help identifying processes, to correct projects course and to mitigate problems. Company A was the only one that showed capability to use process results to support strategic business decisions. Despite of using process results only at operational level, companies B, C and D highlighted the use of process results to help getting knowledge about process capability, as proclaimed by maturity models (SOFTEX, 2012a; Sei, 2010). Company C was the only one mentioning that uses software process results to motivate people involved with the software factory.

A necessary feature for efficacy with process measurements is the presence of a relationship between business objectives and information needs collected from metrics of software processes. It means that it should be possible to identify the relationship between business and process measurements and metrics (SOFTEX, 2012a; SEI, 2010). In addition, it is also necessary to ensure that software process measurements provide operational elements that could be used at tactical level (Fernandes, Teixeira, 2004).

The analysis for AF07 (Relationship Between Metrics for Business and Software Process) showed that all four companies used different mechanisms for defining process measurements, though all are sourced in the business SP. To establish the relationship between business and software metrics, all four companies use artifacts from the software measurement process. For instance, company A uses an Organizational Measuring Worksheet, B uses the Organization Mapping and Definition Worksheet, D uses a Measures Specification Form, and C uses the Key Process Indicators, all as indicates by CMMI and MPS-BR. To ensure the FA07 link to all strategic objectives, the artifacts mentioned go through internal validation procedures. A summary of the analysis for DA03 is presented in Table 4.

Dimensions	Analysis Factor	A	B	C	D
DA03 – Software Process Measurement	FA05 – Process Design	MPS.BR	MPS.BR	CMMI	MPS.BR e CMMI
	FA 06 – Measurement Results	Decision making; Evaluate strategies; Realign Planning Allocate resources	Learning organization; Improving processes; Market comparison; Realign Planning Allocate resources.	Motivate teams; Monitoring operations	Learning organization; Improving processes
	FA07 – Metrics relationship	yes	yes	yes	yes
	FA07 – Metrics Coverage	artifacts	artifacts	paper	artifacts

Table 4 – Comparison of companies' results for AF05, AF06 and AF07.

Source: Interviews and document analysis.

Problems as lack of management support, difficulties to analyze metrics, data collection, and delay in implementing actions once results are obtained are some of the most frequent problems in processes measurement (Wiegers, 2003; Goethert, 2001) and they were all present in the companies analyzed. For instance, Company A showed that the most difficult issue is data collection, due to its volume and need to provide resources, such as tools and personal for collection. Company A also stated the need for greater involvement from business executives to disseminate the culture of measurement and the need for more frequent disclosure of results from projects and processes. Company B claimed that they have not been able to often review metrics results strategically, and that also need to enhance staff expertise about processes measurements and metrics. It all may be a consequence of a lack of perceived value in establishing process measurements. For company C, the time required for taking actions based on project measurements and the need to contextualize results to all projects to obtain a proper analysis are major difficulties. For instance, one of the respondents from company C stated that the time and effort required for the ability to make decisions supported by process measurements is long and it takes hard work in the organizations.

It is important to notice that the four companies showed issues that require attention, such as:

i) company A requires greater executive involvement to disseminate the culture of using process measurements;

ii) company B did not consider the measurement process as strategic;

iii) company C indicates a need to reassess who is responsible for process measurements design and results evaluation (from the quality officer to project managers, since they have more experience in improving software project performance); and

iv) company D is running the PMS based only on the software measurement process, and disregarding its role for an organizational context.

As strengths for the DA03, the four companies stated that are using metrics results from the PMS to further understand and learn about their software development processes capabilities and company's productive capacity. This is also shown in the literature review, as one of the goals of a measurement processes is that of supporting process understanding, as the companies' productive capacity is the sum of all its process capabilities (SOFTEX, 2012a; Sei, 2010). Company A shows a consistent alignment between strategy and operations, in regard to the PMS for software and operational processes. Company B currently uses the metrics only for monitoring the software factory processes, though there are initiatives planned to review the SP and adopt the BSC for strategic management. It should help to align the software processes measurement with the strategic business objectives. Company C communicates results from software processes and uses them to motivate and involve staff in process management at operational and tactical levels. Company D is aware of the need to step further from the software PMS to an organizational PMS and is currently conducting meetings to consolidate the actual apprenticeship to apply in a corporate level.

The analyses carried out in the four companies helped to verify if the software process measurement is able to sustain the organizational PMS. Furthermore, based on the literature review, it was possible for the researchers to identify actual weaknesses and strengths that influence the PMS success in these companies, as shown along with the result analysis.

5. CONCLUSIONS

The current scenario for companies in general demands agility, flexibility, and financially positive, technically viable and business sustainable decisions. For software developing companies these premises also apply, though there is also a challenge due to difficulties establishing process measurements that are capable of providing results to support strategic business objectives (Wiegers, 2003). The use of process measurements from software maturity models shows an opportunity to achieve the alignment between operational and strategic business processes, though it takes a long way to achieve them. This research work shows that the presence of well-defined process measurements provides knowledge that stays in the company, thus increasing its intellectual assets.

The literature review shows that measurement processes based on MPS.BR (SOFTEX, 2012a) and CMMI (SEI, 2010) provide companies with a framework to establish and institutionalize a set of measurements for software development processes. Additionally, the higher the company's maturity level, the higher the number of software process measurements. However, this work showed that three of the companies studied have the same level of maturity, though they are at different levels concerning the measurement process for supporting strategic business decisions. Moreover, the company with the higher maturity level is the one using the measurement process with the least alignment with business strategies. It was also noticed that the

company that adopted the maturity model for a longer time is the one with the best results for the alignment between software process measurements and business strategies. Therefore, the time elapsed since the adoption of a maturity model is also a factor that could affect the alignment.

The literature also indicates the SP as a critical success factor for implementing a software measurement process. The SP helps to identify the measurements required to reflect business strategies, as well as to define the key process for monitoring. All four companies indicated that the SP is crucial for helping to establish the relationship between indicators and business strategies processes and operational software process. Therefore, business and processes results should be part of the SP and analyzed jointly and timely related for supporting strategic business decisions. The analysis in this research work shows that, regardless of the PMS adopted, to succeed in supporting business strategies the measurement process should meet the objectives of the process being measured. Accordingly to the analysis, the use of the BSC helps to recognize the strategic processes that could drive the identification of measurements and metrics for supporting strategic business objectives.

Regarding the use of software process measurement in these companies, it was concluded that PMS results were only used for monitoring its own execution, thus generating knowledge about the companies' software development capacity. This capacity has an important strategic role, as that is the main operational activity of software developing companies. It was also noticed that PMS results could be used as a motivational element, as they can be communicated to employees, as well as considered for the definitions of operational goals to be overcome. Once properly defined, aligned and monitored, PMS results can support strategic business decisions.

The market reality of the studied software developing companies shows a constant need for quick decisions that may heavily influence strategic business positioning and financial results. There is also a need for an effective use of models to formalize performance measurement from software processes and to help supporting decisions in operational and strategic levels (Florac; Goerthert; Park, 1996). This work also shows that measurement systems for software processes could help organizations to manage knowledge about developing capacities and performance monitoring. However, it requires that measurement activities should gather data and provide information at various organizational levels and bring business and operations units together (SEI, 2010).

Market results published by ABES (2012) showed that there is a growing number of software developing companies adopting capability maturity models and process performance measurements. Although results of this study reflects only the reality of the companies studied, and it is not possible to generalize to all other software developing companies, it shows that there is still a way to go to fully align software process measurements with business strategies. Due to the number of companies studied, it is worth highlighting that the studied cases were supported by the literature review and that allowed the conclusions shown in this work. However, results taken from this work do not represent the software developing companies from the south of Brazil or the Brazilian sector as a whole.

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