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Integration of strategic management, process improvement and quantitative measurement for managing the competitiveness of software engineering organizations

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Abstract Strategic management is a key discipline that permits companies to achieve their competitive goals. An effective and explicit alignment and integration of business strategy with SPI initiatives based on measurement is essential to prevent loss of income, customers and competitiveness. By integrating SPI models and measurement techniques in the strategy management process, an organization's investments will be better aligned with strategy, optimizing the benefits obtained as a result of an SPI program. In this paper, the authors propose BOQM (Balanced Objective-Quantifiers Methodology) that integrates properly strategic management, process improvement and quantitative measurement to manage the competitiveness of software engineering organizations. Finally, this paper presents and discusses the results from implementing BOQM in a software development organization.

Keywords Strategic management · Software process improvement · Quantitative measurement · Software engineering organizations · IT governance

1 Introduction

At present, competitiveness is a key factor to assure the survival of companies in the market (Mehra and Inman 2004). Information and communication technologies (ICT) are

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essential elements that contribute to improving a company's competitiveness (Kamel et al. 2009; Kuppusamy et al. 2008).

Nowadays, it is widely known that strategic management is a key discipline that permits companies to achieve their competitive goals (Fahey 2007). However, in 63% of organizations, the role of ICT is essential to achieve their business goals, but often, it is limited to the operational level, having little consideration and influence in the definition of an organization's strategy (Asgarkhani 2006).

Nevertheless, effective management and improvement of internal processes in software development, operation and maintenance organizations [hereafter software engineering organization (SEO)] have contributed to improving the competitiveness of this type of organization in the ICT market (Asgarkhani 2006). Many case studies (Mcloone and Rohde 2007; Qi 2007; El-Emam 2007) demonstrate that software development companies have achieved success by adopting SPI models such as capability maturity model integration (CMMI). Moreover, professionals and managers are agreed on their effectiveness (Oliveira et al. 2009).

So, aligning SPI initiatives and efforts with strategic management principles and techniques is essential to manage and control costs and quality of an SEO (Kojima et al. 2007; Issac et al. 2006).

However, it is important to highlight that, in the software industry, there are few relevant case studies with enough detail (Goethert and Siviy 2004) where SPI initiatives are directed or well aligned with the company's strategy, quantitatively controlled by a measurement program and the information needs of senior management are integrated appropriately.

The problem addressed in this paper is the effective and explicit integration of strategic management, process improvement and quantitative measurement to manage efficiently the competitiveness of SEOs.

The hypothesis of this research work is: "*If there is a methodology available, especially focused on SEOs, that integrates strategic management activities, process improvement principles and measurement techniques, it will be possible to manage an SEO strategy, potentially increasing the synergies among all stakeholders and distributing the knowledge at all levels for effective decision-making.*"

Consequently, the authors decided on the following research activities:

1. Analyze different approaches that enable the integration of strategy management, process improvement and measurement techniques in SEOs (Sect. 2).
2. Define a methodology that allows SPI models to integrate and manage SEO strategy, based on measurement (Sect. 3).
3. Apply in a real organization the methodology defined in order to determine whether it contributes to increasing the synergies among stakeholders and provides key information for decision-making at all levels in the company (Sect. 4).

2 Literature review

As Lamb et al. state, strategic management is "*an ongoing process that evaluates and controls the business and the industries in which the company is involved; and then reassesses each strategy regularly to determine how it has been implemented and whether it has succeeded*" (Lamb 2008).

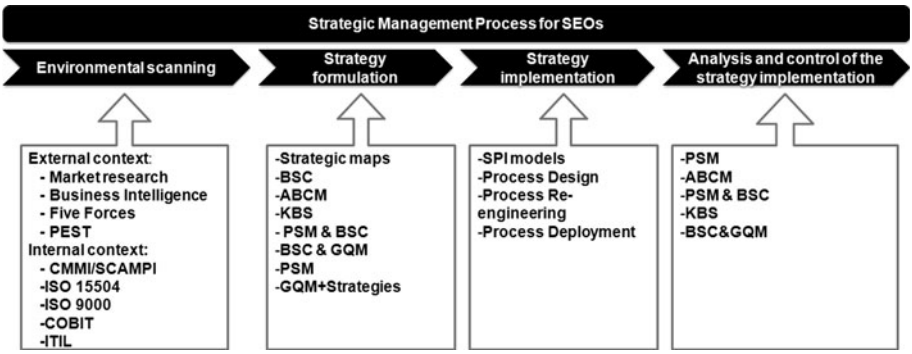

Fig. 1 Current proposals in the strategy management process for software engineering organizations

Strategic management is a combination of three main processes: strategy formulation, strategy implementation and strategy evaluation, which then cycles back to strategy formulation (Kaplan and Norton 2005).

Before formulating the strategy in SEOs, it is necessary to add another sub-process in strategic management, called environmental scanning. SEOs need to be proactive compared to other competitive organizations and to identify all external and internal vulnerabilities.

Next, the current proposals to implement strategy management in SEOs are presented using the four-phase scheme as an analysis framework (see Fig. 1).

2.1 Environmental scanning

The purpose of this strategy management sub-process is to analyze the current situation of an SEO in the environment in which it operates. Trienekens (Trienekens et al. 2009) stresses that a software organization should not only be aware of its own internal conditions, but also its external conditions. A SWOT (strengths, weaknesses, opportunities and threats; Kahraman et al. 2007) analysis is the most common tool to evaluate the current state of an SEO in relation to its strategy. A SWOT analysis can be complemented with other specific techniques to analyze the organization's internal and external context.

The analysis of the external context is centerd on a competitor's evaluation using several techniques. The most representative are: (a) Market research (Belk 2007); (b) business intelligence (Watson and Wixom 2007); (c) five forces (Porter 1979; Chastek et al. 2009); and (d) PEST analysis (Peng and Nunes 2007).

The analysis of the internal context consists of assessing the elements of an organization that influence the strategy such as processes, human resources and the current state of its information systems. In SEOs, there are many approaches to identify the strengths and weaknesses of processes. The most relevant are SCAMPI (standard CMMI appraisal method for process improvement; SEI 2006) and the ISO/IEC 15504 standard (ISO 2004). There are also other quality models that have been successfully applied in SEOs, such as ISO 9000 (ISO 2008), COBIT (Watson and Wixom 2007) and ITIL (Long 2008).

2.2 Strategy formulation

The purpose of this sub-process is to define the strategy in terms of quantitative objectives, without forgetting the organization's vision and constraints. The strategic objectives

formulation requires effective techniques to manage the strategy as a whole. Executives use strategic maps (Kaplan and Norton 2008) to address business strategies effectively. The balanced scorecard (BSC; Kaplan and Norton 2006) clearly specifies how to formulate the strategy map using four quadrants: customers, internal processes, innovation and growth, and financial perspectives.

One of the difficulties in formulating the strategy quantitatively is to link the strategic or business objectives with the product and process measurements and the expected values for improvement based on an appropriate analysis of the current situation. There are two kinds of proposals to solve this problem:

- *Proposals based on a predefined procedure to define indicators*. McGarry's procedure helps to define indicators based on organizational information needs (Card 2003; McGarry 2002). The BSC&GQM proposal (Goethert and Fisher 2003) applies the goal question (Indicator) measurement (GQ(I)M) methodology (Shull et al. 2006) to derive quantitative sub-objectives from strategy objectives allocated in the quadrants of the BSC. The GQM model was extended in a new approach known as GQM + strategies (Basili et al. 2009). It provides a mechanism to align the measurement goals with high-level goals such as business goals, software goals and project goals. Ebert and Dumke (2007) also present a process-based proposal for linking the business goals definitions and operational goals in software companies.
- *Proposals based on predefined indicators or models*. Tuan (Tuan et al. 2006) used the activity-based costing (ABC) method (Kaplan and Cooper 1997) to determine the cost structure of tactical programs. Kanji's business scorecard (KBS; Kanji and e Sá 2007) provides predefined indicators, increasing understanding of the application of the BSC perspectives in an SEO.

2.3 Strategy implementation

This process defines the operational models that implement the actions required to achieve the business and process improvement objectives. The activities in this phase are related to the definition, pilot implementation and improvement of the organization's internal processes.

2.4 Analysis and control of the strategy implementation

In this process, an SEO has to obtain objective data and analyze them to determine the extent to which the strategic objectives have been accomplished. There are two key activities in this process: (a) data collection, whose main goal is to ensure that data gathered is defined and accurate. An ISO standard (ISO 2007) is used, but other proposals (PSM, ABCM and BSC&GQM) provide their own approach; (b) data information is an activity for providing decision makers with useful periodic reports on the state of the software processes and products. ABCM, PSM & BSC, KBS and BSC&GQM use the balanced scorecard as an information system to get the big picture of the current state of the strategy.

As a result of this state-of-the-art analysis, it can be said that the strategy of SEOs is often related to short- and medium-term plans and limited to their domain. Consequently, an SEO attempts to do its part in meeting the overall business strategy, but it is difficult to know how the SEO's performance contributes to implementing the business strategy (Mishra and Mishra 2008; Capell 2004). In order to align efficiently SPI goals and

activities with business objectives, it is necessary to integrate properly and explicitly the SPI management activities with strategic management activities.

By analyzing the measurement proposals previously presented, it can be stated that there are non-integrated proposals that partially solve some specific problems of aligning the definition and control of SPI objectives with business strategy management. Nevertheless, the alignment and integration of business strategy with SPI initiatives in an SEO often fail for several reasons (Harjumaa et al. 2008; Gopal et al. 2005; Dybå 2005):

- Lack of coordination and alignment among all the roles and responsibilities involved in both business and SEO strategies.
- Lack of senior management commitment to implementing the SEO strategy due to insufficient information on how SEO strategic objectives contribute to their business strategy.
- Lack of employee commitment through failure of management to communicate the business and SEO strategies to their employees and lack of incentives given to workers to embrace the new strategy.
- Poor communication resulting from insufficient information sharing among stakeholders or exclusion of stakeholders in the knowledge-sharing processes (El-Emam et al. 2001).

To solve the problems of achieving the synergies required to align business objectives and SEO goals, it is necessary to refine already existing proposals, defining an approach that:

- Seamlessly integrates strategic management, process improvement and measurement to control efficiently the current status of SPI initiatives.
- Specifies the roles, responsibilities and competencies of stakeholders involved, creating the required synergies for effective competitive management.
- Contributes to capturing and disseminating useful knowledge of SPI initiatives and results to control the business strategy at all levels of the organization.
- Governs software process improvement efforts through indicators that link process improvement objectives with business strategy objectives.

3 A balanced objective-quantifiers methodology

The balanced objective-quantifiers method (BOQM) is a process guided by the SEO's key roles to design, implement and control a quantitative strategy through indicators aligned with strategic and improvement objectives in a BSC.

Balanced objective-quantifiers method includes the four perspectives of the BSC (financial, internal, customer and innovation and growth) and presents a clear state of the organization and its strategic advance. BOQM also applies the GQM principles to provide well-informed measures and justify indicators through goals-questions-measures. Finally, BOQM is also based on the main PSM principles to derive indicators and identify cause–effect relations between them.

BOQM is based on the process orientation philosophy. Figure 2 summarizes the BOQM process. The numbers in fig. 2 correspond to the activities described in this section. The complete process will be available after defense of Mitre's dissertation (in mid-2010) at http://sel.inf.uc3m.es/hmitre/BOQM.html.

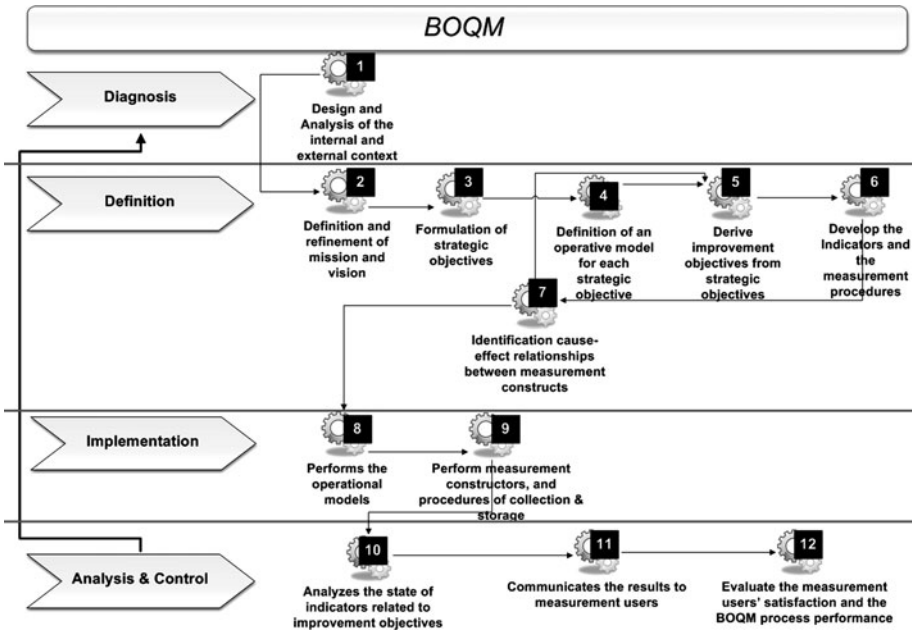

Fig. 2 The process of the balanced objective-quantifiers method (*BOQM*)

3.1 Diagnosis sub-process

This sub-process identifies and analyzes all the external and internal contexts of the organization. This process has only one activity.

1. Analysis of the internal and external context.

a. The internal context is defined by (1) the technological infrastructure, (2) the SPI model or SPI initiatives introduced and (3) the stakeholders. The technological infrastructure, relates to technological resources such as PCs, laptops, servers and networks. The previous SPI initiatives specify the scope and intensity of previous activities in this area and the software model used as a basis for these (CMMI, TSP, PSP, ISO 12207, etc.).
b. The external context, obtained from surveys, is defined by (1) social behavior, (2) the local industry and market, including industry competitors, potential entrants, buyers, substitutes and suppliers. Social behavior is the social levels present in the sector and the ease of access to information technologies. The local industry represents other organizations in the same sector or company-related activity; and the local market is the type of suppliers, purchasers and final clients. A PEST or SWOT analysis can be considered support techniques.

3.2 Definition sub-process

The purpose of this sub-process is to define the strategy in terms of quantitative objectives bearing in mind the organization's vision.

2. *Identify and clarify vision and mission*. The vision statement describes the organization's aims and what specific motivation binds the stakeholders, including members,

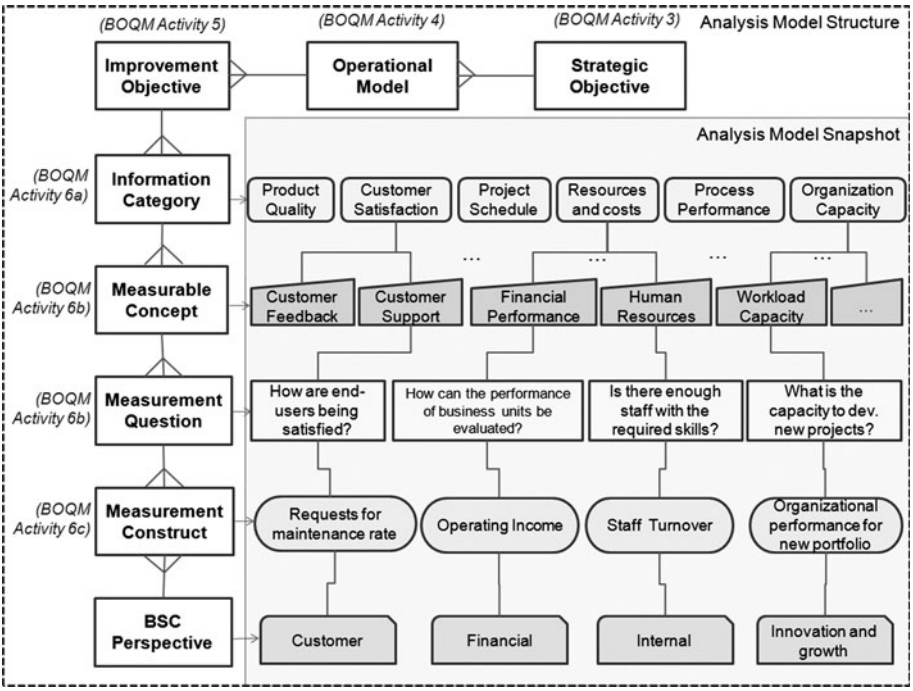

Fig. 3 BOQM analysis model

leaders and anyone else involved. The vision reflects the realization of the organization's values.

3. *Formulate strategic objectives* that are based on the internal and external context, bearing in mind the vision and mission definitions.

4. *Define an operational model for each strategic objective*. The operational model represents the set of actions needed to operate a strategic objective. It is composed of specific actions to implement the strategic and/or improvement objectives. From this activity, the first version of the BOQM analysis model is obtained. Figure 3 presents the structure and a snapshot of a part of the analysis model defined for BOQM; the complete model can be seen at http://sel.inf.uc3m.es/hmitre/AnalysisModel.html. When applying BOQM, this analysis model has to be customized for a specific organization through the following activities.

5. *Derive one or more quantitative improvement objectives* (*IOs*) *from the strategic objectives and their operational model.*

a. To derive IOs, the strategic objective is divided into measurable pieces, taking into account that these IOs can support decision-making during the operational model implementation. The following information categories can be covered in BOQM: (1) *Software products quality*: to improve the product quality, or product functionality and stability; (2) *software process performance*: to analyze and tailor the plan to improve an SEO's process capabilities; (3) *organization capacity*: to direct the performance and structure of the organization's staff toward the desired goals; (4) *technology performance*: to evaluate the effectiveness of the technology; (5) *resources and costs*: to estimate and control the cost of resources and activities; (6) *customer satisfaction*: to

improve customer satisfaction, or to control customer support; and (7) *project schedule*: to improve project management capabilities to meet the organizational commitments in terms of delivery agenda.

b. Identify, if necessary, process area or life cycle phase that affects IOs. This step is addressed by the SPI model selected or the SPI initiative. The process area or life cycle phase can facilitate the source of data required for measurements and data collection for the indicators.
c. Assign priorities to IOs.

6. Develop indicators and measurement procedures. The inputs for this activity are the BOQM analysis model (see Fig. 3) and the resulting catalog of IOs. The output products are the set of measurement constructors. Tasks included in this activity are:

a. As the IOs are measurable pieces obtained from the strategic objectives, this task consists of cataloging the IOs in the information categories (IC) considered in the BOQM analysis model.
b. Identify the measurement concepts (MC) from the information categories. We suggest reading the questions for each measurable concept that can satisfy the IO (see Fig. 3) and selecting the appropriate question and measurement concept. Each question belongs to a BSC quadrant. Therefore, the measurement analyst does not worry about categorizing the questions and improvement objectives into the BSC perspectives.
c. Establish possible base or derived measures for each measurable concept (see Fig. 3). The template to define measurement constructs can be seen at http://sel.inf.uc3m.es/hmitre/MeasurementConstructTemplate.html.

7. Identify cause–effect relationship between indicators and prioritize improvement objectives. Here, the BOQM analysis model and a catalog of IO aligned with constructors are needed. Each IO is aligned with an MC, and the MCs have cause–effect relationships. The measurement analyst identifies the relationships from the BOQM analysis model, and the SEO manager takes the decision to prioritize the IOs.

3.3 Implementation sub-process

The purpose of this sub-process is to perform the strategy and the measurement procedures to collect and store measurable information.

8. Perform the operational models. The strategy manager gets the staff commitment to apply the operational models, and assigns checklists per stakeholder.

9. Perform measurement-related collection and storage procedures. This activity is closely linked to the periods defined in each measurable construct. The measurement librarian collects data from the documents generated by personnel at the operational level (software designers, developers, testers, etc.) and updates the measurement database. In addition, the measurement librarian reports measurement constructs to the measurement users.

3.4 Analysis and control sub-process

In this sub-process, the measurement analyst has to obtain objective data and analyze them to determine the current state of the strategic objectives accomplishment.

10. Analyze the state of the indicators related to the improvement objectives. The measurement analyst updates the analysis models of all the measurement constructs and makes a report on the strategy in the BSC.

11. Communicate the results to measurement users. The measurement analyst sends all the measurement constructs to the corresponding user according to the reporting periods. The BSC generated by the measurement analyst is also sent to senior managers.

12. Evaluate the measurement users' satisfaction and the BOQM process performance in order to make improvements.

4 BOQM application and results obtained

Having defined BOQM, the authors applied it to determine whether it contributes to: (a) managing effectively SEO competitiveness, enabling the alignment of SEO strategic objectives, SPI initiatives and measurement constructs used to monitor the organization's performance; (b) increasing the synergies among all the stakeholders involved in the business strategy management, the SEO performance control and the management of SPI initiatives; and (c) capturing and disseminating useful knowledge of SPI initiatives and results to control business strategy at all levels of the organization.

Results obtained using BOQM were compared with previous initiatives of the same type in the same organization. Information sources for this discussion are:

- Previous SPI initiatives at AGROSEGURO.
- Results of BOQM application.
- Observation of BOQM execution.
- Final group interviews.

The following sections present the activities done and results obtained through the BOQM application in a real software development setting and discuss the lessons learned during the practical validation of BOQM.

Section 4.1 briefly presents the activities carried out and the results obtained from implementing BOQM in a real software development setting. Section 4.2 discusses the lessons learned during the practical validation of BOQM.

4.1 BOQM application

BOQM was implemented in a medium-sized SEO of a company called AGROSEGURO.

4.1.1 Background

The information presented in this section was obtained during the execution of BOQM Activity 1. The company is one of the main insurance corporations in Spain whose clients are farmers, livestock breeders and other insurance companies. It has about 200 employees; around 35 were in the development department (Sept 2008). Staff turnover is very low and the composition of working groups is very stable, with few changes each year. The type of software developed by the SEO is information management systems in host environments (AS/400) with web interfaces developed using Java technologies. There is also a small team for the development and maintenance of windows-based applications to support mobile users without a stable internet connection. There were previous initiatives in this SEO to improve performance and efficiency:

- The first software process improvement initiative was to introduce several process areas included in CMMI level 2 (staged version).

- The second software process improvement initiative was to obtain an ISO 9000-3:2000 certification for development processes.

4.1.2 Process improvement goals and activities

In order to align AGROSEGURO's SEO performance with the business objectives, a new software process improvement initiative was launched. BOQM was used to control the alignment of these three elements: business goals, SEO goals and the SPI initiatives.

4.1.3 Mission and vision

As result of BOQM activity 2, AGROSEGURO SEO's mission was stated. It is to provide good quality and optimize the delivery term for each assignment to the rest of organization areas at AGROSEGURO. The vision of the SEO is to be capable of planning new product portfolios at the beginning of the year, and to achieve the objectives by the end of the year. This means that the development teams would not be burdened with continuous corrective maintenance tasks and support that prevent the annual objectives from being met.

4.1.4 Strategic and SPI objectives

According to the SEO's mission and vision, the strategic objectives (SOs) to be managed using BOQM were defined during the execution of BOQM Activity 3. Moreover, an operational model (OM) was defined for each strategic objective considered as a result of BOQM Activity 4. Finally, the definition of the improvement objectives (IO) was the result of BOQM Activity 5.

4.1.4.1 Strategic objective 1 (S.O.1) Align the organization of the development department with the demands of other units in the enterprise. This strategic objective had to be achieved in 1 year. In order to do so, a set of activities for the organizational reconstruction in the development department was initiated. The specific improvement objective identified for this strategic objective was to reorganize the structure of the teams in the development department (IO1.1).

4.1.4.2 Strategic objective 2 (S.O.2) Optimize the work that can be done by the development department, increasing the capability to manage efficiently the available resources. This strategic objective (SO) had to be achieved in 1 year. The activities to achieve this objective were those required to define and deploy a new process for project control and tracking and the specific improvement objectives identified for this strategic objective were: IO2.1: separate development and support, optimizing the workflow; IO2.2: center and reallocate roles and performance; and IO2.3: strengthen the management control system.

4.1.4.3 Strategic objective 3 (S.O.3) Increase the quality of the work delivered to other units at AGROSEGURO. This strategic objective had to be achieved in 1 year. The activities were those required to optimize the development processes and improve the training of the personnel who use them. The specific improvement objectives identified for this strategic objective were: IO3.1: improve the development software processes displayed and IO3.2: improve personnel capabilities and performance in the development department.

Once the improvement objectives were identified, the SPI initiatives were initiated.

4.1.5 Measurement constructs identified and results obtained

BOQM activity 6 was carried out to identify measurement constructs (indicators) to control strategic and improvement objectives.

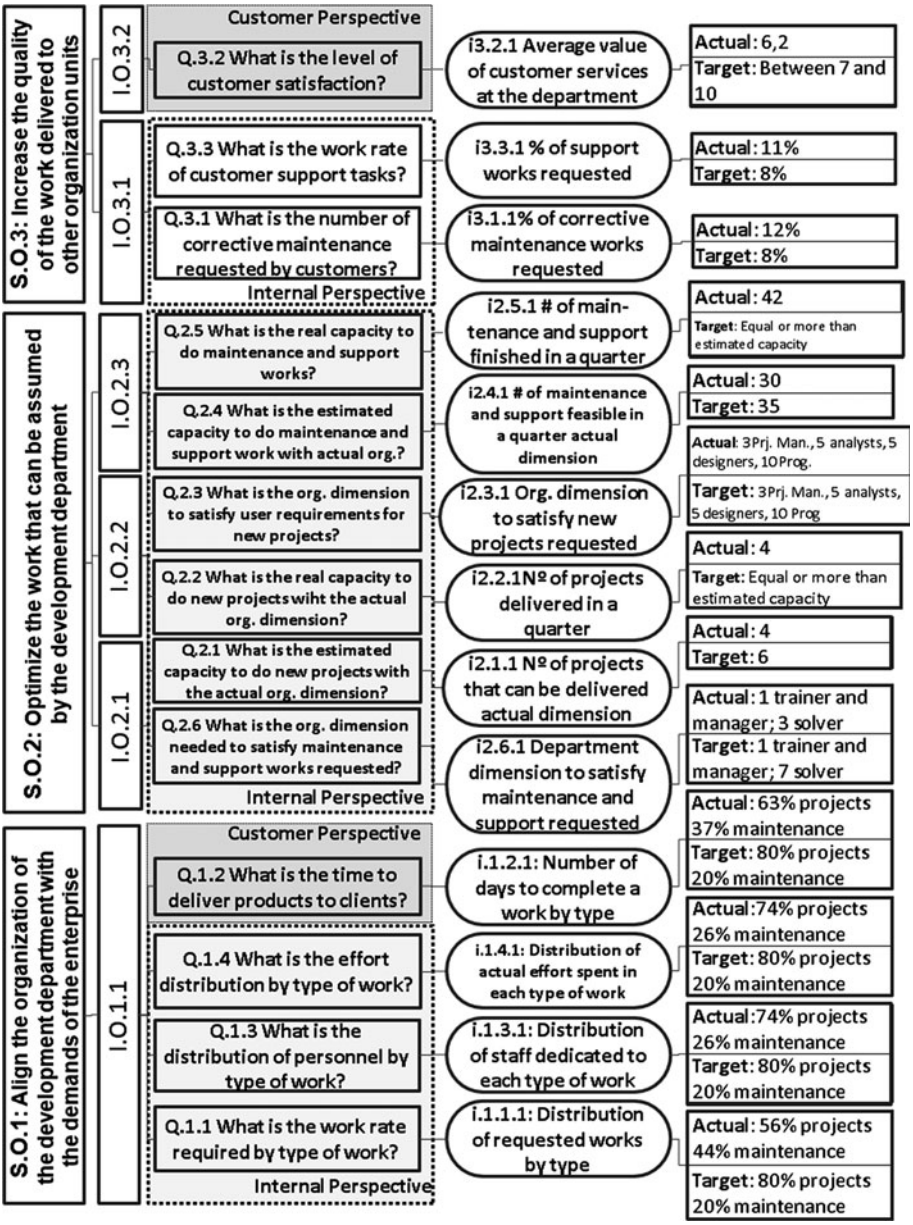

Fig. 4 BOQM analysis model obtained for AGROSEGURO

First, the questions to control the achievement of these objectives were selected and correctly linked to the corresponding strategic objectives (Fig. 4).

Having defined these questions, the activities for defining the measurement constructs were then carried out. The measurement constructs selected and the target values are presented in Fig. 4.

Once measurement constructs were defined, several cause–effect relations among them were identified (BOQM Activity 7). "*i1.2.1, Number of days to do the work by type of work*" affects "*i3.2.1 Average added value of the services provided to users*" is an example of the types of relationships identified. Any problem with schedule overruns has a negative impact on the benefits that the customer obtains from using the solution provided.

Once the BOQM analysis model was adapted to AGROSEGURO, the software process improvement activities were done in parallel with the activities for gathering the required data to compile the measurement constructs considered (BOQM Activities 8 and 9). The evolution of measurement construct values was periodically analyzed (BOQM Activity 10). The conclusions of these analyses were also communicated to AGROSEGURO's SEO staff within the same periods (BOQM Activity 11).

The values achieved at the end of the SPI activities for each measurement construct are presented in Fig. 4 (marked as actual values). In several cases, the organization did not achieve the expected values, but the SEO managers considered that the expected values would be achieved shortly.

Finally, several lessons learned were identified during the evaluation of the participants' satisfaction and the BOQM process performance (BOQM Activity 12). Several of these lessons are discussed in Sect. 4.2.

4.2 Lessons learned from the BOQM application

This section presents the observations gathered during the BOQM application at AGROSEGURO. The discussion is divided in three areas: (a) alignment of an SEO's strategic objectives, SPI initiatives and measurement constructs; (b) synergies among stakeholders involved in the BOQM initiative; and (c) effective knowledge sharing on strategy implementation across all organizational levels.

Table 1 Analysis of added value provided by BOQM (Part I)

Alignment during strategic objectives definition	
Problems in previous initiatives	It is important to note that previous SPI initiatives had a lack of alignment among business goals, SEO goals and the SPI initiatives, although the support of senior management was obtained. This support was implemented by providing the resources required for SPI initiatives and a few senior managers participated in monitoring the process of defining the SPI and measurement initiatives
Analysis of BOQM added value	It is important to state that the active participation of AGROSEGURO's SEO manager in BOQM and the use of the information provided by senior managers helped to achieve a full alignment between the formulation of business and the SEO's objectives In consequence, the BOQM practitioners indicated in final interviews that leadership involvement is not synonymous with success in aligning business and SEO strategies. The BOQM practitioners concluded that senior management participation should not only consist of providing resources and political support, but also it is essential that senior managers provide relevant information on their insights and points of view. The BOQM process orientation facilitated effective senior management participation

Table 2 Analysis of added value provided by BOQM (Part II)

Alignment of the elements to define business strategy, SPI and measurement initiatives	
Problems in previous initiatives	In previous initiatives, an important lack of alignment was detected because the business view was centerd on having a greater amount of products delivered, and the SEO's view on managing more rationally the projects portfolio and delivering products of higher quality. In addition, although senior and SEO managers agreed on the set of measures in the past, the reports submitted to management were very complex, without providing meaningful information on the number and the quality of products delivered
Analysis of BOQM added value	At the end of the BOQM application, the participants indicated that the definition of strategic and improvement objectives were more related to the actual situation at AGROSEGURO's SEO and they were more feasible. This better alignment was obtained because the BOQM process and analysis model enhanced common understanding of business goals among stakeholders, how the SEO could contribute to achieving them and how the organizational problems of the SEO could be solved As the information model obtained for managing the strategy was more aligned, indicators and the cause–effect relationships among them helped to identify the impact of the changes in the values of several measurement constructs on the values of other measurement constructs. So, it was simpler to evaluate the impact of internal changes on the degree of accomplishment of the business and the SEO's objectives Finally, the indicators' aggregation levels provided by the BOQM analysis model contributed to providing the appropriate information to the different stakeholders (senior manager, SEO managers and software engineers). Nevertheless, it is important to mention that measurement is meaningless without interpretation and judgment by those who make decisions and take actions based on indicators

4.2.1 Alignment of an SEO's strategic objectives, SPI initiatives and measurement constructs

The improved alignment of an SEO's strategy with business objectives due to BOQM can be analyzed in two ways: alignment during strategic objectives definition and alignment of the elements configuring the strategic plan (Tables 1, 2).

4.2.2 Synergies among stakeholders involved in the BOQM initiative

Integration of strategic management, process improvement and quantitative measurement requires combining properly the knowledge, experience and competencies of stakeholders involved in this process. The main BOQM contribution is in the enhancement of synergies among stakeholders (Table 3).

4.2.3 BOQM's contribution to capturing and spreading useful knowledge

The practical application of BOQM indicated that the capture and spread of relevant knowledge on the current state of actions and implementing the business strategy, are essential to maintaining the alignment between business goals and SPI initiatives. BOQM's contribution to capturing and spreading useful knowledge can be discussed from three

Table 3 Analysis of added value provided by BOQM (Part III)

Enhancement of synergies between stakeholders involved in the definition of the business strategy, SPI and measurement initiatives	
Problems in previous initiatives	During previous SPI initiatives, it was mentioned that the lack of alignment among the business and the SEO goals, SPI initiatives and the related measurement programs was partially due to a lack of a clear process indicating the specific information to be defined and the roles and responsibilities of those involved. This lack of predefined process created several problems related to the type of relevant information to be obtained. Moreover, there were frequent and serious discrepancies during teamwork sessions because of conflicting points of view. Finally, the lower level employees were reluctant to participate freely and actively in teamwork sessions due to the participation of senior and SEO managers
Analysis of BOQM added value	The application of BOQM provided several benefits: First, the BOQM training was more focused, providing specific training for all participants and more detailed insight into the concepts and activities assigned to each role participating in the process. Moreover, the examples taken from already existing case studies and adapted to BOQM were evaluated positively because they clarified how to complete the BOQM process Second, the use of a formalized process enhanced the visibility of the current state of the process. The stakeholders involved were able to identify what activities remained and what internal products were needed before the process was completed Third, roles and responsibilities were identified and clearly defined at the beginning, so each worker involved knew what was expected of him to define the SEO's objectives and indicators. Participants also considered that the responsibilities assigned to each of them matched their skills and experience Fourth, the way the activities were organized among stakeholders enhanced the combination of expertise in an organized way, preventing bottlenecks in long non-productive discussions and enabling active participation of workers at the lower levels. Finally, participants remarked that the BOQM process orientation reduced back-office work, and promoted more structured interaction among stakeholders

Table 4 Analysis of added value provided by BOQM (Part IV)

Effective use of pre-existing knowledge	
Problems in previous initiatives	During the first two initiatives where there was no use of pre-existing knowledge because the objectives were selected and indicators identified from scratch. In consequence, participants spent more effort than expected in re-work because senior management's orientation and guidelines were not considered appropriately
Analysis of BOQM added value	The observations gathered during the application of BOQM and the interviews conducted at the end of the project indicate that using this predefined knowledge organized in BSC perspectives has had several positive effects. Specifically, the use of predefined schemes of business objectives, SPI goals and measurement constructs reduced the number of arguments on the appropriateness of the improvement objectives and indicators. Moreover, the application of the BSC perspectives helped to organize the information in the same way senior management organize knowledge on business objectives, enhancing meaningful interchange of knowledge between organizational levels

points of view: (a) Effective use of pre-existing knowledge; (b) effective gathering of required data; and (c) knowledge sharing on the current state of the organization (Tables 4, 5, 6).

Table 5 Analysis of added value provided by BOQM (Part V)

Effective gathering of required data	
Problems in previous initiatives	The information provided by the SEO staff was low quality because they did not really know why the data were necessary and what the actual use of the information was for. Due to this lack of information, the SEO staff were concerned about the use of the data
Analysis of BOQM added value	After the application of BOQM, the quality of the information improved. The participation of workers at all professional levels in defining the SEO's objectives and indicators for their control contributed to increasing confidence in using information

Table 6 Analysis of added value provided by BOQM (Part V)

Knowledge sharing on the current state of the organization	
Problems in previous initiatives	Indicators and the related reports were used to provide senior management with data for decision-making and to assess the effects of the improvement actions in the SEO organization
Analysis of BOQM added value	During the BOQM application, several types of reports were prepared. Senior managers and software engineers evaluated very positively the overall picture provided by the four BSC perspectives Although it was positively evaluated at AGROSEGURO, the BOQM philosophy includes not only these traditional uses, but also availability and data feedback, and the use of data to guide SPI actions. This feedback on actual performance not only motivated a change in the behavior of individuals, groups and the organization as a whole, but also guided change in a specific direction The BOQM information model contributed to enabling learning across all organizational levels, instead of enabling exclusively decision-making activities for senior and SEO management purposes

5 Conclusions

In this paper, BOQM was defined to link strategic objectives and IOs with measures in a BSC, using the GQM approach and the integrated analysis model of Practical Software Measurement (PSM). The BSC, GQM and PSM are integrated in such a way that strategy formulation and control are simpler and more traceable.

BOQM was applied in an SEO and compared with previous measurement initiatives in the same organization. This pilot application provides a relevant example, indicating that BOQM can contribute to satisfying the research hypothesis stated in the introduction. The specific findings identified as conclusions of the BOQM pilot application are:

- BOQM offers traceability among strategic objectives, operative models, improvement objectives, questions and indicators.
- BOQM provides a process defining the roles, responsibilities and competencies of the stakeholders involved and creating the required synergies for effective competitive management.
- BOQM provides an effective framework to capture and spread useful knowledge of SPI initiatives and their results to control business strategy at all levels of the organization.

- The BOQM analysis model allows one to see the big picture of the knowledge generated in the formulation activities, analysis and control of the strategy process defined.

Finally, the BOQM measurement context is not only limited to product and process measurement, but also measures staff performance, effectiveness of the technology, costs and customer satisfaction.

The next steps of this research work are focused on an empirical evaluation of BOQM compared to other software measurement approaches such as BSC, GQM and PSM. Moreover, BOQM is being implemented in other organizations, so the BOQM analysis model will be enriched. In addition, a software assistant is being developed to guide BOQM practitioners to follow the process in the most effective way.

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