Towards an Approach to Assess Supply Chain Quality Management Maturity

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Abstract - **Maturity models have been developed in order to help companies to improve organizational performance. Furthermore, due to the globalization and the growing competition, companies need to increase the competitiveness through operational efficiency, internally and in the entire supply chain.**

In this paper, an approach for the design and implementation of a Supply Chain Quality Management maturity model is presented.

The concept of Supply Chain Quality Management has been developed in order to achieve a good integration between the two approaches: Quality Management and Supply Chain Management, and how such integration can help and support the companies to become more effective and efficient.

The proposed approach to assess Supply Chain Quality Management maturity incorporates both quantitative and qualitative information to define several levels corresponding to different integration maturity levels. A case study in a world class company of the automotive industry is being used to validate the approach.

Keywords - **Maturity Model, Supply Chain Quality Management, Key Performance Indicators.**

I. INTRODUCTION

The concept of Supply Chain Quality Management – SCQM has been proposed and developed in the past few years and it is considered an approach based on performance improvement systems aiming to integrate all supply chain players - the down - and the upstream relationships - with a focus on value creation and on customer satisfaction [1-4].

Due to the relevance of this issue, a conceptual model has been developed, reflecting the common dimensions found in both Supply Chain Management (SCM) and Quality Management (QM) approaches [4]. Thus, the SCQM model proposed was developed taking into consideration previous theoretical and applied research that explored and discussed the influence of dimensions of both SCM and QM on the organizational performance. Based on a survey, this model was statistically validated using a structural equation models (SEM), which revealed that all the dimensions of the SCQM conceptual model are statistically significant and with a positive impact on organizational performance. The organizational performance dimension was assessed considering the four perspectives of the balanced scorecard (BSC) (business process, learning and growth, customer and financial perspective), since it enables the companies to align its management processes focusing on implementing long-term strategy [5].

The proposed SCQM maturity model relies on several quality management models namely the Business Excellence Model of the European Foundation for Quality Management (EFQM) which considers nine criteria for assessing the overall strengths of an organization. Five of these criteria are enablers that are related to what an organization should do in order to achieve desired results – the other four criteria are related to what an organization achieves.

The enablers are leadership, strategy, people, partnerships and resources, and processes, products and services. These enablers can be viewed as necessary conditions for the effective development and implantation of the organization's strategy. Regarding the results, the EFQM model offers information on customer, people, society and business results. These four results areas should be aligned with the organization's strategic goals [6].

Both SCQM and EFQM models evaluate companies' performance and excellence and the SCQM Maturity Model also intends to evaluate the company supply chain and its maturity.

So, for the development of the model to assess SCQM maturity, qualitative and quantitative elements should be considered. Regarding the quantitative perspective, a process composite indicator can be used, as well as other performance indicators. Regarding the qualitative perspective, it must be used information already available based on the company reports, e.g. the EFQM model.

The proposed model is being developed and implemented in a Bosch Car Multimedia plant located at Braga, Portugal (Bosch BrgP).

II. MATURITY MODEL

Maturity means maturation/ripeness and reflects the evolution and development of something from an initial stage until a more advanced one through several steps between them [7-10]. For an ease understanding, one usually consider an immature person as someone that has lack of confidence and someone who is passive and dependent. On the other hand, a mature person is someone that can fix several problems and challenges that arise using different tools and approaches learnt along life. In the same way, firms' maturity is related to the objective of a perfection stage of excellence requiring time to evolve towards such stage [8,11-12].

The existence of several stages or levels described by a set of corresponding characteristics is the basis of

maturity models. Each level is limited by a threshold that should be achieved, meaning that the pretended goals for a determined level are already fulfilled. Further, when a level is reached it requires some time to consolidate that stage [7,8,10,13]. In a simple way, maturity models describe typical behaviors, practices, processes and characteristics that should be fulfilled in order to reach each maturity level and to be ready to develop efforts in order to achieve the following level. It is supposed to follow an evolutionary path from the initial stage through systematic efforts of improvement in order to achieve the highest and desired maturity level [8,11,13-15]. Maturity models follow a methodology that emphasizes components related to the definition, measurement, control, and management of processes requiring a good knowledge of activities and processes, thus reflecting the extent of a specific business process [8,10,16,17].

Maturity models are usually defined by a finite number of levels (typically between 3 and 6 levels) which follow a sequential order from an initial to a high maturity level, representing the latter the most advanced stage which corresponds to a higher level of efficiency [15,18]. Further, as stated before, each level is compounded by several characteristics and requisites that should be achieved in order to really fulfill a certain level that encompasses several elements, dimensions, processes or activities [7,8,10].

On the other hand, firms can use maturity models as an example of best practices to implement and guide to a higher level through an evolutionary path enabling also a self-evaluation of the current state of the firm. After the determination of the maturity level, it is easier to determine and define which actions can be taken to improve the firm's performance. Knowing and understanding the actual maturity level contributes to plan and implement better actions, strategies, tools, and techniques [9,10,12,13]. Maturity approaches started in the quality field with the Quality Management Maturity Grid proposed by Crosby, in 1979 [8,11]. Crosby presented the Quality Management Maturity Grid (QMMG) in which five maturity levels describe the typical behavior of a firm terms of quality management [8].

Since then, several maturity models arose in different areas and for a range of different activities. The best known maturity model is the Capability Maturity Model (CMM) in the information technology field, which usually has been the basis for the development of other maturity models. The CMM maturity model was developed by the Software Engineering Institute (SEI) and it comprises five levels and uses a quality grid where a set of key process areas are identified and organized in sections [8,11].

Maturity models have been developed in several areas such as Supply Chain [9], Project Management [19], Business Process Orientation [13,16,17], Construction [20], Logistics [14], Maintenance [12], Reverse Logistics [21], and Integrated Management Systems [7]. Regarding to Supply Chain Management, several important maturity models were already developed such as the model developed by [13] based on business process orientation concepts, the model developed by PRTM with a focus on the capability of each Supply Chain process [9], or even the Supply Chain Management Process model [17]. A brief comparison between some maturity models is presented in Table I.

TABLE I
MATURITY MODELS COMPARISON

Maturity Model	Levels	Briefly description
Quality grid [22]	1 – Uncertainty 2 – Awakening 3 – Enlightenment 4 – Wisdom 5 - Certainty	First maturity model; six measurement categories.
CMM [23]	1 – Initial 2 – Managed 3 – Defined 4 – Quantitatively managed 5 - Optimizing	Used to improve processes through continuous representation (evaluation of process areas individually) or staged representation (measurement of the entire organization).
Supply Chain Management [9]	1 - Ad Hoc 2 – Defined 3 – Linked 4 – Integrated 5 - Extended	Quantitative evaluation using a questionnaire and a Likert-point scale to evaluate one hundred twenty eight questions.
Project Management [19]	1 – Ad Hoc 2- Planned 3 – Managed at Project 4 – Managed at Corporate 5 – Continuous Learning	Process maturity evaluation through nine knowledge areas. Use of questionnaire divided in three main sectors.
Business Process Orientation [13]	1 - Ad Hoc 2 – Defined 3 – Linked 4 – Integrated	Strategic view of the processes. Characteristics for each level.
Logistics [14]	1 – Start up 2 – Managed 3 – Defined 4 – Measured 5 - Optimized	Four pillars and logistics areas to evaluate each area/sub-area/process in comparison with some expected achievements giving a maturity score for each one.
Reverse Logistics [21]	1 – Initial 2 – Managed 3 – Defined 4 – Quantitatively managed 5 - Optimizing	Maturity grid with dimensions and key components describing each level following a holistic approach.
Integrated Management Systems [7]	1 – Uncertainty 2 – Awakening 3 – Enlightenment 4 – Wisdom 5 - Certainty	Relationship between the variables and statistical analysis. Preliminary model based on Crosby's maturity grid and a pyramidal model version taking into account the key process agents, maturity levels and weighting.
Supply Chain Process Management [17]	1 – Foundation 2 – Structure 3 – Vision 4 – Integration 5 - Dynamics	Dendrogram with thirteen groups spread by the five maturity levels. Utilization of statistical analysis in order to evaluate ninety capability process indicators.

As it can be observed on table I, although the similarities regarding structure using descriptive and/or quantitative data to assess the maturity levels, none of the

refer models specifically captures the integration of QM on the SCM.

III. SUPPLY CHAIN QUALITY MANAGEMENT

From the limited studies concerning the integration of QM and SCM it was found that this integration is a process that will improve customer satisfaction, the performance of supply chain parties, and the competitiveness of the companies [24,25]. Due to the limitations of the existent literature, a study merging these two concepts was performed [4]. In order to achieve this goal, some previous works were the key to develop the conceptual model that tries to overcome several dimensions regarding both approaches. The proposed model can be found in Figure 1.

From this model it can be seen that the integration of QM and SCM was defined as being influenced by six common dimensions: Leadership; Continuous Improvement and Innovation; Sustainability; Stakeholders Involvement and Commitment; Information; and Management and Strategic Planning. Although, some other dimensions related to QM (Product/Service Quality and Quality Culture) and to SCM (Procurement, Internal Logistic and Distribution) were also considered of utmost importance to characterize the SCQM, and for that reason were include in the model. Additionally, the output of the model is to understand how these dimensions impact on the overall organizational performance considering the four perspectives of balanced scorecard and on its supply chain processes (meanly Source, Make, Deliver and Return – SCM dimensions adapted from the conceptual model to Bosch Car Multimedia plant reality).

Leadership is a principle that is very important in organizations and it drives the overall supply chain system, thus resulting in improved financial results and customer satisfaction [26, 27]. In a supply chain where people are involved and committed, the achievement of quality goals across all organizations is easier to emerge. Reference [28] have studied the direct and indirect relationships between SCQM and performance, founding that leadership is a

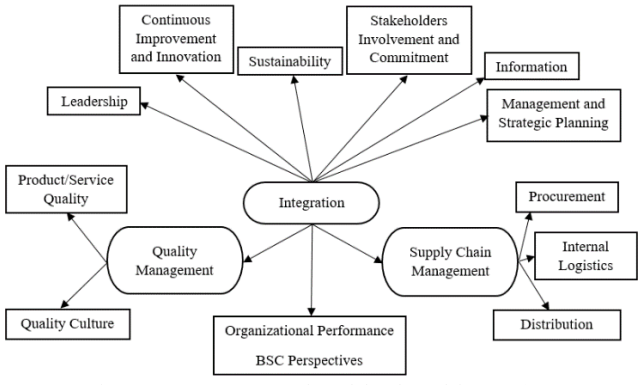

Fig. 1. SCQM Conceptual model (adapted from [4]).

dimension that has an important role in the implementation of quality management in the supply chain, since it affects other dimensions, such as customer focus, human resource management, strategy planning, etc..

SCQM can be translated by Key Performance Indicators (KPIs) and/or policies for which top management sets clear targets, using benchmarking approaches to assess company's performance among the best in class. As an example, targets for increasing production or services provided, targets for customer satisfaction, lower number of complaints on products or services from customers, etc., will allow the organization to be recognized as the best performance in a class.

The continuous improvement and innovation is a dimension that enables companies' competitive advantage due to the development of new ideas that can be implemented in order to improve their processes and products [29]. This fact is considered as being fundamental to the competitiveness of the companies, which is a requirement for the long-term strategy of the organizations, but also to promote dynamic capability to respond to changes in the markets and in customer needs and expectations.

Continuous improvements and innovation can be observed when the organization keeps the focus on trying to reduce internal and external failure costs on a daily basis and setting yearly lower goals to be achieved: continuous focus on reducing scrap, eliminating production losses, reducing set-up times or improving machines maintenance programs.

In this context, sustainability should be considered in the three dimensions: economic, social, and environmental, and it is fundamental to guarantee the success of the companies [30].

Several researchers studied the impact of sustainability in order to understand some issues, namely if a best economic practice is also a best sustainable practice [31], or if the sustainability in the SCM actually contributes to more competitive advantages over their competitors [32].

As example, on the social area, actions like participating and supporting local community where the organization is located or from where their employees are from, local important events, partnering with other organizations in order to provide better benefits for the employees and local community, can be considered. On the environmental side, the use of KPIs to keep track of CO_2 emissions reduction and energy consumption and the increasing usage of returnable packages are some examples of organization's efforts in this area. One other action is the continuous search for nearest suppliers that are capable of meeting product specifications and requirements, but that also are certified according to ISO standards. All these actions not only provide benefits on each referred area, but also economics benefits, either by reducing costs, resulting in investments on local communities, and if possible, supporting community economy with partnerships established with other local organizations.

The interested parts of an organization can impact on the business success due to the importance of people at all

levels of an organization. Thus, in a place where people are involved and committed, their abilities can be used for organization benefits, resulting in a better understanding of the needs and expectations of the customer. Thus, this dimension must be considered in the SCQM model.

Stakeholder's involvement and commitment can be seen by numerous actions imbedded on the daily routine of the organization. Some of these actions are the regular visits of the organization's customers (either for visiting, for auditing or for creating new business synergies, and afterwards filling a visit survey) and the regular presence of suppliers and business partners inside the organization plant, providing support on the daily tasks.

Furthermore, information technology systems can promote several benefits, such as the production of a well-timed information. It is known that the management and the integration of information technology into the supply chain, influences the performance of the supply chain [33]. For that reason, besides others, the implementation of information technology systems highly recommended.

In terms of indicators, there are several that can be considered for the maturity model, such as tracking external suppliers compliance to products specifications and requirements; number of formal complaints presented to external suppliers for quality issues or other business details; or controlling how many times an external supplier does not deliver orders on time. These examples of indicators show that the organization exchanges information with theirs suppliers and uses that information/knowledge to schedule their internal works. On an internal supply chain point of view, the organization shows a clear supplier/customer relationship regarding the fulfilment process, and measures of how is a process affecting the following one in terms of quantities delivered, timings, quality and production schedule compliance, should constantly be performed.

Finally, concerning the dimension of Management and Strategic Planning, it is known that the success of the SCQM will depend on how well these areas are introduced and managed [34], thus making this dimension is an important management tool for the competitiveness of the companies. As the Management and Strategic Planning area will influence all other areas of the company, the organization seeks to articulate all those mindsets, policies and targets, so that it can sustainably and continuously be successful.

As some of the mentions dimensions are also reflected directly in the EFQM model, others are not implicit and, as according to other QM and SCM models, should go deeper under the organizations intra and external supply chain. This is the reason for the development of a maturity model that merge these two models.

IV. SCQM MATURITY MODEL

As point out on the end of the previous sections, although there are several models for assessing organization's maturity, such as the ones developed by [9] and [17] for the SCM, or the EFQM model to assess the excellence level, to the best of our knowledge, none were found that assess the maturity of the concept of SCQM.

Thus, on figure 2 is presented an approach of the SCQM maturity model that will be implemented in Bosch BrgP for assessing the organization supply chain.

The maturity model that is being developed are expected to have both qualitative and quantitative assessment (Fig. 2).

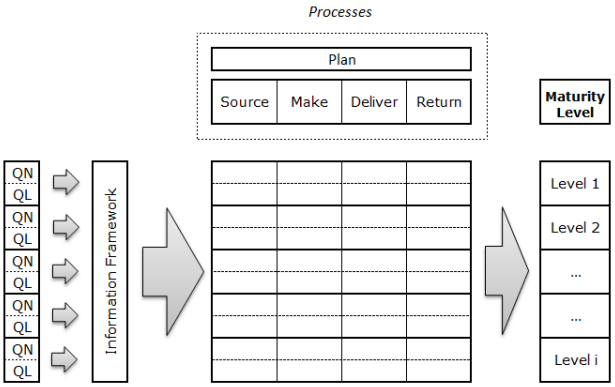

Fig. 2. SCQM Maturity Model (QN - quantitative inputs; QL - qualitative inputs; i – number of the last level, ⩽5).

In the company under study, Bosch BrgP, the model will start to be implemented on the Return process due to easy access to information.

The quantitative element is related to KPIs that are in use in Bosch BrgP, as well as a composite indicator, and will be considered as an evaluation point for the computation of the maturity level regarding the effectiveness and the efficiency performance. The qualitative element plans to use reports that are produced in Bosch BrgP, such as Management Review or EFQM.

Seizing the refer elements, and using an information framework to be defined, it is intended to assess how information is use and dispose throughout the company's supply chain processes (Source, Make, Deliver and Return).

V. CONCLUSIONS AND FUTURE WORK

Based on the literature review performed, although there are several maturity models that assess the QM or SCM, none were found that assess the maturity of the integration concept of SCQM. Also, the SCQM conceptual model and all its proposed dimensions were previously validated on a work to be published, as having a positive impact on the organizational performance. Therefore, an approach to a maturity model that assess the SCQM throughout the supply chain was presented.

The maturity model that is being design and will be implement on the company under study, will be based on the EFQM model and the SCQM model, on a composite indicator and also other relevant information such as information integration.

The next step is to define the maturity levels of the

maturity model, including the goals, the turning points and expected requirements in each level. As an example, the identification of critical indicators for each level of the model, as well as their respective weights, is crucial for the success of this study.

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