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AMANDA OLIVEIRA VOLTOLINI

DEVELOPING A MODEL FOR SUPPLY CHAIN PERFORMANCE MEASUREMENT BASED ON OPERATIONS STRATEGY

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Supervisor: Prof. Dr. Edson Pinheiro de Lima.
Co-supervisor: Prof. Dr. Sérgio Eduardo Gouvêa da Costa.

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“Success comes from wanting, determination and persistence in reaching a goal. Even if you do not reach the target, those who seek and overcome obstacles, at least will do wonderful things.”

(José de Alencar)

ABSTRACT

Supply chain management (SCM) is a key element in corporate competitiveness. The issue of performance measurement plays an essential role in SCM and has received increasing attention from the research community. However, literature and practice indicate that inadequate supply chain performance measurement systems are still amongst the major barriers to successful supply chain collaboration. In order to bridge this gap, this work aims at developing a model for supply chain performance measurement. A systematic literature review is conducted so as to identify research trends in the supply chain performance field. Then, the research seeks to derive and organize from the literature a set of measures for supply chain performance measurement systems, by means of applying content analysis procedures. The literature recommendations base the model development, and a Delphi study is designed to refine the model through an empirical-based approach. This research contributes to the theoretical field in terms of mapping and reviewing supply chain performance measurement recommendations, and by creating conditions for academics to identify future research opportunities. For practitioners, the model may contribute in the challenges of designing, implementing and enhancing supply chain performance measurement systems.

Keywords: Supply chain performance measurement model; Performance measurement system; Supply chain management; Delphi Study.

RESUMO

A gestão da cadeia de suprimentos (SCM) é um elemento-chave da competitividade das empresas. A medição de desempenho tem um papel essencial na SCM e tem recebido uma crescente atenção por parte da comunidade de pesquisa. No entanto, a literatura e a prática indicam que sistemas inadequados de medição de desempenho da cadeia de suprimentos ainda estão entre as principais barreiras para o sucesso da colaboração nas cadeias de suprimentos. A fim de preencher essa lacuna, este trabalho visa desenvolver um modelo para a medição de desempenho nas cadeias de suprimentos. Uma revisão sistemática da literatura é conduzida a fim de identificar as tendências de pesquisa na área de desempenho de cadeias de suprimentos. Em seguida, a pesquisa pretende derivar e organizar, a partir da literatura, um conjunto de indicadores para sistemas de medição de desempenho de cadeias de suprimentos, por meio da aplicação de procedimento de análise de conteúdo. Os indicadores recomendados na literatura fundamentam o desenvolvimento do modelo, e um estudo Delphi é projetado para refinar o modelo através de uma abordagem empírica. Esta pesquisa contribui para o campo teórico pelo mapeamento e revisão das recomendações para a medição de desempenho de cadeias de suprimentos, e ao criar condições para que os acadêmicos identifiquem oportunidades de pesquisas futuras. Para a comunidade prática, o modelo poderá contribuir no desafio de formular, implementar e melhorar sistemas de medição do desempenho de cadeias de suprimentos.

Palavras-chave: Modelo de medição de desempenho de cadeias de suprimentos; Sistemas de medição de desempenho; Gestão da cadeia de suprimentos; Estudo Delphi.

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ABBREVIATIONS

BSC – Balanced Scorecard Approach

IT – Information Technology

PMS – Performance Measurement System

SC – Supply Chain

SCC - Supply Chain Council

SCI – Supply Chain Integration

SCM – Supply Chain Management

SCOR – Supply Chain Operations Reference

SCP – Supply Chain Performance

SCPM – Supply Chain Performance Measurement

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1 INTRODUCTION

According to Li *et al*. (2006) effective supply chain management (SCM) has become a potentially valuable way for developing a sustainable competitive advantage and improving organizational performance since competition is no longer established by organizations, but among supply chains.

Highly competitive environments require that supply chain managers respond quickly to competitive challenges, inventory shortages, customers' requirements in product customization, quality improvement, inaccurate order processing and unreliable transport situations. On the other hand, they need to reduce production cost, shorten lead times and lower inventory levels to ensure profitability (CHITHAMBARANATHAN *et al.*, 2015; SMITH *et al.*, 2005).

In modern business environments characterized by ever increasing competition and economy globalization, manufacturers have been exploiting innovative technologies and strategies to achieve and sustain competitive advantage (CHANDRA and KUMAR, 2000). In order to survive under these pressures, more and more enterprises are striving to develop long-term strategic partnerships with a few competent supply chain partners and collaborate with them in product development, inventory control, distribution and non-core process outsourcing (CHITHAMBARANATHAN *et al.,* 2015; CHAN and QI, 2003b).

The supply chain environment calls for collaboration among supply chain partners, who often establish strong relationships with each other (PAPAKIRIAKOPOULOS and PRAMATARI, 2010). Performance analysis can provide important feedback information to enable supply chain managers to monitor implementation, review progress, enhance communication and diagnose problems. It can also provide insights about the effectiveness of the systems in place and procedures practiced, and it can help on identifying potential opportunities for improvement. Also, the analysis on supply chain performance can provide a basis for better integration among the supply chain members and, especially, for better decision-making in supply chain management, particularly in redesigning business goals and strategies, and in reengineering processes (SHARMA and BHAGWAT, 2007).

In such a complex setting, the quest for performance is still an open issue (FAWCETT *et al.*, 2008). Relevant research efforts in supply chain performance measurement focus either on the identification of significant performance metrics (GUNASEKARAN *et al.*, 2001; HOFMAN, 2004; LAMBERT and POHLEN 2001) or on the examination of the collaborative success of the supply chain (CORSTEN and KUMAR, 2005; FAWCETT *et al.*, 2008). The idea of a common performance measurement system (PMS) was suggested by Holmberg (2000), who identified the fragmented measurement activities of a Swedish home furnishing business supply chain and proposed the use of systems thinking when developing PMSs. Moreover, the importance of the topic has been recently recognized by Busi and Bititci (2006) who have indicated collaborative performance measurement as an issue for further research. Other research works addressing performance measurement in supply chains, extended enterprises and virtual enterprises specify a range of performance measures, which should be used in managing supply chains and virtual organizations but fail to integrate these within a strategic performance measurement framework (BITITCI *et al*., 2005).

Supply chain management is a multidisciplinary field and it is addressed from many different perspectives. By means of desk research, Otto and Kotzab (2003) identified system dynamics, operation research, logistics, marketing, organizational theory and strategy as relevant scientific fields to performance measurement in supply chains. These findings are in line with the suggestions of Neely *et al.* (1995) who proposed that a PMS should incorporate different perspectives, because it is of equal importance from a management perspective. The existence of different perspectives blurs the decision regarding what it is (or not) significant to measure in a supply chain, thus a growing, yet important, number of performance measures has been suggested in the literature (PAPAKIRIAKOPOULOS and PRAMATARI, 2010).

In order to bridge this gap, this research project derives and organizes from the literature a set of recommendations for supply chain performance measurement systems. The result is the proposition of a model proposition for supply chain performance measurement, which is refined and confirmed by means of an empirical-based approach.

1.1 RESEARCH QUESTION

The field of performance measurement in a supply chain context is maturing. However, many critical drawbacks prevent the existing performance analysis methods from making a significant contribution to the development and improvement of supply chains. Some of the major drawbacks with the existing methods are: inability to capture holistic aspects; lack of suitability to the different levels of measurement; complexity in methods; requirement of intricate details; and inadequacy to capture vagueness in human judgement. These obstacles characterize the need of a suitable framework which can take into account the commonalities of practical supply chains when analyzing performance (CHITHAMBARANATHAN *et al.,* 2015; PIOTROWICZ and CUTHBERTSON, 2015).

Inadequate supply chain performance measurement systems are still amongst the major barriers to successful supply chain collaboration. Systems architecture concepts provide a new perspective to study supply chain performance measurement. Various supply chain characteristics such as complexity, differences of business cultures and firm's orientation, emergence versus control of processes, and the great number of interfaces between firms can and should be viewed through the wider measure of supply chain interoperability (CHALYVIDIS *et al.*, 2013).

Based on this context it is possible to establish the research question that guides this research: What are the generally applicable measures for measuring supply chain performance?

1.2 RESEARCH OBJECTIVES

1.2.1 Main objective

The research question entails the following research general primary objective: Propose a model for supply chain performance measurement.

1.2.2 Specific objectives

In order to accomplish the primary objective, a set of specific secondary objectives is decomposed:

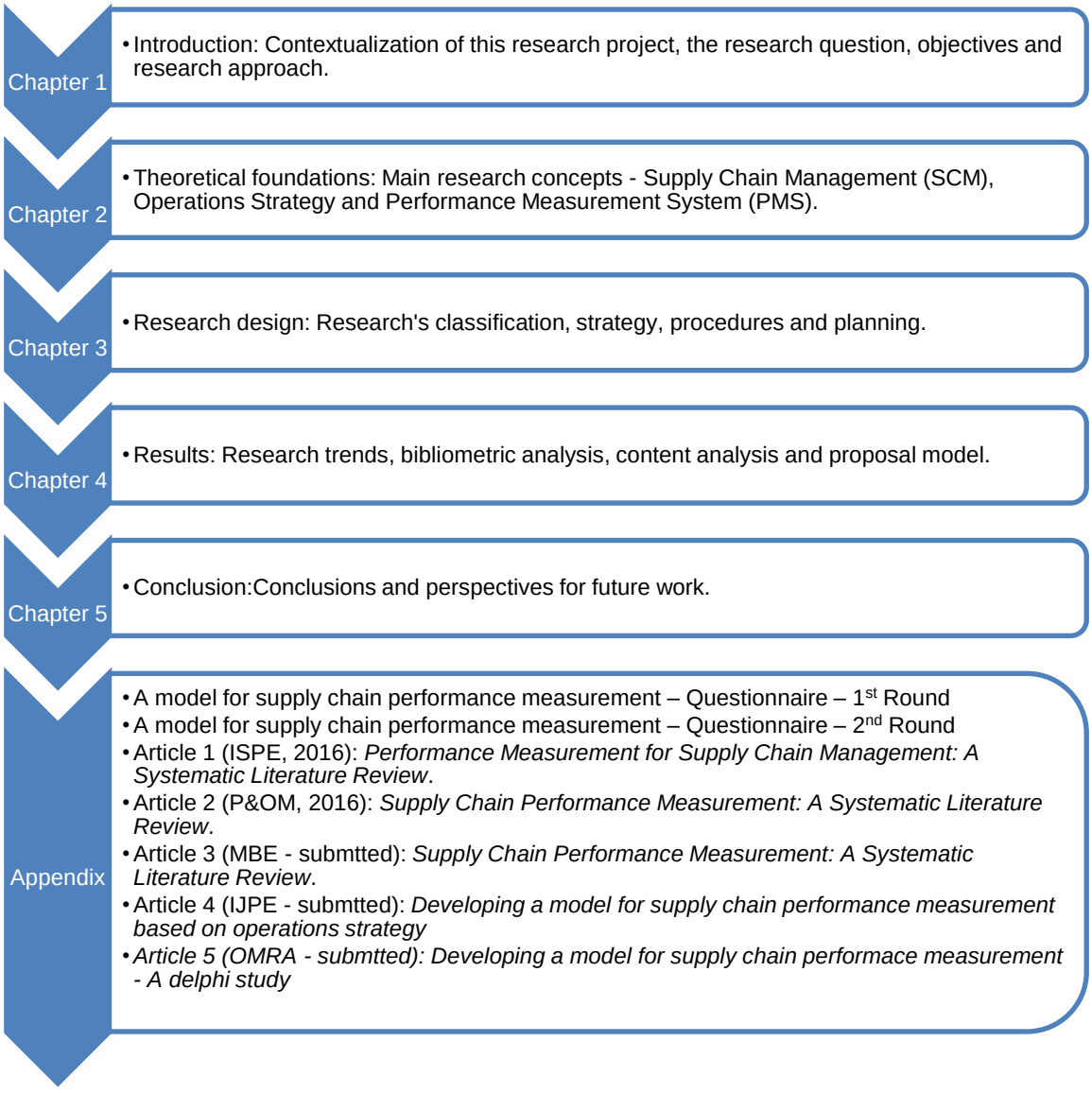
a) Identify and organize from the supply chain literature a set of research trends related to supply chain performance;
b) Select from the literature the measures for a supply chain performance measurement system and propose a model;
c) Refine the proposal model from an empirical-based approach.

1.3 RESEARCH STRUCTURE

This study is characterized as a qualitative study based on interviews with experts to propose a supply chain performance measurement model. This research is organized in 5 chapters and appendix, as follows: the first chapter presents the contextualization of this research project, which comprises the introduction, the research question, the research objectives and the research approach. The following chapter presents the theoretical foundations, from which the main research concepts are defined. Chapter three presents the research design in detail, which includes the research procedures and the research planning. Chapter four presents the results of research, which include the critical review on research trends, the bibliometric analysis and the proposal and validation of the model. The last chapter presents the conclusions and final remarks of this research project, and also discusses the research limitations and perspectives for future work.

The Appendix presents the dissertation articles, which were submitted to journals. Figure 1 exhibits the dissertation structure.

Figure 1 - Research structure



Source: the author, 2017.

Presented the research objectives and approach, the next section presents the theoretical background.

2 THEORETICAL BACKGROUND

This is a multidisciplinary study, since its core concepts have interfaces with different research fields. In order to provide a view on the major context of supply chain performance measurement models, three major disciplines are outlined in this document section: supply chain management, operations strategy and performance measurement systems.

2.1 SUPPLY CHAIN MANAGEMENT

According to Chopra and Meindl (2007) supply chain consists of all parties involved, directly or indirectly in fulfilling a customer request. The supply chain not only includes the manufacturer and the supplier but also transporters, warehouses, retailers, wholesalers, service providers and customers themselves. Supply chain is a network of companies, which influence each other. Within each organization, such as a manufacturer, the supply chain includes all the functions involved in receiving and fulfilling a customer request. The primary aim of supply chain is to maximize the overall value generated (CHEN and GONG, 2013; CHOPRA and MEINDL, 2007; HUGOS, 2011). The concept of supply chain can also be found in variations such as extended enterprise, supply network, operations network and value chain.

Supply chain management has been emerging as one of the main areas in businesses that can offer sources of competitive advantage (LOCKAMY III; MCCORMACK, 2004). The importance of this topic to organizations is reinforced by factors such as increasing competition, globalization, greater product variety, outsourcing, shorter product life cycles, continuous advances in technology and ever-demanding clients (GIUNIPERO *et al*., 2008; GUNASEKARAN *et al.*, 2001; LOCKAMY III and MCCORMACK, 2004).

Although there are many definitions in the literature, supply chain management (SCM) can be defined as the management of different types of physical, informational and financial flows from the raw-materials stage through to the finished products, connecting material suppliers, manufacturers, distributors and customers (CHITHAMBARANATHAN *et al.,* 2015; VILLA, 2001). According to Vollmann *et al.* (2005) SCM has the objective of coordinating these

flows across companies, recognizing that major improvements are gained in the overall coordination.

According to Stevens (1989) supply chain management is primarily concerned with managing relationships with suppliers and customers in order to deliver the best customer value at the lowest cost.

Mentzer *et al*. (2001) define SCM as the “systematic and strategic coordination of the traditional business functions within a particular company and across businesses within the supply chain, with the aim of improving the long-term performance of the individual companies and the supply chain as a whole”. This coordination and the relationships established among enterprises within the supply chain can offer competitive advantages, either by cutting costs or by adding value for customers (COOPER *et al.,* 1997; LAMBERT *et al.*, 1998).

According to Bagchi *et al.* (2005) the implementation of SCM requires different companies to stop attempting to improve their own processes independently, as has been done up until now, in order to achieve a global benefit. In this context Bititci *et al*. (2005) define an extended enterprise as chain of enterprises, which essentially behave as a single enterprise trying to maximize the corporate goals of the extended enterprise, thus optimizing the performance of each individual enterprise. An extended enterprise is a knowledge-based organization, which uses the distributed capabilities, competencies and intellectual strengths of its members to gain a competitive advantage to maximize the performance of the overall extended enterprise (BITITCI *et al*., 2005; CHILDE, 1998).

2.2 OPERATIONS STRATEGY

The complexity and dynamics of current business environments offer several challenges to the strategic management frameworks, particularly in the front line levels, in which the companies relate with their suppliers and customers (MELNYK *et al.*, 2004).

Today’s management systems’ specifications aim at developing operations management processes that are multidimensional and provide better balancing, integration, flexibility. Such priorities should reflect the performance

specifications of a strategic management framework (GOMES *et al.,* 2004; PINHEIRO DE LIMA *et al.*, 2008).

Hayes and Wheelwright (1985) define “operations strategy” as a pattern of decisions taken through the course of time so that the business unity may accomplish a desired competitive advantage. It consists in the operations of a business unit providing support for the company’s business strategy. The operations strategy formulation begins with defining the business strategies for the different niche markets in which the company compete.

As to (SLACK; LEWIS, 2008), operations strategy is the general pattern of decisions that determines the long term competences and their contribution to the global strategy, for any kind of operation, by means of conciliating market requirements and operations capabilities.

The operations strategy content can be organized in two major layers: defining competitive objectives and relating them to performance measures. These measures set up references to the decision-making processes for each dimension of the operations – i.e., for each “decision area” in the operations. The performance measures along with the decision areas define the content of the operations strategy (HAYES and WHEELWRIGHT, 1985; HOFER and SCHENDEL, 1978).

2.2.1 Performance dimensions

An organization may articulate its market positioning in different ways. For instance, it may compare itself with an important competitor, or perhaps it may address the needs of a particular group of customers. In any case, one end up defining its market positioning in a range of dimensions, such as quality, price and variety flexibility. The strategic choice varies according to the business model of a company and the strategy it adopts (SLACK; LEWIS, 2008).

Competitive criteria, or performance dimensions, are defined as a consistent set of objectives that can be applied to any operation and that satisfy the market requirements. Hence, the competitive criteria represent the dimensions one should value in order to succeed in a given market (SLACK; LEWIS, 2008). The selection of competitive criteria should be done taking into account aspects such as: the customers’ needs; the possible trade-offs between

performance requirements; the company's current performance on the criteria in comparison to the competitors; and the current resources and capabilities that are accessible to the company's operations (BARNEY, 2001).

Slack (2002) consider the following performance dimensions for the manufacturing function:

- Quality: offering products and services in compliance with design specifications;
- Flexibility: adapting the operations to changes in the customers' requirements as needed and with the demanded quickness;
- Speed: producing and delivering products and services within the shortest interval time as possible;
- Reliability: meeting the deadline promises and other conditions agreed with the customers;
- Cost: offering products and service with lower prices than those of the competitors;
- Innovation: designing and launching new products and services – and doing that quicker than the competitors.

The formulation of goals and objectives to the manufacturing function is a matter of translating the customers' needs into a set of terms that are meaningful to those customers. It implies on deciding whether the price of a product is more important than the delivery time, in the customers' perspective. Some of the competitive criteria may be more or less important to the customers than others. One way to distinguish these interpretations is to separate the competitive criteria into "order winners" and "order qualifiers" (SLACK, 2002).

Hill (2000) provided a useful definition to properly differentiate "order winners" and "order qualifiers". In this author's point of view, "order qualifiers" are the criteria for which the company must achieve a minimum performance degree in order for it to be able to compete in a given market, that is, those criteria that represent minimum or basic requirements so that the customers at least consider the company as a possible supplier. As to the "order winners", these are the criteria that directly influence the customers' choice, therefore, for a company to be an "order winner", it must be at least as good as the competitors.

2.3 PERFORMANCE MEASUREMENT

There is no unique conceptual definition to performance measurement systems (PMS). According to Neely *et al.* (1995), performance measurement is the technique for quantifying the efficiency and effectiveness of business activities. The efficiency addresses the economic utilization of resources, taking into consideration a given level of expectation. The effectiveness, in turn, evaluate the result of a process in comparison to the clients' expectations.

According to Amaratunga *et al*. (2002), a strategic performance measurement system is one that utilizes information about performance to produce a positive change on the organization's culture, systems and processes. Folan *et al.* (2007) points out that the PMS is responsible for managing the implementation of operations strategy.

Measurement systems are part of a wider system, which includes the design of metrics, feedback and incentive mechanisms. The performance measurement processes are elements of a strategic control system and can be used to influence behavior (OLSEN *et al*., 2007; PINHEIRO DE LIMA *et al.,* 2009; VAN VEEN-DIRKS, 2005).

Many authors agree about the necessity of a performance measurement framework, such as the Balanced Scorecard (BSC), the performance prism and the dynamic PMS (JOHNSTON *et al.,* 2002; NEELY *et al.,* 2002; KAPLAN and NORTON, 1992). These frameworks play the role of providing a clear and balanced structure for the performance dimensions of an organization.

Such a framework must be exclusive for each company (AHN, 2001). The strategic maps provide a structure in which to organize, describe and visually represent the strategic objectives, initiatives, targets, metrics and the cause-and-effect relations between the components that shape an organization's strategy. The aim of the strategic maps is mainly to facilitate the translation of strategy into operational terms (measures) and to help the workers to obtain a better comprehension and visual representation about the factors upon which they must concentrate their energy (KAPLAN and NORTON, 2001).

The identification and selection of the appropriate measures and targets will help the company to implement its intended strategy at all organizational levels (KAPLAN and NORTON, 2001; MALINA and SELTO, 2001;

VASCONCELLOS, 1988). The strategy of a company is probably the most important issue in its management agenda. One of the fundamental roles played by a PMS is to guarantee that the corporate strategy is effectively implemented and continues to be valid (KAPLAN and NORTON, 2001; NEELY, 1998).

Over time, the PMSs are clearly changing, decreasing their emphasis on control to become more oriented to learning. Even though the performance measurement literature recognizes that there is certainly a relationship, more and more evident it becomes that performance measurement is a social phenomenon, in which individual and organizational behaviors are shaped by the values and perceptions of people and by the communities to which they belong (BITITCI *et al*., 2012; DAVENPORT *et al.*, 2010).

The fundamental components for developing performance measurement initiatives – usually materialized in systems – are guidelines for the performance measurement. These guidelines define the content and structure of performance measures, organizing them into a framework that underlies the performance measurement system design (FOLAN and BROWNE, 2005a).

Decisions regarding the content, structure and subsequent selection and organization of performance measures are strongly related to their ‘usefulness’, which in turn define the PMS itself. At this level, the focal point is the selection of measures that will compose the PMS. A framework for selecting performance measures can be built based on the performance dimensions of manufacturing and services operations, which can be tailored for well-defined purposes (KUMAR et al., 2008; LEONG; SNYDER; WARD, 1990; NENADÁL, 2008; PLATTS, 1995; SLACK; LEWIS, 2008; VERBEETEN; BOONS, 2009).

The PMS is an important part of the strategic management system, since it affects the latter’s dynamics. Franco-Santos and Bourne (2005) list several factors that impact positively or negatively in the way organizations manage through measures. Likewise, Bourne (2005) organizes the factors that influence the PMS implementation into three main categories: purpose, structure and culture. These categories may cover business management as a whole or focus on improvements in the PMS.

There are four basic processes related to performance measurement systems, namely: design, implementation, use and reconfiguration/update (BOURNE *et al.,* 2005; BOURNE et al., 2000; NEELY *et al*., 2000).

According to Bourne *et al*. (2000) the design phase can be subdivided into identifying the key objectives to be measured and designing the measures themselves.

The implementation process highlights the importance of dynamic facilitators, especially those related to changes in culture, systems and processes. The process view is an important element for the integration of performance information into strategic management systems. Adopting a process view shows how the PMS roles can be deployed in systems or networks operations. There are specific skills that are associated with the process view, such as continuous improvement, organizational learning and change management (BOURNE *et al.,* 2005; BOURNE *et al.*, 2000; NEELY *et al*., 2000).

The use of performance measures is split into two main subdivisions:

i) first, as the measures are derived from strategy, the initial use to which they should be put is that of measuring the success of implementation of that strategy;

ii) second, the information and feedback from the measures should be used to challenge the assumptions and test the validity of the strategy (BOURNE *et al*., 2000; KAPLAN and NORTON, 1996; ECCLES and PYBURN, 1992).

The reconfiguration (and/or update) process can be understood as the redesign or review of the performance measurement system design, including the dynamic behavior, causal relationships, evolutionary properties, development of skills and maturity levels. The PMS can lose its effectiveness over time, if not reshaped to better meet new environmental and organizational demands (BOURNE *et al*., 2005; BOURNE *et al*., 2000; NEELY *et al*., 2000).

3 RESEARCH DESIGN

This chapter presents the research approach and strategy, the research procedures and the research planning aimed at meeting the study objectives.

3.1 RESEARCH CLASSIFICATION

This research is characterized as an exploratory and descriptive study with a qualitative approach. It is exploratory because it seeks to deepen knowledge on a subject that has been gaining research attention in recent years, especially in the concern of understanding the design, implementation, use and reconfiguration of supply chain performance measurement systems. It is descriptive because it confronts the application characteristics of performance measurement systems in corporations, through the eyes of experienced experts in the field, in relation to the characteristics identified in the literature. It is qualitative because the problem approach is based on the collection and analysis of qualitative data, since it is intended to capture the perspectives and interpretations of people and organizations surveyed and therefore the subjective reality and context of the organizations studied is considered relevant to the study design (MIGUEL *et al.*, 2012).

According to Bryman (1989) the qualitative research characteristics are:

- Emphasis on the subjective interpretation of individuals;
- Design of the research environment context;
- Approach less structured than qualitative studies;
- Multiple sources of evidence;
- Importance of organizational reality design;
- Proximity to the studied phenomenon.

As opposed to the quantitative approach, which uses structured ways like statistical methods to analyze the data collected, the qualitative approach has not established forms for data analysis. In recent years, some analytical methods have been applied, as grounded theory, content analysis, discourse analysis, etc. and software applications have been developed to facilitate this task (BRYMAN, 1989b; CAUCHICK MIGUEL et al., 2012).

3.2 RESEARCH STRATEGY

The research design strategy is based on the application of bibliographic procedures for the model construction and empirical studies for its refinement and for the assessment of its applicability against its objectives.

A systematic literature review is carried out in order to map the research trends in the supply chain field. To identify recommendations for the design, implementation and use (and reconfiguration) of a supply chain performance measurement system and to propose a consolidated model, the content analysis technique will be applied. To refine the model and compare the literature recommendations with practice, a Delphi Study will be conducted.

3.2.1 Systematic literature review

According to Tranfield *et al.* (2003), in management research, the literature review process is a key tool used to manage the diversity of knowledge for a specific academic inquiry. The literature review is a process which is conducted to provide a map of the body of knowledge in a specific field (TRANFIELD; DENYER; SMART, 2003).

The objective of a systematic and structured literature review is to observe and understand the past trends and extant patterns/themes in the research area, evaluate contributions and summarize knowledge, thereby identifying limitations, implications and potential directions of further research (KAMAL; IRANI, 2014). A systematic literature review (SLR) requires an extensive review of papers following a list of specific steps to ensure that the most relevant information with regard to a specific topic (subject) is obtained in an unbiased manner. Eventually, this ensures the fidelity, completeness and rigorous nature of the review (CHOONG, 2014; GONZÁLEZ *et al*., 2010).

According to Tsay (2008), bibliometric analysis is a statistical method for counting references to evaluate and quantify the literature growth for a particular subject. Bibliometric studies were used in the present work as techniques for supporting SLR strategy, and the study applies such techniques as a set of research methods to map the structure of knowledge in the researched theme through a quantitative and statistical approach from different bibliographic data.

Thus, from the processing of information relating to the authors of the research papers, the publication's outlets (journals), the research institutions and keywords, it is possible to evaluate the trends and behavior of scientific production developed in a specific field (TREINTA et al., 2014; VANTI, 2002).

3.2.2 Content analysis

The content analysis is a research technique for conducting an objective, systematic, and quantitative description of the manifest content of communication (BERELSON, 1952; MARCONI and LAKATOS, 2011). Quantitative consists of counting the numbers of occurrences per category. Systematic in the sense that the researcher must count all relevant aspects of the sample and not arbitrarily select aspects to be widespread. It is objective as meaning that the units selected for analysis and the categories formation must be clearly defined according to a criterion (GAO, 1989).

According to Graneheim and Lundman (2004) the basic assumption in qualitative content analysis is that reality can be interpreted in many ways and the understanding is dependent on subjective interpretation. In this sense, a text always involves multiple meanings and there will always be some degree of interpretation. According to (BARDIN, 2011), "the content analysis is a set of methodological instruments constantly improving, which apply to extremely diverse discourses". For this reason, content analysis appears as a set of communication analysis techniques that make use of systematic and objective procedures for the description of messages' content (BARDIN, 2011).

The content analysis conduction includes several stages, so that one can give meaning to the collected data. These steps are organized in three phases: pre analysis, material exploration, and treatment of results, inference and interpretation (BARDIN, 2011; SILVA; TREVISAN, 2013). The first phase, pre-analysis, is designed to systematize the initial ideas put by the theoretical framework and establishes indicators for the interpretation of the information collected. It comprises general reading of the chosen material for the analysis. The second phase, material exploration, consists of the coding operations, considering the text clippings in data records units, the definition of counting rules and the classification and aggregation of information in symbolic or thematic

categories. The third phase comprises the treatment of results, inference and interpretation. It is to capture the manifest and latent content contained in all material collected – interviews, documents and observations (BARDIN, 2011; SILVA; FOSSÁ, 2015).

3.2.3 Delphi Study

According to Britto Júnior and Feres Júnior (2011) the scientific research starting point should be based on a data collection. For this collection, it is necessary, first of all, to do a literature search. In the second phase, the researcher should perform an observation of facts or phenomena so that it gets more information and, in a third stage of the research, the researcher aim is to get information or collect data that would not be possible only through literature research and observation. The Delphi Study is one of the techniques used by researchers to collect data in this third stage.

A Delphi study is a systematic, iterative process to elicit a consensus view from a panel of experts. The expert panelists' knowledge and presumptions on an issue or development process under study are collected in an interactive process by means of series of questionnaires combined with controlled feedback. As a technique, it is well designed to handle opinions rather than objective facts. By nature, Delphi can fall into the category of both quantitative and qualitative study (FLYNN, 1990; LAAKSO; RUBIN; LINTURI, 2012; MCKENNA, 1994; SCHMIDT, 1997).

The Delphi technique embodies the following key characteristics (CHOCHOLIK *et al.*, 1999; MELNYK *et al.*, 2007; WHITMAN, 1990):

- The use of a panel of "experts" for obtaining data;
- Participants do not meet in face-to-face discussions;
- The use of sequential questionnaires and/or interviews;
- The systematic emergence of a concurrence of judgment/opinion;
- The guarantee of anonymity for subjects' responses;
- The use of frequency distributions to identify patterns of agreement.
- The use of two or more rounds between which a summary of the results of the previous round is communicated to and evaluated by panel members.

The panel of experts should comprise a group of people who are both familiar with, and knowledgeable on the problem domain being considered and they should be mutually anonymous. The panel is then asked to respond to a questionnaire. Then all questionnaire responses and comments are combined and analyzed in order to statistically collate and summarize the results for another round of the process. This iterative process may be continued further until consensus and/or clarity is produced. Finally, the results from the process are reported (MACCARTHY; ATTHIRAWONG, 2003).

The Delphi technique is most appropriate under the following conditions (LINSTONE; TUROFF, 1976; MELNYK *et al.*, 2007):

1. The research problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis;
2. The research population may present diverse backgrounds with respect to experience or expertise;
3. More subjects are needed than can effectively interact in a face-to-face exchange;
4. Disagreement among individuals may be so severe or politically changed that anonymity must be insured;
5. Time, cost, and logistics would make frequent meetings of all the subjects unfeasible.

Of these five conditions, it was the first and the second that proved to be the primary reasons for the selection of the Delphi technique for this study.

3.3 DATA COLLECTION AND ANALYSIS

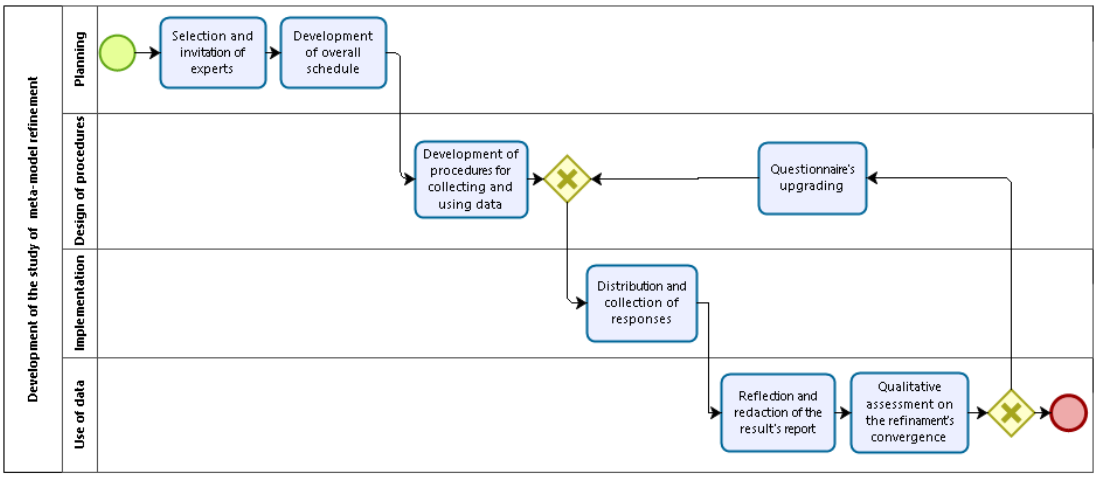
Data collection includes primary and secondary data. The primary data are from Delphi study, which will be conducted for the model refinement. The secondary data are from the following sources: content of papers, which will be analyzed in order to derive recommendations for the implementation and use of performance measurement systems in supply chains. The “Atlas.TI” and the “NVivo” software applications are used to support this qualitative analysis process. The questionnaire's results that make up the Delphi study for validation of the model proposed.

3.3.1 Delphi study procedure

The procedure for conducting the Delphi study is derived from the work of Silveira (2014), who conducted a study with similar characteristics of the present work. His workflow for refinement studies through expert interviews was considered to be suitable for the refinement of the supply chain performance measurement recommendations, because it provides a structured procedure for a proper planning, design, implementation and use of data from Delphi study.

The first step in the process will be the general planning of the study. This involves, firstly, the selection of the range of experts to be invited for the study. The selection of possible experts will be based on their profile, taking into account mostly the experience factor. Naturally, the feasibility of getting the interview with the expert is also a factor to be considered. After the possible experts' invitation, an overall schedule will be planned and managed, especially for the study to be properly carried out in the deadline. Figure 2 shows an overview of the process.

Figure 2 - Workflow of the study of model refinement



Source: the author, 2017.

In the design phase, the procedures and formularies will be developed, which should involve, specifically:

i. The procedure for conducting the interviews and collecting the necessary data;
ii. The procedure for analyzing and synthesizing the data collected;
iii. Design of the formularies applied in the process (questionnaire and interview report);
iv. Upgrading of the questionnaire to each new iteration.

The implementation phase consists of carrying out the Delphi study procedures, i.e. it is the phase in which the distribution and collection of responses will be conducted.

The collected data involves not only the refinement of the model itself, but also the discussion underlying it. Thus, following round, the collected data should be registered and organized in such a manner that enables the researcher to critically analyze the round's results.

3.3.2 Content analysis procedures

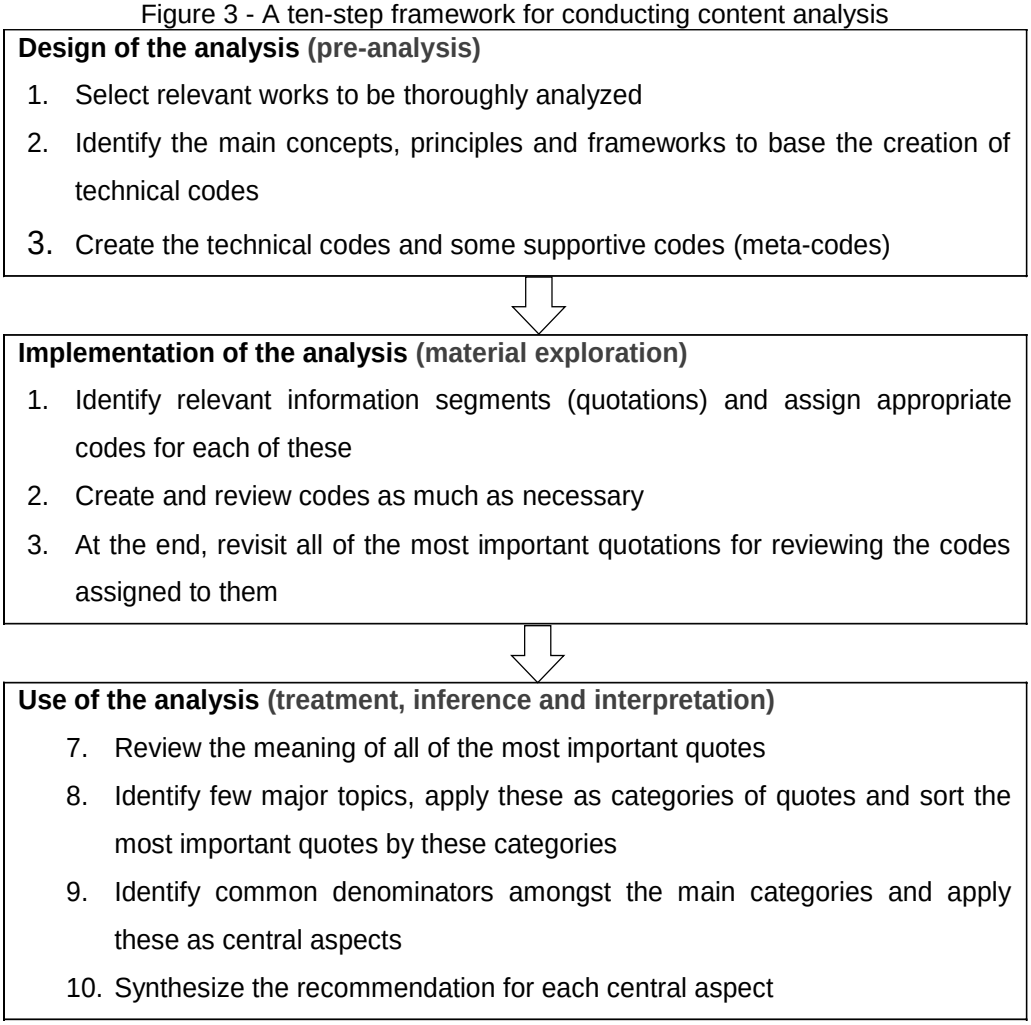
The content analysis to be conducted in this research can be described as a ten-step procedure adapted from Silveira (2014), as shown in Figure 3. This procedure is a ten-step framework for conducting content analysis studies, especially those aimed at deriving and organizing recommendations, requirements, conditions and/or guiding principles from literature. This framework classifies the content analysis in three phases: the design phase is equivalent to ‘pre-analysis’, which was described earlier in this document; the implementation phase is equivalent to ‘material exploration’; and the use phase is equivalent to ‘treatment, inference and interpretation’ of data. This procedure was adapted to the particular context of the present research, as follows.

In order to prioritize relevant works – within the dataset of 76 papers filtered as the result of the systematic literature review – to be considered sooner in the content analysis sequence for the extraction of recommendations that may lead to the derivation of the model, a sorting will be done based on each article’s objective and keywords, as well as on the journal’s impact factor, the authors’ h-index and the article's number of citations. The thorough reading and analysis of the most cited articles will be held first, in order to identify the main concepts and frameworks within the Supply Chain Performance Measurement field and its context. The perspectives derived from literature may be seen as qualitative dimensions from which to organize the content analysis. Thus, the concepts and frameworks identified within the most cited articles will base the design of the initial set of codes to be considered thereafter in the content analysis.

The content analysis of each article will be conducted by a procedure of critically reading and scrutinizing the article, identifying relevant information and marking it as a “quote”, and assigning the appropriate codes for each quote. A relevant quote should contain a segment of information related to a recommendation or guideline, a key element or principle that could lead to the derivation of the model. Naturally, new codes may arise during this process. So, after concluding the content analysis for all of the articles in the dataset, a global review will be undertaken and each quote will be revisited for a check on the codes assigned to it.

After that, the most important quotes will pass through a final review, to make sure that every quote is understandable and meaningful. Next, the quotations will be sorted by category, according to the codes assigned to each quote. Then, each category – composed as a set of various quotations from different authors – will be thoroughly analyzed in order to identify underlying common denominators. These common denominators will be applied as subcategories – central aspects within each major category. Hence, the most relevant topics agreed by different authors will be converted into a recommendation for the design of a supply chain performance measurement model.

Figure 3 - A ten-step framework for conducting content analysis



Source: Adapted from Silveira (2014).

An advantage of conducting content analysis guided by a procedure and using a computational tool is to obtain traceability of data, in such a manner that the analysis results may be easily traced back to their original sources. In addition, new codes can be easily incorporated into the analysis framework if necessary, allowing already-handled data to be examined from new perspectives. This iterative process provides a robust basis for analyzing and for better synthesizing the relevant information in the research project and strengthen the credibility of the study results.

4 RESULTS

This chapter presents the results of the systematic literature review, research trends mapping, a content analysis of 76 papers and the Delphi Study.

4.1 SYSTEMATIC LITERATURE REVIEW

A method adapted from Tranfield *et al.* (2003) was applied to produce a robust and comprehensive knowledge base in supply chain performance measurement. Table 1 exhibits the adapted model.

Table 1 - Systematic literature review phases

Phase	Steps
Define	1. Identification of need for a literature review 2. Development of a literature review protocol
Collect and Select	3. Identification of documents 4. Selection of relevant documents
Analyze	5. Categorization of documents 6. Data extraction
Result	7. Document findings

Source: adapted from Tranfield *et al.* (2003).

The systematic literature review was conducted to find all relevant papers about supply chain performance measurement and management and to identify the factors that influence supply chain performance.

Table 2 presents the protocol, which was used in this research. The protocol is a plan that helps to protect objectivity by providing explicit descriptions of the steps to be taken. It contains information about the keywords, the search strategy, and the criteria for inclusion and exclusion of studies in the review (DAVIES; CROMBIE, 1998; TRANFIELD; DENYER; SMART, 2003).

In order to comprehensively cover the literature in the search for articles, a range of keywords was considered: Group 1 refers to the search terms for supply chain, Group 2 refers to the search terms for performance measurement and Group 3 aims at searching for propositions oriented to practice – i.e. to find references about models and performance measurement practices in the supply chain literature. Both groups 1 and 2 were considered mandatory in the articles' title and abstract, that is, both the title and the abstract would have to have one of the terms from Group 1 and one from Group 2. The term 'performance' was applied as mandatory in the articles' abstract and at least one of the search terms

from Group 1 or Group 2 should be present in the keywords. Papers addressing humanitarian chains or services were excluded from the sample.

Table 2 - Literature review protocol

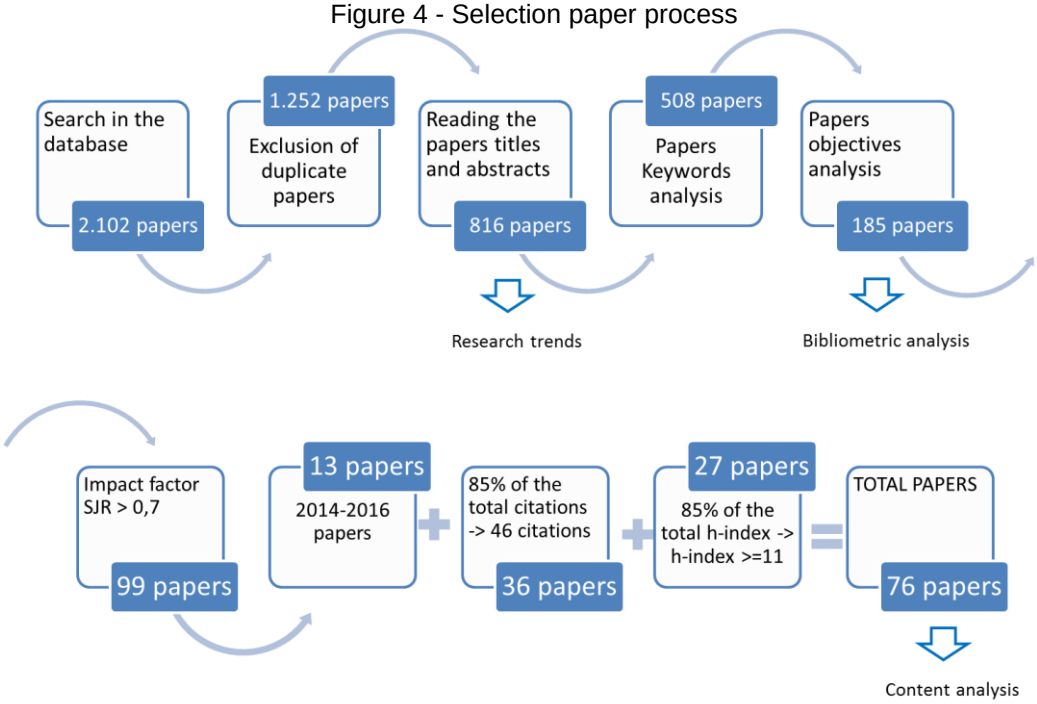
Keywords	Group 1 - Supply Chain; SCOR; Operations Network; Supplier; Collaboration Network; Extended enterprise; Inter-organizational Group 2 - Performance; Indicator; Metric; Measure; KPI; Performance Measurement; Performance Management Group 3 - Model; Framework; Process; Method; Technique; Tool; System
Boolean Operator	Title: OR between keywords; AND between groups 1 and 2 Abstract: Performance it is mandatory; OR between keywords; AND between groups Keywords: OR between keywords of groups 1 and 2.
Databases	Web of science, Scopus, Science Direct, Emerald, Taylor & Francis and Wiley
Exclusion criteria	NOT humanitarian chains NOT services
Language	English; Portuguese
Publication Type	Articles

Source: the author, 2017.

The search for the articles considered six different databases that contain important journals in the field of supply chain. The search for articles was carried out between December 2015 and January 2016.

In total 1252 papers were identified in the six scientific bases. All papers abstracts were reviewed in order to exclude works not pertinent to the research and to identify the main methodology, authors, years, journals and keywords of each paper. Repeated papers among the databases were also excluded, resulting in a dataset of 816 papers. Then, an analysis was conducted regarding the papers' keywords and goals in order to identify the ones related to performance measurement models in supply chain, which resulted in a set of 185 papers. The next step was to perform a bibliometric analysis within the filtered set of papers in order to understand the evolution of the theme under various perspectives. Figure 4 presents the whole procedure for the selection of papers.

Figure 4 - Selection paper process



Source: the author, 2017.

The last filtering procedure considered four layers: publication impact factor, publication year, recurrence of citations and the authors' h-index factor. First, all papers published in journals with impact factors (SJR) greater than 0.7 were selected, resulting in a sample of 99 papers. Then, the three other layers were applied, but now with an inclusive function, that is, to include the papers in the final dataset, rather than to exclude. All of the most recent publications were selected – a set of 13 papers from 2014 to 2016. Another set of 36 papers representing 85% of the total of citations was selected to be included in the final data set. Finally, a set of 27 papers representing 85% of the total of authors h-index was also included. The sum of the 13 recent papers, the 36 often cited and the other 27 papers with high h-index resulted in a final data set of 76 papers to base the content analysis to be carried out, i.e., the content analysis considers these 76 papers.

4.2 RESEARCH TRENDS

This section presents the research trends identified as the result of the systematic literature review. During the reading of the papers' abstracts, they were classified according to its central theme. On that account, the research

works included in the dataset of 816 papers can be classified in five main groups, according to their common themes: i) Supply chain integration and collaboration; ii) IT and information sharing in supply chains; iii) Supply chain management practices; iv) Green supply chain; and v) Supply chain performance measurement and management. The discussion on these common subjects addressed in the supply chain literature provide an overall comprehension upon the context in which the present research work is positioned, especially to the extent that these themes involve issues and aspects that impact on supply chain performance.

The last research trend, which is related to strategic performance measurement systems, is the group that addresses the core scope of the present research work. This particular perspective will be thoroughly examined and scrutinized by means of the bibliometric analysis of the 185 papers filtered from the systematic literature review and in the content analysis upon the final selected dataset of 76 papers, as it is presented later in this document.

4.2.1 Supply chain integration and collaboration

Supply chain integration (SCI) has been a highly researched topic during the last 20 years. The purpose of Armistead and Mapes (1993) article is to identify the extent to which greater integration along the supply chain leads to improved operating performance. Trkman and Groznik (2006) show how the supply chain performance can be improved with the integration of various tiers in the chain. Integration is a prerequisite for effective sharing and utilization of information among different companies in the chain. Their work deals with business renovation, effective utilization of information technology and the role of business process modeling in supply chain integration projects.

Lee *et al.* (2007) developed multivariate regression models in order to identify the characteristics of linkages determinants in the supply chain stakeholders (suppliers, internal stakeholders and customers). The purpose of their research is to present the relationship between supply chain linkages and supply chain performance (cost-containment and reliability of supply chain partners).

According to Fabbe-Costes and Jahre (2008) more supply chain integration (SCI) does not always improve performance. Definitions and

measures of SCI and performance are diverse to the extent that a conclusion such as “the more (SCI) the better (the performance)” cannot be drawn. Zhao *et al.* (2015), for instance, argue that supply chain integration may impair financial performance under certain conditions.

Danese and Romano (2011) investigate whether there are synergies that a firm could or should exploit by simultaneously implementing customer and supplier integration. In particular, their aim is to analyze the impact of customer integration on efficiency, and the moderating role of supplier integration. They found that supplier integration positively moderates the relationship between customer integration and efficiency, whereas the analyses do not support the hypothesis that in general customer integration positively impacts on efficiency and when supplier integration is at a low level, customer integration can even produce a reduction in efficiency.

According to Gimenez *et al.* (2012) the supply chain integration increases performance if supply complexity is high, while a very limited or no influence of supply chain integration can be detected in case of low supply complexity, and in high supply complexity environments the use of structured communication means to achieve supply chain integration has a negative effect on cost performance.

Leuschner Rudolf *et al.* (2013) use an analytic approach to provide a quantitative review of the empirical literature in SCI, and examine relevant design and contextual factors.

Innovativeness is an accepted driver to leverage firm performance. Seo *et al.* (2014) study the impact of innovativeness on supply chain integration and supply chain performance (SCP) and the role of SCI in mediating between innovativeness in the supply chain and SCP. SCI and SCP require innovativeness in the supply chain, but their interrelationships have rarely been researched empirically.

Didonet *et al.* (2014) verify the alignment between market orientation and supply chain integration practices for improving performance in small and medium-sized enterprises (SMEs). The findings show that market orientation indirectly and positively influences performance via supply chain integration. The direct relationship between market orientation (MO) and SCI was also confirmed. Likewise, the relationship between market orientation and supply chain

integration was found to be strong and positive. The findings suggest that the generation of information in market oriented SMEs favors their sharing information both inter-and intra-organizational.

4.2.2 IT and information sharing in supply chains

The influence of information technology (IT) and information and knowledge sharing in the performance of the supply chain is also targeted by investigators. Jayaram and Vickery (2000) found that the three dimensions of information system infrastructure (ISI) - design-manufacturing integration (DMI), manufacturing technology (MT), and information technology (IT) - directly influenced at least one dimension of time-based performance. For example, DMI influenced manufacturing lead time, MT influenced new product development time, and IT influenced customer responsiveness. Process improvement also directly influenced supply-chain time performance. Finally, ISI and process improvement had a positive and complementary effect on time-based performance. The findings strongly support the idea of joint deployment of information system infrastructure and process improvement to streamline cycle time performance in a supply chain.

In their study, Byrd and Davidson (2003) examined the impact of IT on the supply chain through a survey of 225 large profit-making US firms. Specifically, it involved the determination of IT antecedents to IT impact on the supply chain and the effect that these relationships had on overall firm performance. Fawcett *et al*. (2007) carried out a large-scale survey and semi-structured interviews to understand how IT is used to enhance supply chain performance. They identified and analyzed two distinct dimensions to IT - connectivity and willingness. Both dimensions are found to impact operational performance and to be critical to the development of a real information sharing capability. The research presents a two-by-two matrix to help managers and academics understand the related nature of connectivity and willingness and a roadmap is presented to help guide IT development and investment decisions.

The purpose of Collins *et al*. (2010) paper is to provide a conceptual overview of the relationship between knowledge management, supply chain technology investments, and overall firm performance.

Baihaqi and Sohal (2012) conceptualized and assessed several factors that influence the degree of information sharing in supply chains, namely integrated information technologies, internal integration, information quality and costs–benefits sharing and then they tested the relationship between the degree of information sharing and organizational performance. Huo, *et al.* (2014) use data from 617 Chinese manufacturing firms to investigate the relationships among competitive environments, supply chain information sharing (SCIS) and supply chain performance. According to Tyagi *et al.* (2014) IT is the most important concern for the existence of a company in the competitive market. A model based on analytic hierarchy process (AHP) is proposed to evaluate the alternatives – namely top management support, IT advancement and supply chain integration – on the behalf of performance improvement in IT-enabled supply chain.

Based on the dynamic capabilities perspective and the view of a hierarchy of capabilities, Liu *et al*. (2013) proposed a model to examine how IT capabilities (i.e., flexible IT infrastructure and IT assimilation) affect firm performance through absorptive capacity and supply chain agility in the supply chain context.

According to Ryoo and Kim (2015) the extent of knowledge complementarities (KC) is an important theoretical and practical issue in inter-firm relationships. However, extant research on KC is not clear about what constitutes KC and how the benefits of KC are realized and few empirical studies have examined the impact of KC on inter-firm performance. Their study purpose is to identify the dimensions of KC and to empirically examine the relationships among KC, inter-firm knowledge exchange, and supply chain performance.

4.2.3 Supply chain management practices

In recent years, numerous approaches have been proposed to improve operations performance. Three in particular – Just in Time (JIT), Supply Chain Management (SCM), and Total Quality Management (TQM), have received considerable attention. While the three are sometimes viewed and implemented as if it was independent and distinct, they can also be used as three prongs of an integrated operations strategy. Kannan and Tan (2005) examine the extent to which JIT, SCM and TQM are correlated, and how they impact business

performance. Results demonstrate that at both strategic and operational levels, linkages exist between how JIT, TQM and SCM are viewed by organizations as part of their operations strategy. Results also indicate that a commitment to quality and an understanding of supply chain dynamics have the greatest effect on performance (KANNAN and TAN, 2005). Hsu *et al*. (2009) use mediated regression analysis and structural equation modelling to test the proposition that supply chain management practices mediate the relationship between operations capability and firm performance. They define operations capability in terms of a firm's new product design and development, TQM and JIT capabilities.

Vanichchinchai (2014) aim to assess the level of supply chain management practices (SCMP), total quality management practices (TQMP) and firm's supply performance (FSP) in the automotive industry in Thailand and investigate the differences across organizational characteristics on SCMP, TQMP and FSP.

Li *et al*. (2006) conceptualize five dimensions of SCM practice (strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement) and tests the relationships between SCM practices, competitive advantage, and organizational performance. The results indicate that higher levels of SCM practice can lead to enhanced competitive advantage and improved organizational performance. Peng Wong *et al*. (2011) investigate how SCM practices and knowledge management (KM) capabilities affect firm performance.

Chavez *et al*. (2012) examine the effect of industry clock speed on the relationship between SCM practices, from both upstream and downstream sides of the supply chain, and SCM performance. Gawankar *et al.* (2013) collected the data through questionnaire survey from 157 operations and supply chain heads from leading retail stores in India with the aim to design a scale with a high degree of reliability, validity and dimensionality which helps to determine appropriate supply chain practices and their interrelations.

In their paper Okongwu *et al.* (2015) purpose to empirically investigate, from a balanced scorecard strategy map (BSSM) perspective, the types of linkages through which supply chain management practices (SCMPs) impact on financial and non-financial performance, and consequently lead to the achievement of the firm's strategic objectives.

4.2.4 Green supply chain

The first work related to green supply chain in this review is the study of Green *et al.* (1998) that discusses the following issues: how does green purchasing change the environmental performance of the firms in a supply chain/network and what is the influence of supply chain and industry structure on that performance? Do such changes contribute to companies' overall environmental performance and to sustainability?

In 2005, Hervani *et al.* (2005) introduce and provide an overview of the various issues related to environmental (green) supply chain management performance measurement. Their work relies on experiences, case studies and other literature related to performance measurement in environmental supply chains. As a result, they provide an integrative framework for the study, design and evaluation of green supply chain management performance tools.

According to Vachon and Klassen (2008) the literature characterizing environmental management within the supply chain has been slowly building, but remains sparse. Using a survey of North American manufacturers, their work examines the impact of environmental collaborative activities on manufacturing performance. Environmental collaboration was defined specifically to focus on inter-organizational interactions among supply chain members, including such aspects as joint environmental goal setting, shared environmental planning, and working together to reduce pollution or other environmental impacts.

Shaw *et al.* (2010) review extant literature and present a proposed research agenda to examine whether green performance measures can be integrated within an existing supply chain performance framework, also to explore what a meaningful industry-recognized environmental measure should look like, and to understand the direct benefits of incorporating environmental measures within a supply chain performance framework.

Olugu *et al.* (2011) reviewed various literatures on green supply chain performance measurement, environmental management, traditional supply chain performance measurement and automobile supply chain management. In order to comprehensively and effectively establish the relevant measures, a suitable framework which considered the automobile green supply chain as a two-in-one chain was adopted. The study of Ahi and Searcy (2014) identified and analyzed

the metrics that have been published in the literature on green supply chain management (GSCM) and sustainable supply chain management (SSCM). In a subsequent research effort, Ahi and Searcy (2015) focused on metrics used in the literature to measure social issues.

Using coordination theory, Zhu *et al.* (2012) examine three models used to evaluate the mediation relationships between the external and internal practices of GSCM with respect to environmental, economic, and operational performance. They posit that the strategic stance of manufacturing enterprises in improving their overall performance and competitive position requires a joint coordination of internal and external GSCM practices.

According to Uysal (2012), evaluating the supply chain and improving supply chain performance require the development of sustainable supply chain performance measurement systems. In his study, The Decision Making Trial and Evaluation Laboratory (DEMATEL) Method was applied to deal with the importance and causal relationships between the sustainable performances measurements criteria by considering the interrelationships among them and the proposed frameworks are tested using data obtained from three different manufacturing companies that take place on the same supply chain.

Bhattacharya *et al*. (2014) delineated a green supply chain performance measurement framework using an intra-organizational collaborative decision-making approach. Chin *et al.* (2015) reviewed the extant literature on the relationship between green supply chain management, environmental collaboration and sustainability performance and proposed a conceptual model to elucidate the relationship between these three variables in the context of Malaysian manufacturing companies.

4.2.5 Lean and agile supply chain

In a context of increasing competition with ever-demanding customers and ever-shorter product life cycles, SCM needs right direction for a better performance. According to Soni and Kodali (2009), a "*Leagile*" Supply Chain (LASC) – which refers to a taxonomy for a combination of lean and agile supply chain management – provides a competitive advantage over other models/strategies of supply chain. These authors develop a multi-attribute

decision model named as Performance Value Analysis (PVA) to justify the LASC, and the usefulness of the proposed PVA is demonstrated though a case study.

Khan and Pillania (2008) explore the dimensions of strategic sourcing and determine its relationship with supply chain agility and organizational performance. Anvari *et al*. (2011) discuss the relationship between performance measurement systems in supply chain management and lean manufacturing.

Another relevant concept in supplier evaluation. The issue regarding suppler evaluation is that it is a multiple attribute decision-making (MADM) problem involving a mixture of qualitative and quantitative attributes. Some mathematical programming techniques have difficulty in dealing with the qualitative attributes that are not easy to measure but very important in supplier evaluation. Tsai (2009) presents a procedure for supplier evaluation by incorporating fuzzy set theory into the evaluation process to handle the qualitative attributes in the problem. All the quantitative and qualitative performance measures are normalized and then, by using the proposed model, data are integrated into a single score to rank suppliers. The model application is demonstrated through two previously reported data sets under lean philosophy.

In regard to the adoption of lean practices across the supply chain, Agus and Shukri Hajinoor (2012) develop a research effort to look for a better understanding of the extent to which lean production permeates manufacturing companies in Malaysia, by drawing on SCM managers' or production managers' perception of lean production practices and level. Sezen *et al.* (2012) develop a model for measuring adherence to lean practices for automotive part suppliers and to assess the relationship between the firm performance and the adoption of lean principles.

Sukwadi *et al.* (2013) explore how lean–agile operations and supplier–firm partnership can improve garment small and medium enterprise (SME) supply chain performance. Their study is based on cross-sectional survey research that provides longitudinal evidence to show how lean–agile operations and partnership strategy influence supply chain and garment SME performance. The results show that agile supply chain and partnership strategy are critical for garment SMEs because these strategies influence their supply chain performance. However, the leanness strategy does not necessarily influence their supply chain performance. The supply chain performance and partnership

strategy have a positive influence on the SME performance.

Among the available strategies lean, green and resilient are considered as new management strategies for the supply chain management to achieve competitiveness. Cruz-Machado *et al*. (2015) aim to identify the critical lean, green and resilient practices on which top management should focus in order to improve the performance of automotive supply chains. Arif-uz-Zaman and Nazmul Ahsan (2014) present supply chain metrics and propose a fuzzy-based performance evaluation method for lean supply chain.

4.2.6 Supply chain performance measurement and management

Measuring performance in the supply chain is crucial to identify whether an organization is on 'target' with regard to achieving supply chain objectives. Gunasekaran *et al.* (2004) develop a framework for supply chain performance measurement and provide a detailed 'measurement and metrics classification' and use a survey aiming at assessing importance within each metric group. Bititci *et al.* (2005) found that due to structural differences between traditional and extended enterprises, the systems required to measure and manage the performance of extended enterprises, whilst being based upon existing performance measurement frameworks, would be structurally and operationally different. Based on this, they propose a model for measuring and managing performance in extended enterprises which includes intrinsic and extrinsic inter-enterprise coordinating measures.

Camarinha-Matos and Abreu (2007) introduced an approach for the analysis of benefits in collaborative processes for networks of enterprises. Chae (2009) recognized that developing key performance indicators (KPIs), or metrics, is very challenging and a set of practical guidelines is not readily available for companies and supply chain management practitioners. His paper offers a practical approach to performance measurement and present a list of essential KPIs (for example, forecast accuracy, inventory turnover, days of inventory, planning cycle time, etc.).

In order to understand the interactions between SCM practices and firm performance, Ou *et al*. (2010) considered four internal contextual factors, namely: human resource management, quality data and reporting, design management,

and process management. Three levels of firm performance are also examined, including internal operational performance, external customer satisfaction, and firm financial performance.

Akyuz and Erkan (2010) reviewed 24 articles from 1999 to 2009, and concluded that the frameworks and models of supply chain performance measurement were still immature. Frederico and Martins (2014) identify eleven PMSs for SCM, two maturity models for PMS and six dimensions which drives the maturity of PMS. Also, it was possible to verify that the PMS for SCM focus only on the measurement scope, which is only one dimension to manage the maturity of the PMS. Moreira and Tjahjono (2016) develop a conceptual framework that adopts performance measures for ex-ante decision-making at an operational level within the supply chain and carried out a case study at a major global brand beverage company.

4.2.6.1 Supply chain performance measures and metrics

Lambert and Pohlen (2001) provide a framework for developing supply chain metrics that translates performance into shareholder value. The framework focuses on managing the interfacing of customer relationship management and supplier relationship management processes at each link in the supply chain.

Chan (2003) present the formulisation of both quantitative and qualitative performance measurements for easy representation and understanding. Apart from the common criteria such as cost and quality, five other performance measurements are defined: resource utilisation; flexibility; visibility; trust; and innovativeness. In particular, new definitions are developed for visibility, trust, and innovativeness.

Angerhofer and Angelides (2006) show how the constituents, key parameters and performance indicators are modelled into the environment and through a case study illustrate how the decision support environment may be used to improve the performance of a collaborative supply chain by pinpointing areas for improvement.

Cai *et al*. (2009) propose a framework using a systematic approach to improving the iterative KPIs accomplishment in a supply chain context and quantitatively analyzes the interdependent relationships among a set of KPIs (for

examplo, Supply chain responsiveness; number of new products launched; order fulfillment lead time; delivery flexibilit; Information sharing; etc.). A scenario of a large retail company is also discussed to explain the application of this framework.

Akyuz and Erkan (2010) present some characteristics and requirements that the new era performance measurement metrics should have. Lin and Li (2010) propose an integrated framework for supply chain performance measurement that adopts the six-sigma metrics and includes three components (i.e., team structure measurement, supply chain process measurement, and output measurement) to provide a more complete coverage of performance requisites, which had not been adequately addressed in relevant literatures before.

According to Bai and Sarkis (2012) formal modelling tools and approaches for organisations to help evaluate the relationships between the performance measures and the desired competitive outcomes are limited, especially in logistics and supply chain management functions. To help address this gap, they introduce a novel application of neighbourhood rough-set theory for the identification and selection of performance measures related to externally derived desired outcomes on the sourcing function.

Anand and Grover (2015) identify key indicators for performance measurement for retail industry and classified them into four major categories: transport optimization, information technology optimization, inventory optimization and resource optimization, while Piotrowicz and Cuthbertson (2015) explore the approaches and metrics used to measure SC performance and to understand the relative perceived importance of such measures.

4.2.6.2 The use of balanced scorecard approach

The Balanced Scorecard (BSC) approach was proposed by Kaplan and Norton (1992) as a framework and process for performance assessment and it was designed to complement traditional measures maintaining a balance between short-term and long-term objectives, financial and non-financial measures, lagging and leading indicators, and internal and external performance perspectives (BHAGWAT and SHARMA 2007 b).

Folan and Browne (2005b) discuss the development of a performance measurement system specifically designed for the requirements of the extended enterprise, via two performance measurement frameworks: the structural extended enterprise Balanced Scorecard and the procedural framework for the selection and implementation of measures.

Bhagwat and Sharm (2007) propose the use of the analytical hierarchy process (AHP) methodology as aid in making SCM evaluation decisions that can help firms to prioritize and formulate viable performance measurement strategies in the volatile and complex global decision environment from different BSC perspectives.

Bhagwat and Sharma (2007b) suggest that a balanced SCM scorecard can be the foundation for a strategic SCM system provided that certain development guidelines are properly followed, appropriate metrics are evaluated, and key implementation obstacles are overcome.

According to Shafiee *et al.* (2014), vast studies have been recorded on supply chain efficiency evaluation via BSC approach, but these studies do not focus on the relationships between the four perspectives of BSC. Then, after reviewing different tools to evaluate the performance of supply chain, a new approach, relying on network data envelopment analysis (DEA) with BSC approach, was generated focusing on these relationships, especially the returnable ones.

4.2.6.3 SCOR model

The Supply Chain Operations Reference (SCOR) model is a framework for examining the supply chain in detail through defining and categorizing the processes that make up the chain, assigning metrics to these processes and reviewing comparable benchmarks (AGAMI; SALEH; RASMY, 2012).

Lockamy III and McCormack (2004) investigate the relationship between SCM planning practices and supply chain performance based on the four decision areas provided in SCOR Model Version 4.0 and nine key SCM planning practices derived from SCM experts and practitioners. The results show that planning processes are important in all SCOR supply chain planning decision areas.

Based on the survey data from 232 companies that have obtained ISO 9000 certification, Li *et al.* (2011) studied the five decision areas of the SCOR model by integrating quality assurance measures in the supply chain process. The results show that, individually, each decision area has a positive impact on both customer-facing supply chain quality performance and internal-facing firm level business performance. Collectively, 'Plan' and 'Source' decisions are more important to customer-facing supply chain performance (reliability, response and flexibility), and 'Make' decisions positively affect internal-facing performance metrics (cost and asset).

Thunberg and Persson (2013) evaluated construction material supplier and construction site performance according to the SCOR model. Sellitto *et al*. (2015) present a SCOR-based model for performance measurement in supply chains and apply it in the context of Brazilian footwear industry. The model has two dimensions: SCOR processes (source, make, deliver and return) and performance standards adapted from original SCOR (cost, quality, delivery and flexibility).

4.2.6.4 Multi criteria model to evaluate supply chain performance

An innovative performance measurement method was proposed by Chan *et al.* (2003) to provide necessary assistance for performance improvement in SCM. The proposed method addresses this purpose in four aspects: a simplified supply chain model; tangible and intangible performance measures in multiple dimensions; a cross-organizational performance measurement; and fuzzy set theory and weighted average method.

Wong and Wong (2007) illustrated the use of data envelopment analysis (DEA) in measuring internal supply chain performance. Two DEA models were developed – the technical efficiency model and the cost efficiency model. The information obtained from the DEA models helps managers to identify the inefficient operations and take the right remedial actions for continuous improvement.

A mathematical model is proposed by Bac and Erkan (2011) to evaluate supply chain performance using some KPIs. This model can be used to evaluate the flexibility characteristics of logistic, market, supplier, machine, labor,

information system, and routing of the supply chain. Chen and Yan (2011) constructed an alternative network DEA model that embodies the internal structure for supply chain performance evaluation. Three different network DEA models are introduced under the concept of centralized, decentralized and mixed organization mechanisms, respectively.

A conceptual model for measuring supply chain performance which can be used for most organizations with the same class at various industries is proposed by Najmi and Makui (2012). The model has been developed according to performance metrics interdependencies and some existing shortcomings in the available literature of performance models. Furthermore, it has tried to see the key features of a performance evaluation model. The methodology which was used for solving and integrating the model is a combination of the analytical hierarchy process (AHP) and Decision Making Trial and Evaluation Laboratory (DEMATEL) methods.

Arif-Uz-Zaman and Nazmul Ahsan (2014) present supply chain metrics and propose a fuzzy-based performance evaluation method for lean supply chain and Chithambaranathan *et al.* (2015) develop a conceptual model for the task of analyzing the performance of members of supply chains.

4.2.7 Supply chain performance context

This systematic literature review considers a broad perspective of supply chain performance, in order to comprehensively identify the supply chain performance measurement and management models and the factors that influence supply chain performance.

The holistic comprehension of supply chain performance is organized and illustrated in Figure 5. It is worth observing that the network view considers only the elements that were identified during the literature review.

The relationships between supply chain management, operations strategy and performance measurement systems are outlined and depicted based on the Pettigrew's framework (1987), which is a framework for strategic change in organizations, founded on a systems perspective. Pettigrew's ideas are often applied in studies of Performance Measurement and Operations Strategy literature, such as in the works of Bourne and Franco-Santos (BOURNE *et al.*,

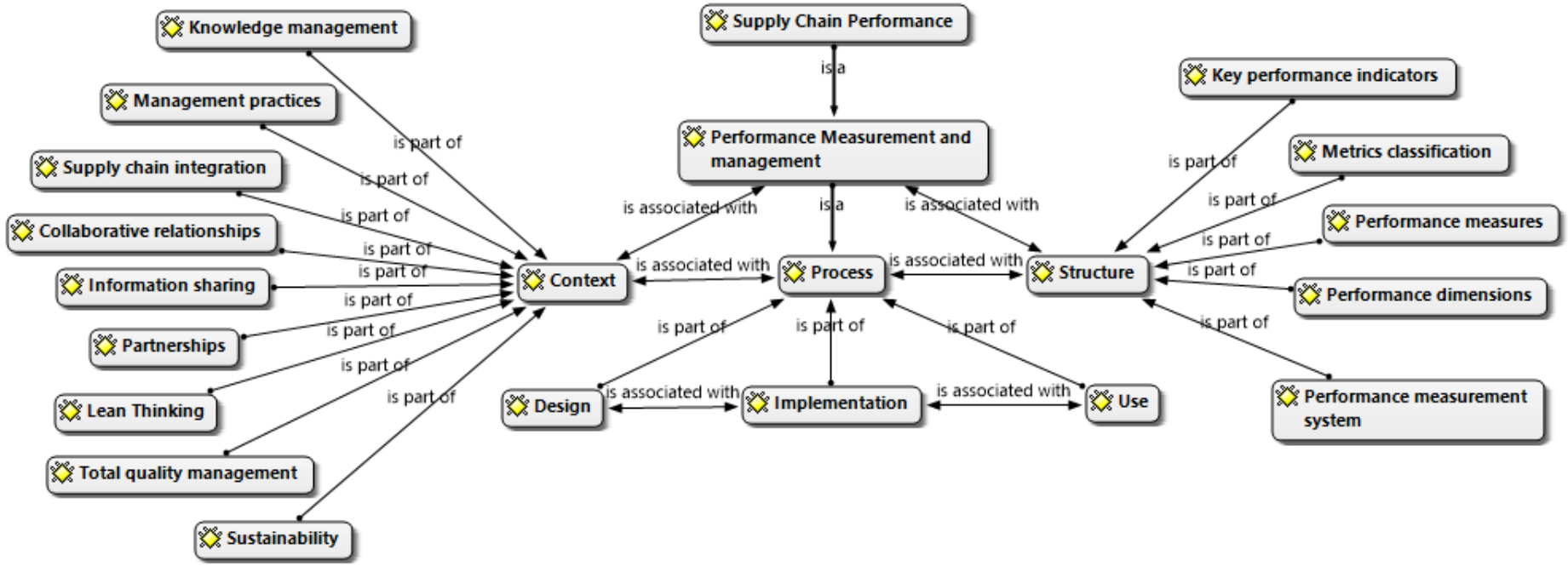
2005; BOURNE *et al.*, 2000; FRANCO-SANTOS and BOURNE, 2005). The Pettigrew's framework provides a 'contextualist' approach that contains three basic components: the context, the process and the content of change (PETTIGREW, 1987).

The 'context' involves the identification of the contextual factors that influence or are being influenced by the process or system under examination. These factors may be external or internal. Amongst the context elements, this work considered, for instance, factors presented within the research trends from groups 1 to 4.

The 'process' component involves the exploration of the process itself, which is seen as the sequence of actions and events undertaken by the people and resources involved. The process can be divided into the stages of design, implementation and use, based on the framework provided by Bourne *et al*. (2000). These three elements are inter-associated, since each phase informs the subsequent. Thus, the "use" phase also provides feedback to the "design" stage, although the inter-association between "use" and "design" has not been made explicit through a specific arc for achieving a clean network visual representation.

The third component, 'content', is considered here under a broader definition of 'structure', based on a broader work regarding enterprise engineering guidelines (DESCHAMPS *et al*., 2013). The 'structure' can be seen not only as the content of performance measures, but also as the infrastructure, resources and technologies that enable the system or process to be performed. Amongst the structure elements, this work considered, for instance, factors that are present in group 5. As all of these three components are inter-associated by definition, the structure is also associated with the context, although no specific arc establishing this association was depicted in the network for getting a cleaner picture.

Figure 5 - Holistic comprehension of supply chain performance



Source: the author, 2017.

For the present work, Pettigrew's ideas imply that a model for Supply Chain Performance Measurement Systems should take into account not only the content/structure of such a system, but also the process through which this system may be developed and also the context that influence the system's structure and process.

4.3 BIBLIOMETRIC ANALYSIS

This section presents the bibliometric analysis with 185 papers related to performance measurement models in supply chains in order to identify the theme evolution. Table 3 presents the main themes of the 185 papers and the publications related to each theme.

Table 3 - Publications by theme

Subject	**Publications**
Supply chain performance measurement and management	van Hoek (1998); Chan and H. J. Qi (2003); Schmitz and Platts (2003); Chen and Paulraj (2004); Min and Mentzer (2004); Angerhofer and Angelides (2006); Akyuz and Erkan (2010); Park and Chang (2010); Ip *et al*. (2011); Frederico and Martins (2014); Kache and Seuring (2014); Teimoury *et al.* (2014); Li and Nagurney (2015); Kim and Wemmerlöv (2015); Aramyan *et al.* (2007); Wickramatillake *et al*. (2007); Papakiriakopoulos and Pramatari (2010); Blanc *et al.* (2007); Varma *et al.* (2008); Ou *et al*. (2010); Estampe *et al*. (2013); Prajogo *et al*. (2012); Brun *et al.* (2009); Asdecker and Heigoldt (2010) Agami *et al.* (2012); Sillanpää (2015); Piotrowicz and Cuthbertson (2015); Anvari *et al*. (2011); Dhone and Kamble (2016); Raj Thangavelu and Samavedham (2007); Nikabadi and Shahrabi (2015); Frederico and Martins (2012); Madhavan (2015); Chalyvidis *et al.* (2013); Lai (2010); Widyaningrum and Masruroh (2012); Cedillo-Campos and Sánchez-Ramírez (2013); Du *et al.* (2013); Yang (2010); Chen *et al.* (2012); Morgan and Dewhurst (2007); Oztemel and Tekez (2009); Shepherd and Günter (2006); Lin and Li (2010); Hald and Ellegaard (2011); Banomyong and Supatn (2011); Morgan (2007); Lehtinen and Ahola (2010); Saad and Patel (2006); Morgan (2004); Thakkar *et al.* (2009); Basu (2001); Cuthbertson and Piotrowicz (2011); Singh *et al.* (2006); Cagnazzo *et al.* (2010); Gopal and Thakkar (2012); Gilmour (1999); Charan *et al.* (2009); Keebler and Plank (2009); Pettersson and Segerstedt (2012); Forslund *et al.* (2008); Inemek and Tuna (2009); Stefanovic and Stefanovic (2011); Yaibuathet *et al.* (2007); Turhan and Vayvay (2011); Singh and Acharya (2014); Chelariu *et al.* (2014); Cheng (2014); Lauras *et al.* (2011); Leeuw and Beekman (2008); Fattahi *et al.* (2013); Chaharsooghi and Heydari (2011); Chan *et al.* (2006)
Supply chain performance measures and metrics	Lambert and Pohlen (2001); Beamon (1999); Gunasekaran *et al.* (2001); Gunasekaran *et al*. (2004); Chan (2003); Sánchez and Pérez (2005); Huang and Keskar (2007);(Cai *et al.* (2009);Stewart (1995); Otto and Kotzab (2003); Mummalaneni *et al*. (1996); Appelqvist *et al*. (2013); Chae (2009); Christensen *et al*. (2007); Pettersson and Segerstedt (2013); Moreira and Tjahjono (2016); *Li et al.* (1997); Dabhilkar *et al*. (2009); Martin and Patterson (2009); Camarinha-Matos and Abreu (2007); Foroughi *et al.*(2003); Anand and Grover (2015); Katiyar *et al.* (2015); Kurien and Qureshi (2015); Sanjika and Bezuidenhout (2015); Singh *et al*. (2013); C. Böhm *et al.* (2007); Constangioara (2013); Kusrini *et al.* (2016); Cuthbertson and Piotrowicz (2008); Elrod *et al.* (2013); Terpend and Ashenbaum (2012); Wong and Wong (2008); Cirtita and Glaser-Segura (2012); Ramanathan *et al.* (2011); Azevedo *et al.* (2013); Sambasivan *et al.* (2009); Sambasivan *et al.* (2009); Ambe (2014)
Balanced Scorecard approach	Rajat Bhagwat and Sharma (2007); Charkha and Jaju (2015); Thunberg and Persson (2013); Kleijnen and Smits (2003); Bititci *et al*. (2005); Halman and Voordijk (2012); Shafiee *et al*. (2014); Schmitz and Platts (2004); Bullinger *et al.* (2002); Kall *et a*l. (2013); Tracht *et al.* (2013); Kim and Rhee (2012); Jalali Naini *et al.* (2011); Chia *et al.* (2009); Bigliardi

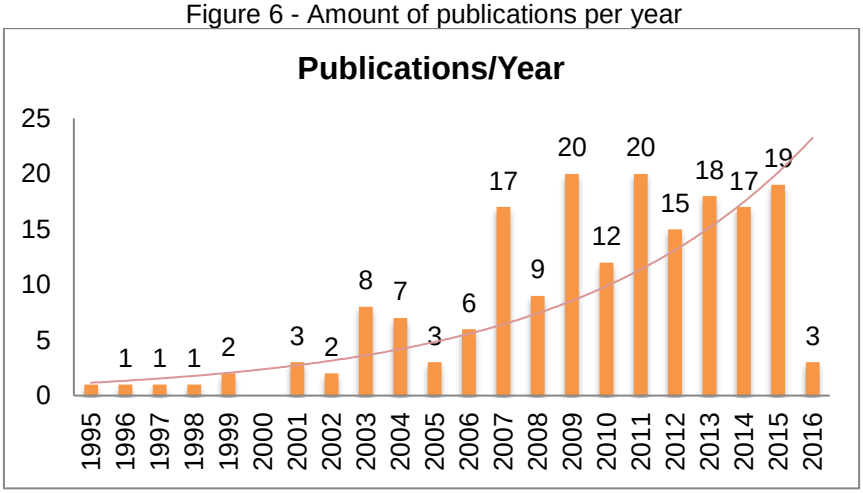
	and Bottani (2010); Doolen *et al.* (2006); Varma and Deshmukh (2009); Cunha Callado and Jack (2015)
SCOR model	Lockamy III and McCormack (2004);Folan and Browne (2005b); Stone and Love (2007); Huang (2009); Gulledge and Chavusholu (2008); Hwang *et al.* (2008); Theeranuphattana and Tang (2008); Pan *et al.* (2010); Ganga *et al.* (2011); Li *et* al. (2011); Bai and Sarkis (2012); Kocaoğlu *et al.* (2013); Medini and Rabénasolo (2014); Sellitto *et al*. (2015); Jamehshooran *et al.* (2015)
Multi criteria model to evaluate supply chain performance	Bac and Erkan (2011); Chan *et al.* (2003); Chan and Qi (2003); Bhagwat and Sharma (2007); Chen and Yan (2011); Tavana *et al*. (2013); Najmi and Makui (2012); Dey *et al*. (2015); Agami *et al*. (2014); Wong and Wong (2007); Bhagwat and Sharma (2009); Olugu and Wong (2012); Berrah and Clivillé (2007); Xu *et al*. (2009); Chan and Qi (2002); Tavassoli *et al.* (2015); Eraslan and Atalay (2014); Öztayşi and Sürer (2014); Wang (2013); Chithambaranathan *et al.* (2015); Clivillé and Berrah (2012); Kumar (2015); Rostamy-Malkhalifeh *et al.* (2013); Tsai (2009); Adel El-Baz (2011); Ganga and Carpinetti (2011); Jain *et al.* (2004); Parkan and Wang (2007); Bhagwat *et al.* (2008); Yang (2013); Charkha and Jaju (2014); Vaidya and Hudnurkar (2013); Arif-Uz-Zaman *et al.* (2014); Sahu *et al.* (2014); Chen *et al.* (2011); Yaxin *et al.* (2011); Galankashi *et al*. (2014); Hankun and Xiyao (2015); Adarme-Jaimes *et al.* (2012); Wang *et al.* (2009)

Source: the author, 2017.

4.3.1 Publications over time

The first analysis is related to publications distribution over the years. Research on performance measurement in the supply chain have begun in the 90s, but more than 80% of the papers were published during the last ten years of which 35% of the publications were carried out in the last three years. Figure 6 exhibits the publications evolution over the years.

Figure 6 - Amount of publications per year



Source: the author, 2017.

It is worth noting that the number of articles analyzed published in 2016 is not significant since the search for articles was carried out between December 2015 and January 2016.

The fast growth of research in this particular field may be justified not only by the strengthening of academic communities in general, but also by the increasing importance given to the supply chains management leading to the need of developing ways to measure and manage performance of companies working together.

It is possible to verify that the performance measurement development field experienced different phases over time. In the 50s, a focus on efficiency; then a focus on financial indicators until the 70s; from the 80s emerged a concern with measuring and balancing new dimensions; by the time the supply chain management field arose, in the 90s, the performance measurement field was changing its focus from measuring to managing performance, and then began the need for researching supply chain performance measurement and management. On that account, it is not surprising that the bulk of studies in this particular field has begun to take place after 2003, with faster growth in recent years.

It is worth noting that the year of 1999 holds the most cited article, according to database Scopus, entitled "Supply chain measuring performance" from Beamon (1999), who proposed new flexibility measures for supply chains.

4.3.2 Journals

The 185 identified papers were published in 91 different journals. The twelve most expressive journals, listed in the Table 4, represent 45% of all publications.

Table 4 – Papers distribution by journals

Journal	JCR	SJR	Publications
Benchmarking: An International Journal	-	Q1	11
International Journal of Operations and Production Management	1,736	Q1	10
International Journal of Productivity and Performance Management	-	Q1	10
International Journal of Production Economics	2,752	Q1	10

Supply Chain Management: An International Journal	3,500	Q3	8
International Journal of Production Research	1,477	Q1	8
Production Planning and Control	1,466	Q1	7
International Journal of Supply Chain Management	-	Q3	4
Journal of Intelligent Manufacturing		Q1	4
Industrial Management and Data Systems	1,226	Q2	4
International Journal of Business Performance Management	0,204	Q3	4
International Journal of Logistics Systems and Management	-	Q3	4

Source: the author, 2017.

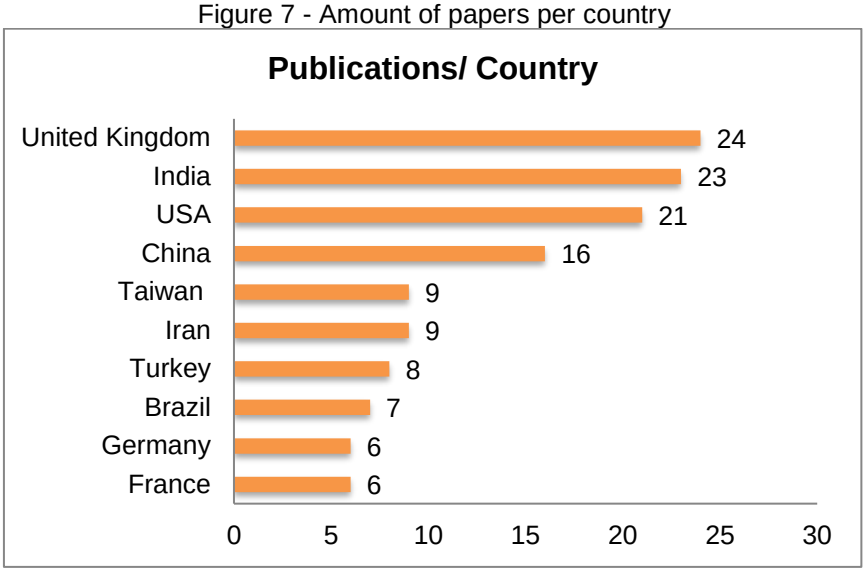
According to the databases, the subject area of the publications varies widely. The fields that seem to be more interested in supply chain performance measurement and management are Business, Management and Accounting; Engineering; Decision Sciences; Computer Science; Economics, Econometrics and Finance; Social Sciences and Environmental Science.

Important journals of the Performance Measurement field stand out with a representative number of articles, such as *International Journal of Operations and Production Management*, *International Journal of Productivity and Performance Management* and *International Journal of Production Economics.* Also, one can note that sustainability issues are already being explored in the performance measurement field, as Bititci *et al*. (2012) point out in their literature review.

4.3.3 Publishing countries

The analyzed publications are from 39 different countries. The ten most representative countries are shown in Figure 7.

Figure 7 - Amount of papers per country



Source: the author, 2017.

There is certainly a growth of publications from the emerging Asian countries, which seems to be an effect of a natural trend in recent years in the overall context of global economics and education. The rates of investment in science, technology and education in countries such as China and India have significantly increased over the last decades[1].

In this panorama, the first publication from China was in 2002, and Chan F.T.S is the author with more participation in publications, with 8 publications from 2002 to 2006. The most representative article is "Performance Measurement in the Supply Chain" from Chan (2003) with 217 citations. As to India, the first publication within the dataset is from 2004. The most representative authors of this country are listed in Table 5, and the most cited article is "Performance measurement of supply chain management: The Balanced Scorecard approach" from Bhagwat and Sharma (2007a) with 216 citations.

Brazil also appears among the countries with more publications in this field, although the amount of publications can still be considered small. The papers from Brazil are related to the use of performance measurement systems in supply chains, especially the Balanced Scorecard approach and the SCOR model.

[1] A recent report of the US' National Science Board points out to the growth of Asian investments in science, as it is discussed in the following NYT's article: LOWREY, A. U.S. Dominance in Science Faces Asian Challenge. The New York Times. Feb 13, 2014.

4.3.4 Leading authors

We considered for this analysis all authors of each identified paper, not just the corresponding author. As a result, 396 different authors are listed, of which 91% are present in only one paper. Table 5 shows information about twelve researchers who authored three or more papers, and their correspondent h-index.

Table 5 - Leading authors

Authors	Papers	University/Department	Country	h-index
Chan, F. T.S.	8	Hong Kong Polytechnic University, Department of Industrial and Systems Engineering	China	42
Qi, H. J.	5	The George W. Woodruff School of Mechanical Engineering	United States	21
Bhagwat, R.	4	Jai Narain Vyas University, Department of Mechanical Engineering	India	14
Gunasekaran, A.	4	University of Massachusetts Dartmouth, Decision and Information Sciences	United States	44
Sharma, M. K.	4	Jai Narain Vyas University, Department of Production and Industrial Engineering	India	12
Morgan, C.	3	Humboldt State University, Department of Chemistry	United States	24
Piotrowicz, W.	3	University of Oxford, Sad Business School	United Kingdom	5
Cuthbertson, R.	3	University of Oxford, Saïd Business School	United Kingdom	5
Deshmukh, S. G.	3	Atal Bihari Vajpayee Indian Institute of Information Technology and Management	India	32
Wong, K. Y.	3	University Technology Malaysia, Department of Manufacturing and Industrial Engineering	Malaysia	17

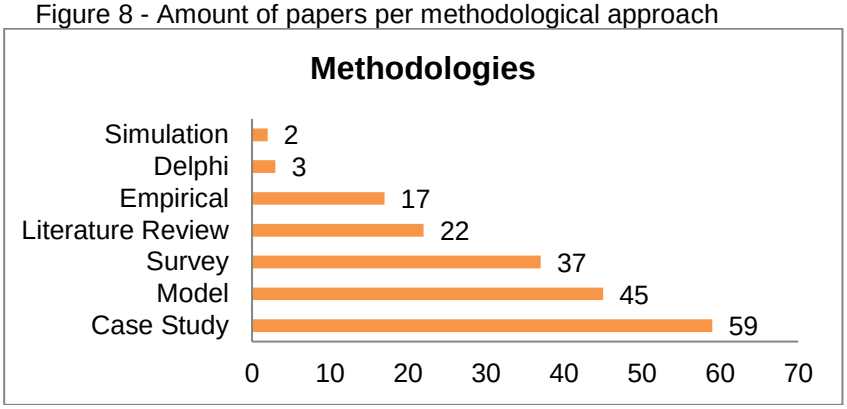
Source: the author, 2017.

It is possible to notice that the authors with more relevance are from the 4 countries with more publications on the subject.

4.3.1 Methodologies

All papers on the dataset were classified by its most important methodological approach, based on the authors' description of their works. The following Figure 8 presents the amount of papers identified for each of these categories.

Figure 8 - Amount of papers per methodological approach



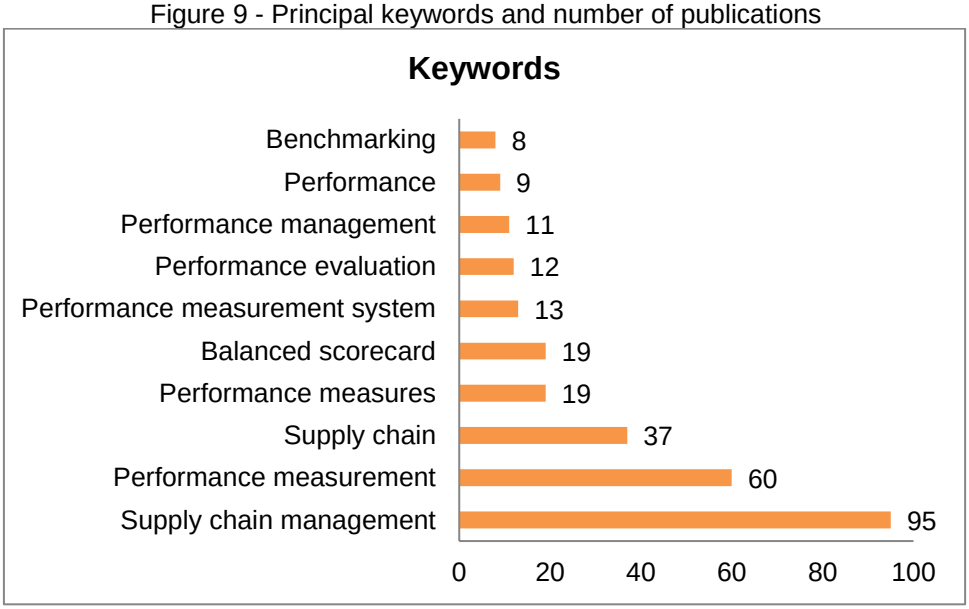
Source: the author, 2017

It is notable that the authors are concerned with carrying out practical investigations in case studies, from which we can infer that there is a variety of models/systems/frameworks being implemented and tested in the real context of supply chains. The development of models also stands out in this bibliometric analysis, which comprises use of both quantitative and quantitative methods. The use of survey is also highlighted and gives a clue on the concern with conducting studies in broader samples of data collection.

4.3.2 Keywords

The most recurring keywords used for represent the studies in supply chain performance management, presented in the analyzed papers, were identified. Figure 9 lists the amount of papers studied that used the ten most expressive.

Figure 9 - Principal keywords and number of publications



Source: the author, 2017.

Interestingly, among the most frequent keywords in papers, only the words "benchmarking" and "performance evaluation" were not applied in the search string. As to the other keywords found, they are either a word present in the groups described earlier in this document or a word that represents an intersection between the groups. The latter is the case of "supply chain management", for instance, which is an intersection between words from groups 1 and 2, and also "performance measurement system", which is an intersection between words from groups 2 and 3.

By observing the ten most recurring keywords, one can infer that the academic community indeed considers performance measurement in supply chains as an important topic.

4.4 CONTENT ANALYSIS

This section presents results about the content analysis. The effort of content analysis it was aided by the software "Atlas.TI". During the reading of the selected documents, the quotations that were considered to be relevant were selected and coded according to the concepts that ground this research work. It is worth noting that, some constructs for SCM have been identified and are similar to the relationships found in the previous literature review described earlier in this document, about supply chain, operations strategy, and performance measurement.

The quotations analysis allowed to identify the main limitations and characteristics of the systems of measurement of performance of the supply chains, which will be presented in the next sections and will be used as reference for the model proposition.

4.4.1 Limitations of current supply chain PMS

Although the study of supply chain performance measurement was enriched by different researchers and findings, some gaps still exist (GUNASEKARAN; PATEL; MCGAUGHEY, 2004; NAJMI; MAKUI, 2012; SHAFIEE; LOTFI; SALEH, 2014). While there are many ongoing research efforts on various aspects and areas of SCM, so far little attention has been given to the

performance evaluation, and hence, to the measures and metrics of supply chains (GUNASEKARAN; PATEL; TIRTIROGLU, 2001) . Gunasekaran, *et al.* (2004) identified that there are a lack of empirical analysis and case studies on this field. According to Bai and Sarkis (2012), the barriers to effective PMS can derive from too many and poorly fitting performance measures. One of the main problems with PMSs is that often there are too many data. This excess of data may make the PMS less effective (NEELY, 1998).

Lack of valid measurement criteria and inadequate methodologies to aggregate different performance measures into a single index is one of the limitations. None of the current strategic models and frameworks for performance measurement, such as balanced scorecard, performance prism, IPMS, smart pyramid etc., consider performance measurement and management from an extended enterprise perspective. Inter-enterprise coordinating (or partnership) measures are essential to ensure that various partners within an extended enterprise coordinate effectively and efficiently to ensure that the performance of the extended enterprise is maximized. Some works specify a range of performance measures, which should be used in managing supply chains but fail to integrate these within a strategic performance measurement framework (BITITCI *et al.*, 2005; SHAFIEE; LOTFI; SALEH, 2014).

Some of the main problems cited by the researchers in the studies about performance evaluation of the supply chains are:

– Lack of connection with the strategy (BEAMON, 1999; CHAN et al., 2003; CHAN; QI, 2003b; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; HUMPHREYS; MCIVOR; CHAN, 2003; SHAFIEE; LOTFI; SALEH, 2014).

– Lack of a balanced approach. For a balanced approach, companies should bear in mind that, while financial performance measurements are important for strategic decisions and external reporting, day-to-day control of manufacturing and distribution operations is better handled with non-financial measures. (BEAMON, 1999; CHAN et al., 2003; CHAN; QI, 2003b; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; MASKELL, 1991; NAJMI; MAKUI, 2012; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006).

– Focus on cost to the detriment of non-cost indicators (BEAMON, 1999; DE TONI; TONCHIA, 2001).

– Lack of a clear distinction between metrics at strategic, tactical, and operational levels. Using a classification based on these three levels, each metric can be assigned to a level where it would be most appropriate (GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; NAJMI; MAKUI, 2012).

– Large number of performance measures. Quite often, companies fail to realize that performance measurement can be better addressed using a good few metrics (GUNASEKARAN; PATEL; MCGAUGHEY, 2004; NAJMI; MAKUI, 2012).

– Insufficient focus on customer and competitors (BEAMON, 1999; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006).

– Loss of supply chain context, thus encouraging local optimization (BEAMON, 1999; CHAN; QI, 2003b; SHAFIEE; LOTFI; SALEH, 2014).

– Lack of system thinking (CHAN, 2003; CHAN; QI, 2003b; SHEPHERD; GÜNTER, 2006).

– Encouragement of short termism (SHAFIEE; LOTFI; SALEH, 2014).

– Failure to provide adequate information on what competitors are doing through benchmarking (SHAFIEE; LOTFI; SALEH, 2014).

4.4.2 Supply chain performance measurement models and characteristics

In this section, the most important supply chain performance measurement characteristics and models identified in the content analysis are mentioned.

In the 1990s the identification of performance measurement systems was a key concern, having as its main objective the planning of measurement systems whose dimensions would be broadly aligned with the corporate strategy (NEELY; GREGORY; PLATTS, 2005). There have been a wide variety of measurement systems mainly oriented to a measurement of autonomous entities (companies, subsidiaries, business units, etc.) and these models did not take into account the complexity of value-creating company chains (ESTAMPE *et al*., 2013). In the 2000s was defined a number of measurement models that helped to analyze supply chains in terms of some of their components (collaboration, human resource management, sustainability, etc.) (BEAMON, 1999; ESTAMPE *et al*., 2013; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN;

PATEL; TIRTIROGLU, 2001). Estampe *et al.* (2013) summarized the 16 best-known models of supply chain performance measurement and their particularities, as shown in Annex 1.

The operations strategy literature suggests that a supplier's operational competences can enhance the value of its products on the following dimensions: quality, cost, delivery, flexibility, and new product development (KAPLAN, 1984; KIM; WEMMERLÖV, 2015; SKINNER, 1969; SLACK; LEWIS, 2015).

In 1999, Beamon (1999) identified three types of performance measure as vital components for the supply chain performance measurement system including resource, output and flexibility. The author also mentioned that the result of each one affects the others and supply chain performance measurement system must contain at least one individual measure from each of the identified types (BEAMON, 1999; FREDERICO; MARTINS, 2014; GUNASEKARAN; PATEL; MCGAUGHEY, 2004). She divided performance measures into two groups, quantitative and qualitative, to discuss customer satisfaction and responsiveness, flexibility, supplier performance, cost and other elements of supply chain efficiency modeling. Extending these measures leads to providing a new framework for supply chain evaluation that measures the strategic, tactical, and operational level of performance (BEAMON, 1999; BITITCI *et al*., 2005; SHAFIEE; LOTFI; SALEH, 2014).

Gunasekaran, Patel and Tirtiroglu (2001) proposed a framework for determining the performance of supply chain according to the strategic, tactical and operational levels and along the five elements of an integrated supply chain: plan performance, source performance, production performance, deliver performance and customer satisfaction. This has been done so as to assign them where they can be best dealt with by the appropriate management level, and for fair decisions to be made (GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001). This framework deals with supplier delivery, customer service, inventory and logistic cost. The metrics are also distinguished as financial and non-financial so that a suitable costing method based on activity analysis can be applied. In some cases, a metric is classified as both financial and non-financial. According to Gunasekaran, Patel and Tirtiroglu (2001), taken together, these three representations of metrics can give a clear picture of which metric should be used for the performance assessment

study, where it can be used, and who will be responsible for that. Such a representation is a step closer to bridging the gap between the need for a model with which supply chain performance can be assessed, and the potential areas of improvement that can be identified.(BITITCI *et al.*, 2005; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014). The framework developed by them is shown in Annex 2 and Annex 3.

In 2002, Hausman (2002) claimed that an supply chain needs to be evaluated by three criteria including service, asset and speed. He also emphasises that the metrics must be suitable for the value proposition of the SC (NAJMI; MAKUI, 2012; SHAFIEE; LOTFI; SALEH, 2014).

Apart from the common criteria such as cost and quality, Chan (2003) proposed five other performance measurements: resource utilisation - to measure the resource utilization, a company can directly investigate the percentage of surplus or deficit of that resource within a period. Resource utilization also shows the efficiency of that company, flexibility, visibility - for a supply chain is important for accurate and fast delivery of information. It is clear that measurement of visibility is the time and accuracy of information transfer, trust - it is the reliability and consistency between different levels of the supply chain and enhances the long-term relationship between them, and innovativeness. In Annex 4, a framework for performance measurement is described and it is based on quantitative and qualitative measurements. Of the seven attributes identified as important measures for the performance of the supply chain, two of them are direct quantitative measures (i.e. cost, and resource utilization), and the other five are qualitative (i.e. quality, flexibility, visibility, trust, and innovativeness) (CHAN, 2003).

Shepherd and Günter (2006) summarize the taxonomy of supply chain performance measures, shown in Annex 5, delineated according to: the processes identified in the SCOR model (plan, source, make, deliver or return); whether they measure cost, time, quality, flexibility or innovativeness; and, whether they are quantitative or qualitative shows this framework. Agarwal, Shankar and Tiwari (2006) applied a framework in which the market sensitiveness, process integration, information driver and flexibility are used for determining the performance of the supply chain. They explored the relationship

among lead-time, cost, quality and service level with the leanness and agility of an SC in the fast-moving consumer goods business. Lead- time, cost, quality and service level are the major determinants of the proposed framework. (AGARWAL; SHANKAR; TIWARI, 2006; NAJMI; MAKUI, 2012; SHAFIEE; LOTFI; SALEH, 2014).

A framework in which the reliability, responsiveness, flexibility, reconfigurability and cost criteria have been proposed by Xia *et al.* (2007) for measuring SC performance. They also used analytical hierarchy process (AHP) to link the company performance measures to SC strategy, and identify some important attributes and metrics in the SC. Cai *et al.* (2009) developed a methodology which used a process-oriented SCOR model to identify basic performance measures and key performance indicators. Their proposed measurement system includes five categories of measures: resource, output, flexibility, innovativeness and information. Annex 6 gives examples of specific measures and selected basic KPIs for this work's analysis (CAI *et al.*, 2009; NAJMI; MAKUI, 2012; XIA; MA; LIM, 2007).

Melnyk *et al*. (2010) suggest that supply chains operating in the current working environment should have the ability to provide one or more of the six basic outcomes depending on the customer/market requirements, which are cost, responsiveness, resilience, security, innovation and sustainability. Cost: Traditional supply chain outcome which combines criteria for monetary cost along with delivery and quality measures. Responsiveness: Ability to respond quickly to volume, mix, and location demand changes. Security: Ability to protect product integrity and consistency while ensuring a supply chain’s products will be otherwise safe. Sustainability: Environmental responsibility through reduction in waste, pollution and carbon footprint and ensuring minimal resource impact. Resilience: Ability to identify and monitor supply chain risks and recover quickly and effectively from both external and internal disruptions. Innovation: Develop new products and services, or new ways to produce and deliver products (MELNYK *et al*., 2010).

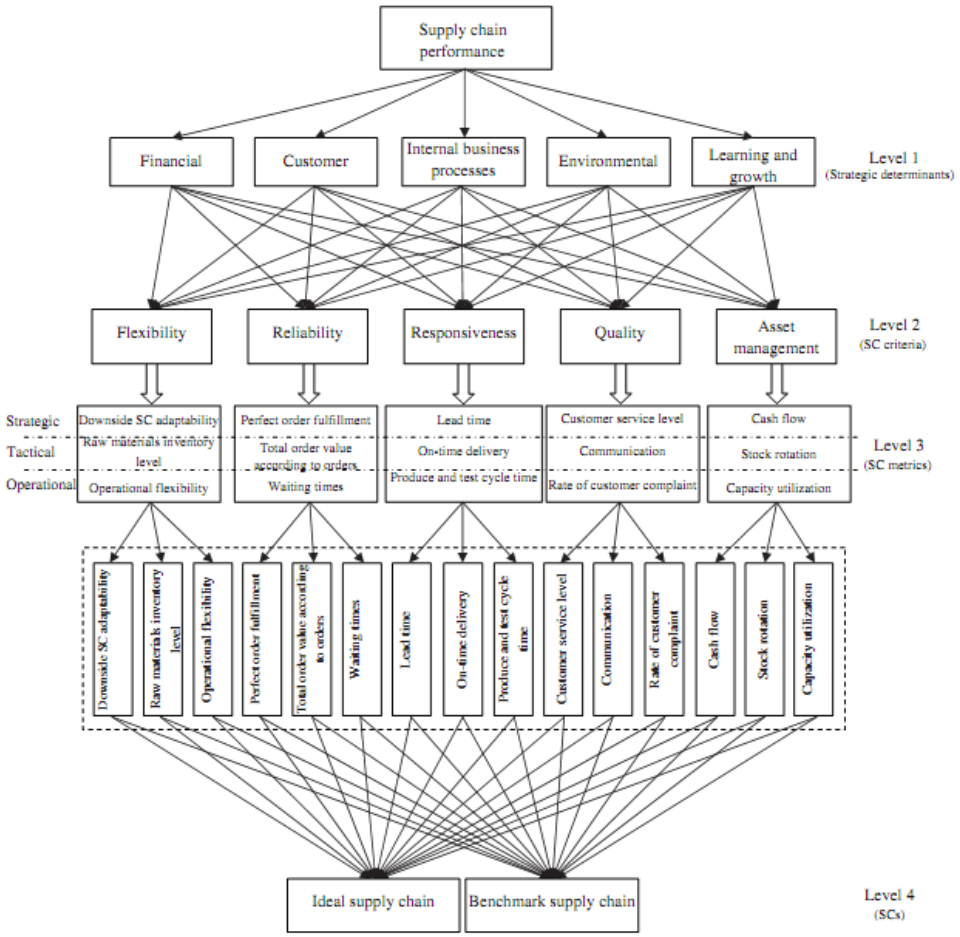
Soni and Kodali (2010) argue that the categories of measurement proposed by Chopra and Meindl (2007), referred as “drivers” of supply chain performance, are found to be most suitable for comparing performance of various supply chains and pointing out the poorly performing functions, as the idea behind

performance measurement is to assess all the levels of management from strategic level to operational level and spanning all the practices in a supply chain. These drivers of SCM are: facilities, transportation, information, inventory, sourcing, and pricing (CHOPRA; MEINDL, 2007; SHAFIEE; LOTFI; SALEH, 2014; SONI; KODALI, 2010).

Najmi and Makui (2012) too defend that the coordination between performance measures and metrics can be evaluated from two viewpoints. In the first view, levels of strategic, tactical and operational, are hierarchical based tasks in which the policies and trade-offs are distinctive and appropriate control is applicable (BALLOU, 1992). The second view, includes financial and non-financial metrics, that is the main difference between the new performance measurement models and traditional ones. According to the authors for performance measurement, measurement goals should be set in accordance with the organisational strategy, they must show the organisation objectives. Performance criteria should be coordinated and evaluated based on the organisation's strategy and selected metrics should reflect coordination between financial and non-financial measures and capable of being related to strategic, tactical and operational levels (NAJMI; MAKUI, 2012).

Based on the basic concepts from BSC and SCOR, Najmi and Makui (2012) proposed a hierarchical model with a top–down view to performance measurement via four levels. In the first level, the strategic aspects of the organisation are defined as the main goals and frameworks of the performance measurement model. This level was determined according to BSC concepts, the only difference is that the environmental determinant has also been added. In the second level, the SC performance criteria and their importance for accessing the strategic objectives is defined according to SCOR attributes, with the difference that the cost attribute has been replaced with quality attribute. For monitoring the state of each criterion obtained in level 2, we must choose and define suitable metrics, level 3, having the potential of converting the criterion's states to measurable values. And finally in level 4, the performance of the considered SC can be evaluated in comparison with an ideal one, based on metrics defined in level 3 (NAJMI; MAKUI, 2012). The proposed model is shown in Figure 10.

Figure 10 – Najmi and Makui proposed model



Source: Najmi and Makui (2012).

Shafiee, Lotfi and Saleh (2014) work's has focused on a comprehensive method to study the measures of the supply chain performance and efficiency with end-to-end approach. To do so, it is clear that to have effective SCM, it should represent a balanced approach and should be classified as strategic, tactical and operational levels and be financial and non financial measures as well. Taking into account the above factors, a balanced SCM scorecard has been proposed and developed to discuss several measures and metrics of SCM. According to the authors a balanced performance evaluation of SCM not only helps organizations in faster and wider monitoring of their operations, but can also help them in improving their internal and external function of business such as engineering and design applications, production, quality improvement, material management, quick response, gaining lost market shares, and proper implementation of business strategies (SHAFIEE; LOTFI; SALEH, 2014). In the Annex 7 are listed the metrics of supply chain efficiency evaluation into four

perspectives of BSC found in several studies (BHAGWAT; SHARMA, 2007a; BIGLIARDI; BOTTANI, 2010; CHIA; GOH; HUM, 2009; SHAFIEE; LOTFI; SALEH, 2014; SHARMA; BHAGWAT, 2007; VARMA; WADHWA; DESHMUKH, 2008).

In their paper, Sellitto *et al.* (2015) develops and applies a model for Supply Chain Performance Measurement (SCPM) based on SCOR model. The model includes a multivariate structure, relating SCOR processes except plan (source, make, deliver, return), and performance standards (reliability, responsiveness, agility, cost, assets). For purposes of their model, such performance standards were translated as quality (understood as reliability or perfect order fulfilment, and return as assets for clients satisfaction), delivery time (taken as responsiveness or order fulfilment cycle time), flexibility (or agility), and costs (total costs to serve, including inventory budget and level of sales) as proposed by Slack and Lewis, (2008b) and Ward *et al.*, (1998) (SELLITTO *et al*., 2015).

In the following sections will be detailed the SCOR and BSC models that will be used as reference for the for the proposed model.

4.4.3 SCOR model

The Supply Chain Operations Reference (SCOR) model it has been developed in 1996 by the Supply Chain Council (SCC) and AMR Research, now Gartner, has become a benchmark by its pioneering spirit. The SCOR model it was launched to help supply chains to conduct systematic analysis and promote communication among its members (HWANG; LIN; LYU, 2008; SUPPLY CHAIN COUNCIL, 2012).

The SCOR model provides a unified framework that relates business processes, terminology, metrics, best practices, and technology capabilities to support communication and integration among business partners and a systemic approach for identifying, evaluating and monitoring supply chain performance. The model provides not only an opportunity to see how the firm is doing, but also a common frame of reference and language across the supply chain (BOLSTORFF, 2004; HOLMBERG, 2000; HWANG; LIN; LYU, 2008; JAMEHSHOORAN; SHAHAROUN; HARON, 2015; NASLUND; WILLIAMSON, 2010; STEPHENS, 2001)

According to Naslund and Williamson (2010), this model can be used to identify, measure, reorganize, and improve supply chain processes through a cyclical approach to identifying supply chain structure and all interested parties, measuring performance, redefining processes based on best practices, and goals comparison. It uses, for these purposes, well-known concepts, such as process reengineering, benchmarking and performance indicators measurement in a structure that brings together several functional areas (JAMEHSHOORAN; SHAHAROUN; HARON, 2015).

The SCOR model is a management tool, spanning from customer to supplier, that enables companies to benchmarking of the whole supply chain (and not just on internal processes) and influence future application development to improve business processes in six distinct functional areas: plan, source, make, delivery, return and enable, as shown in Figure 11 (JAMEHSHOORAN; SHAHAROUN; HARON, 2015; NAJMI; MAKUI, 2012; SUPPLY CHAIN COUNCIL, 2012; THUNBERG; PERSSON, 2013).

Figure 11 - SCOR is organized around six major management processes

Source: Supply Chain Council (2012).

The model has been developed to describe the business activities associated with all phases of satisfying a customer demand. Each of these components is considered both an important intra-organizational function and a critical inter-organization process and each of these processes is developed in four detail levels, as presented in Figure 12 (JAMEHSHOORAN; SHAHAROUN; HARON, 2015; NAJMI; MAKUI, 2012; SUPPLY CHAIN COUNCIL, 2012; THUNBERG; PERSSON, 2013).

Figure 12 - SCOR is a hierarchical process model

	Level		Examples	Comments
	#	Description		
Within scope of SCOR	1 	Process Types (Scope)	Plan, Source, Make, Deliver, Return and Enable	Level-1 defines scope and content of a supply chain. At level-1 the basis-of-competition performance targets for a supply chain are set.
	2 	Process Categories (Configuration)	Make-to-Stock, Make-to-Order, Engineer-to-Order Defective Products, MRO Products, Excess Products	Level-2 defines the operations strategy. At level-2 the process capabilities for a supply chain are set. (Make-to-Stock, Make-to-Order)
	3 	Process Elements (Steps)	• Schedule Deliveries • Receive Product • Verify Product • Transfer Product • Authorize Payment	Level-3 defines the configuration of individual processes. At level-3 the ability to execute is set. At level-3 the focus is on the right: • Processes • Inputs and Outputs • Process performance • Practices • Technology capabilities • Skills of staff
Not in scope	4 	Activities (Implementation)	Industry-, company-, location- and/or technology specific steps	Level-4 describes the activities performed within the supply chain. Companies implement industry-, company-, and/or location-specific processes and practices to achieve required performance

Source: Supply Chain Council (2012).

Based on the Supply Chain Council (2012), the SCOR performance section consists of two types of elements: performance attributes and metrics. A performance attribute is a grouping of metrics used to express a strategy. An attribute it is used to set strategic direction. The metrics are categorized in five performance attributes: reliability, responsiveness, agility/flexibility, costs and asset management efficiency. The first three attributes are considered customer-focused; the latter two are internally focused. This structure can be applied to all industrial and service sector companies, at strategic, tactical and operational levels for an implementation of decisions relating to the company's strategic planning. The Table 6 shows the SCOR attributes and metrics (level 1) (ESTAMPE et al., 2013; NAJMI; MAKUI, 2012; SUPPLY CHAIN COUNCIL, 2012).

Table 6 – SCOR attributes and metrics

Performance Attribute	**Level-1 Strategic Metric**
Reliability	Perfect order fulfillment (RL 1.1)
Responsiveness	Order fulfillment cycle time (RS 1.1)
Agility /Flexibility	Upside supply chain flexibility (AG 1.1) Upside supply chain adaptability (AG 1.2) Downside supply chain adaptability (AG 1.3) Overall value at risk (AG 1.4)

Costs	Total cost to serve (CO 1.001)
Asset Management Efficiency (Assets)	Cash-to-Cash cycle time (AM 1.1) Return on supply chain fixed assets (AM 1.2) Return on working capital (AM 1.3)

Source: Supply Chain Council (2012).

One of the main limitations of this model is that it does not offer a systematic method for prioritizing measures. Also, due to the importance of the quality criterion for evaluating SC performance which has been given in the literature, the SCOR model shown the weakness in this regard (NAJMI; MAKUI, 2012; SHEPHERD; GÜNTER, 2006).

4.4.4 Balanced Scorecard model

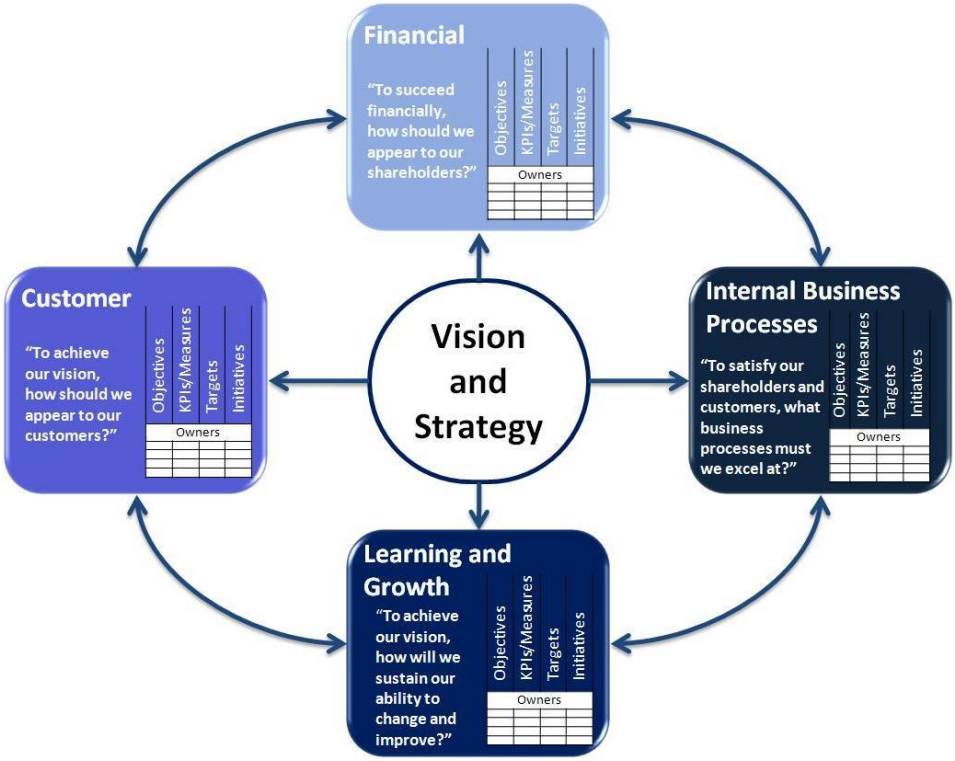
The Balanced scorecard (BSC) from Kaplan and Norton (1992) is one of the best-known performance measurement frameworks. In observing and working with many companies, the authors realize that no single measure can provide a clear performance target or focus attention on the critical areas of the business. It is necessary a balanced of both financial and operational measures (KAPLAN; NORTON, 1992). According to its idealizers, the principles of BSC are: to clarify and translate vision and strategy, and to communicate and associate strategic objectives and measures (KAPLAN; NORTON, 1992; MAIA; MARTINS, 2008).

According to Pinheiro de Lima *et al.* (2009) the balanced scorecard provides in the same system, a planning technique and also a performance measurement framework. It could be classified as a strategic management framework, as it integrates strategic maps process to performance dimensions. The main role of this strategic management system is to create value that is perceived by customers, through the improvement and development of business processes (KAPLAN, 1998; PINHEIRO DE LIMA; GOUVÊA DA COSTA; REIS DE FARIA, 2009).

The BSC allows managers to look at the business from four important perspectives as described below and shown in Figure 13 (KAPLAN; NORTON, 1992; NAJMI; MAKUI, 2012):

- Financial perspective: Identifies how the companies wish to be viewed by its shareholders.
- Customer perspective: Shows how the companies would be seen by customers.
- Internal processes perspective: Explains the processes that the company should be particularly adept in order to satisfy its shareholders and customers.
- Learning and growth perspective: Includes changes and improvements which the company needs to understand to achieve its vision.

Figure 13 – Balanced Scorecard Perspectives



Source: Adapted from Kaplan and Norton (1992).

According to Shafiee *et al.* (2014) the strongest point of BSC is its ability to illustrate the cause and effect relations between strategies and processes through the four perspectives. Based on this reasoning, to achieve its financial benefits, an organization has to take its customers' needs and expectations into account, initially. To do this, organizations should take on a process approach when developing and implementing a quality management system (KAPLAN; NORTON, 1992; SHAFIEE; LOTFI; SALEH, 2014)

4.4.5 Proposed model

The basic concepts of the model are taken from BSC and SCOR models and the Operations Strategy concepts.

Like the model proposed by Najmi and Makui (2012), the proposed model is a hierarchical one with a top–down view to performance measurement via three levels. The strategic objectives of organizations and supply chains lie at the first level of the model and they are represented by the BSC perspectives - Financial, Customer, Internal business processes and Learning and growth (defined in section 0).

Supply chains performance is measured by criteria which are specific for the SC, and achieving them will help the chain to achieve goals (NAJMI; MAKUI, 2012). Thereby, the criteria which a SC must encompass to achieve strategic objectives, are placed at level 2. In the proposed model, those criteria are the same as SCOR model attributes, with the difference that the 'Asset Management Efficiency' attribute has been replaced for quality and innovation attribute. Due to the importance which has been given in the literature of the quality and innovation criterion for evaluating SC performance. Description of the given criteria in this level is as following:

- Quality: Offering products and services in compliance with design specifications and in conformance to customers' expectations, in other words, 'doing things right'(CHAN, 2003; SLACK; BRANDON-JONES; JOHNSTON, 2013; SLACK; LEWIS, 2008).
- Reliability: Delivery the correct product to the correct place at the correct time in the correct condition and packaging in the correct quantity with the correct documentation to the correct customer, ie to meet the deadline promises and other conditions agreed with the customers (NAJMI; MAKUI, 2012; SLACK; BRANDON-JONES; JOHNSTON, 2013).
- Responsiveness: The elapsed time between customers requesting products or services and them receiving them. It can also be considered in the development of new products (development speed or launch speed) (MOREIRA, 1996; NAJMI; MAKUI, 2012; SLACK; BRANDON-JONES; JOHNSTON, 2013).

- Flexibility: It is about the ability or the adaptability of the company to respond to diversity or change, ie., to adapt the operations to changes in the customers' requirements as needed and with the demanded quickness. This may mean changing what the operation does, how it is doing it, or when it is doing it (CHAN, 2003; MOREIRA, 1996; SLACK; BRANDON-JONES; JOHNSTON, 2013).
- Cost: To offer products and service with lower prices than those of the competitors. To the companies which compete directly on price, the cost will clearly be their major operations objective. The lower the cost of producing their goods and services, the lower can be the price to their customers. Even those companies which do not compete on price will be interested in keeping costs low (SLACK; BRANDON-JONES; JOHNSTON, 2013; SLACK; LEWIS, 2008).
- Innovation: refers to the competence of rapidly designing and launching new products and services – and doing that quicker than the competitors (KIM; WEMMERLÖV, 2015; SLACK; LEWIS, 2008). Innovations in product and process technology, management systems and structure are particularly important (MOREIRA, 1996).

For monitoring the supply chain performance, it's necessary choose and define suitable measures for which criteria. Therefore, the measures are defined in level 3. The most relevant measures that has been proposed in the literature has been chosen to compose this model. It should be noted that the measures should be selected in a balanced manner, cover the three levels of strategic, tactical and operational and are classified as both financial and non-financial. In addition to measures related to the model dimensions, relevant economic and financial measures were selected.

The Table 7 presents the most representative measures in the literature, organized according to the dimensions and perspectives to which they belong.

Table 7 – Proposed model

Perspective	Dimension	Measures	Strategic	Tactical	Operational	Financial	Non-financial	References
Results perspective	Economic and financial	Rate of return on investment	x			x		(BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Market share	x			x		(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; SHAFIEE; LOTFI; SALEH, 2014)
		Net profit vs productivity ratio	x			x		(BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Total cash flow time	x			x	x	(BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
	Quality	Buyer–supplier partnership level	x			x	x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a, 2009; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Delivery reliability		x		x	x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; TAJBAKHSH; HASSINI, 2015)
		Supplier rejection rate			x	x	x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
		Delivery performance		x		x	x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
	Cost	Manufacturing cost			x	x		(BEAMON, 1999; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHEPHERD; GÜNTER, 2006)
		Inventory carrying cost			x	x		(CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
		Information carrying cost			x	x	x	(BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Variations against budget	x			x		(BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN;

								PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Supplier cost saving initiatives		x		x		(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Cost per operation hour			x	x		(BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Responsiveness	Customer query time	x			x	x	(GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
Customer perspective	**Quality**	Customer satisfaction	x				x	(CHARKHA; JAJU, 2015; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Product quality			x		x	(SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Delivery performance		x			x	(BHAGWAT; SHARMA, 2007a; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Delivery reliability		x		x	x	(BAI; SARKIS, 2012; BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; TAJBAKHSH; HASSINI, 2015)
		Level of customer perceived value of product	x				x	(SHAFIEE; LOTFI; SALEH, 2014) (BHAGWAT; SHARMA, 2007a) (GUNASEKARAN; PATEL; TIRTIROGLU, 2001) (CHARKHA; JAJU, 2015) (SHEPHERD; GÜNTER, 2006) (BERRAH; CLIVILLÉ, 2007)
		Effectiveness on delivery invoice methods		x			x	(SHAFIEE; LOTFI; SALEH, 2014) (BHAGWAT; SHARMA, 2007a) (GUNASEKARAN; PATEL; TIRTIROGLU, 2001) (GUNASEKARAN; PATEL; MCGAUGHEY, 2004) (SHEPHERD; GÜNTER, 2006) (CHARKHA; JAJU, 2015)
		Effectiveness of distribution planning schedule		x			x	(SHAFIEE; LOTFI; SALEH, 2014) (BHAGWAT; SHARMA, 2007a) (GUNASEKARAN; PATEL; TIRTIROGLU, 2001) (GUNASEKARAN; PATEL; MCGAUGHEY, 2004) (SHEPHERD; GÜNTER, 2006) (CHARKHA; JAJU, 2015) (BERRAH; CLIVILLÉ, 2007)
		Quality of delivery documentation			x		x	(SHAFIEE; LOTFI; SALEH, 2014) (BHAGWAT; SHARMA, 2007a) (GUNASEKARAN; PATEL; TIRTIROGLU, 2001) (SHEPHERD; GÜNTER, 2006) (CHARKHA; JAJU, 2015)
		Quality of delivery goods			x		x	(BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)

	Flexibility	Responsiveness to urgent deliveries		x			x	(BHAGWAT; SHARMA, 2007a; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Flexibility of service systems to meet particular customer needs	x				x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Flexibility to meet particular customer needs	x				X	(BHAGWAT; SHARMA, 2009; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Range of products and services	x				X	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
	Cost	Information carrying cost			x	x	x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Responsiveness	Order fulfillment cycle time			x		x	(SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; THUNBERG; PERSSON, 2013)
		Delivery lead time	x				x	(BHAGWAT; SHARMA, 2007a, 2009; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Customer query time	x			x	x	(BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Order lead time	x			x	x	(BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Reliability	On-time delivery			x		x	(BERRAH; CLIVILLÉ, 2007; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; SHAFIEE; LOTFI; SALEH, 2014)
		Perfect order fulfillment	x				x	(SHEPHERD; GÜNTER, 2006; THUNBERG; PERSSON, 2013)
The internal process perspective	**Quality**	Level of supplier's defect free deliveries	x				x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Trust with partners/ mutual trust	x				x	(BAI; SARKIS, 2012; BEAMON, 1999; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Accuracy of forecasting techniques		x			x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Flexibility	Flexibility of service systems to meet particular customer needs	x				x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)

	Responsiveness	Product development cycle time		x			x	(BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
		Efficiency of purchase order cycle time		x	x		x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Supplier lead time against industry norms	x				x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Total supply chain cycle time	x				x	(BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Planning process cycle time		x			x	(BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Reliability	On-time delivery			x		x	(BERRAH; CLIVILLÉ, 2007; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; SHAFIEE; LOTFI; SALEH, 2014)
		Inventory accuracy			x		x	(SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Cost	Capacity utilization			x		x	(GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Total Transportation cost		x		x		(BHAGWAT; SHARMA, 2009; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
		Effectiveness of master production schedule		x			x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Inventory cost			x	x		(CHARKHA; JAJU, 2015; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Capacity utilization			x	x		(BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)
	Innovation	Number of new products launched		x			x	(BEAMON, 1999; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Use of new technology	x				x	(SHEPHERD; GÜNTER, 2006)
The learning and growth perspective	**Quality**	Level of customer perceived value of product	x				x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Supplier assistance in solving technical problems		x			x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)

		Buyer–supplier partnership level	x			x	x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
		Order entry methods		x	x		x	(BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Accuracy of forecasting techniques		x				(BHAGWAT; SHARMA, 2007a; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; SHAFIEE; LOTFI; SALEH, 2014)
		Level of information sharing						(BAI; SARKIS, 2012; BEAMON, 1999; SHAFIEE; LOTFI; SALEH, 2014)
	Flexibility	Flexibility of service systems to meet particular customer needs	x				x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Supplier ability to respond to quality problems		x			x	(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
	Innovation	Product and Project development cycle time						(BAI; SARKIS, 2012; BHAGWAT; SHARMA, 2007a; SHAFIEE; LOTFI; SALEH, 2014; TAJBAKHSH; HASSINI, 2015)
	Cost	Supplier cost saving initiatives		x		x		(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006)
		Capacity utilization			x		x	(BHAGWAT; SHARMA, 2007a; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014)

To refine and evaluate the proposed model, a Delphi study will be conducted with a group of experts. The Delphi study conduction and the results will be presented in the next session.

4.5 DELPHI STUDY

This section presents the Delphi study procedures adopted and results achieved.

4.5.1 Planning, design and implementation phases

In the case of this research, the Delphi study was developed and conducted over a period of months from June 2017 to August 2017.

Respondents from various backgrounds were invited to participate, academics, consultants and industry professionals, with experience in supply chains and performance measurement and were selected according to the researchers' network of contacts. Initially, 61 experts were selected to participate.

All communication with experts (panelists) was via electronic mail, which proved to be convenient and quite immediate. The geographical base for the study was Brazil and United States. The international composition was important, as the supply chain performance measurement system is a global trend. The use of electronic mail enables such an international study to happen.

Having selected the panelists, the next step was to develop the Delphi survey. This survey was developed by drawing on the model proposed starting from findings of the literature review. The questionnaire contained a total of 11 questions, with a mixture of Likert scale, multiple choice, and open-ended questions. The experts were questioned about the relevant performance dimensions to the supply chain performance measurement and their agreement level with the measures found in the model.

The initial questionnaire was subjected to through the pilot-test, in which 10 experts were invited to participate, but only six panelists responded the complete survey. The pilot test took three weeks.

Based on feedback received from the pilot-test group, the initial Delphi questionnaire was revised (see Appendix A). Once revised, it was started the first round that took three weeks. The questionnaires were sent with the language option in Portuguese or English. Of the 61 experts invited to participate in the study, 30 individuals agreed to participate, but only 22 panelists participated in the first round.

The Delphi questionnaire was reformulated based on feedback received from the first-round panelists (see Appendix B). The new questionnaire contained a total of 8 questions. The experts were questioned to indicate whether the presented measure is context-dependent to the supply chain which it belongs, or it is nondependent, that is, applicable to any supply chain (generalist). Once again, the questionnaires were sent with the language option in Portuguese or English. Once revised, it was started the second round that took two weeks. A total of 11 panelists participated in the second round.

4.5.2 Use of data phase

In this section will be present the results obtained and the changes made in each round of the Delphi study.

The three sections of pilot test questionnaire were covered with questions about panelist classification, the relevant performance dimensions to the supply chain performance measurement and the agreement level by the panelists with the measures found in the model. This structure was also applied in the 1st round.

In the panelist classification, they were questioned about interviewee specialty, the area of activity and the interviewee's acting time (years). Among the panelists who participated in the pilot test, 50% are supply chain specialists and the other 50% are specialists in both supply chains and management and performance measurement. The Table 8 presents a comparison between the panelist's specialties of the pilot test and of the other rounds.

Table 8 – Interviewees' specialty

Specialty	Pilot Test	1st Round	2nd Round
Supply chain Management	3	9	2
Performance Management and Measurement	0	4	3
SC Management and Management and measurement performance	3	7	5
Total	6	20	10

Source: the author, 2017

When questioned about the acting area, the respondents could mark more than one option among those listed. Table 9 presents the context of acting of the panelists of the pilot test and of the following two rounds.

Table 9 - Interviewees' acting area

Area	Pilot Test	1st Round	2nd Round
Industry	4	14	5
Consulting	2	5	4
Academy	2	10	6
Total	8	29	15

Source: the author, 2017

The last question of this section concerns the interviewees' acting time in the informed specialty. Table 10 shows the interviewees' acting time. It is possible to realize that all the panelists of the pilot test have more than 5 years of experience and that 50% of them have more than 15 years of experience.

Table 10 - Interviewee's acting time (years)

Interviewee's acting time (years)	Pilot Test	1st Round	2nd Round
From 0 to 5 years	0	2	0
From 6 to 10 years	1	4	1
From 11 to 15 years	2	6	6
From 16 to 20 years	1	3	2
From 21 to 25 years	1	2	0
From 26 to 30 years	1	2	2
From 31 to 35 years	0	0	0
From 36 to 40 years	0	1	0
Total	**6**	**20**	**11**

Source: the author, 2017

In the second stage of the questionnaire the specialists were asked to select the performance dimensions that they thought were important for the management and measurement of a supply chain. The dimensions found in the literature review were presented to the specialists, among them those used in the model. The dimensions presented were: quality, innovation, trust, flexibility, responsiveness, costs, asset management, resource utilization, reliability, visibility, security, resilience.

The only dimension that was not considered by any of the panelists was 'asset management'. In order to confirm its relevance, the dimension will be exposed again in the first round of Delphi. In addition to the dimensions presented, the need for other dimensions such as sustainability and polyvalence was identified. In the questionnaire review for the first round of the Delphi, it was added the polyvalence dimension. The sustainability dimension was not added

because one of the initial definitions for this research it was not to address issues related to sustainability.

In the last section of the questionnaire, the interviewees were presented with the measures used in the model construction, according to the dimensions to which they belong (one question per dimension). Using a Likert 5-point scale, panelists should express their agreement degree of on the measures relevance for the management and measurement of performance in supply chains. In addition to measures evaluating, the panelists suggested the inclusion of new measures in each dimension, as follows:

- Quality: Number of retained customers;
- Flexibility: Delivery flexibility; Responsiveness to product changes; Responsiveness to changing processes; Materials variety (number of materials available); Adaptability of the upstream and downstream chain;
- Cost: Emergency transportation cost; Machine downtime;
- Reliability: Demand forecast accuracy;
- Innovation: Chain involvement in the development of the new project; New processes implemented per year; Sales ratio of existing products X new products; Investment in R&D; Revenue from new projects.

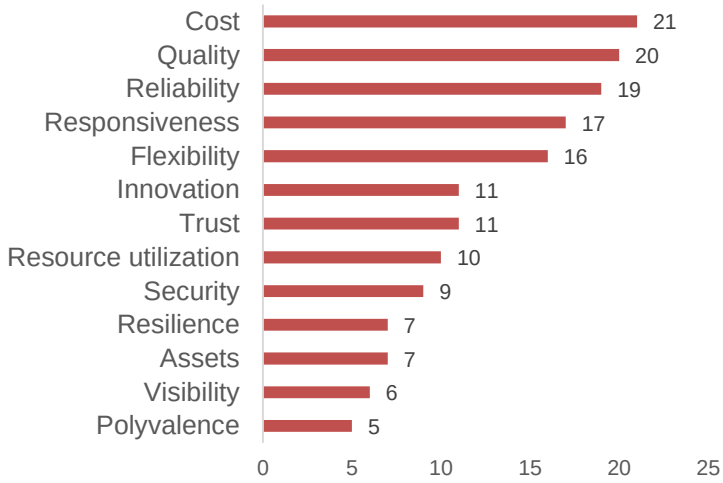
Once revised, it was started the first round. As well as in the pilot test, in the panelist classification, they were questioned about interviewee specialty, the area of activity and the interviewee's acting time (years). Among the panelists who participated in the first round, 41% are supply chain specialists, 32% are specialists in both supply chains and management and performance measurement, 18% are management and performance measurement specialists and 9% of the panelists are specialists in another area, one in Six Sigma and the other one in Operations Strategy. These results are present in Table 8.

As shown in Table 9, 48% of respondents acting in the industrial area, 34% are academic and only 17% acting in consulting. It is possible to notice that 7 panelists operate in more than one area. In relation to the interviewees' acting time, it is possible to conclude that 90% the panelists of the first round have more

than 5 years of experience and 40% of them have more than 15 years of experience, as shown in the Table 10.

When asked which performance dimensions are important for supply chain performance measurement (SCPM), the six dimensions proposed in the model are among those most selected by the experts, as can be seen in Figure 14. The cost dimension was considered by 95% of the respondents, followed by the quality dimension with 91%. The innovation dimension, among the dimensions proposed in the model it was the least considered by the interviewees, only 50% of respondents considered this dimension.

Figure 14 – Performance dimensions related to SCPM – 1st Round



Dimensions	*%*
Cost	95%
Quality	91%
Reliability	86%
Responsiveness	77%
Flexibility	73%
Innovation	50%

Source: the author, 2017

In the last section of the first round, using a 5-point Likert scale, the panelists were asked to express their degree of agreement on the relevance of measures refined in the pilot test for the supply chains performance measurement and management.

Table 11 shows the relevance of the economic and financial measures, according to the interviewees' opinion. All measures were considered relevant by experts. It is worth noting that despite the majority of panelists had considered relevant, 'market share' was considered as indifferent in the supply chains management by 29% of the respondents.

Table 11 - Quality measures

Measure	Strongly Disagree		Disagree		Indifferent		Agree		Strongly **Agree**	
Market share	5%	1	0%	0	29%	6	38%	8	29%	6
Rate of return on investment	5%	1	5%	1	9%	2	23%	5	59%	13
Net profit vs productivity ratio	5%	1	5%	1	0%	0	29%	6	62%	13
Total cash flow time	0%	0	0%	0	5%	1	50%	11	45%	10

Source: the author, 2017

All quality measures were considered relevant by panelists. Table 12 presents the relevance degree considered by the specialists for the quality dimension. It is possible to notice that the measures 'Quality of delivery goods', 'Delivery performance' and 'Delivery reliability' were considered relevant by all the interviewees.

Table 12 - Quality measures

Measure	**Strongly Disagree**		**Disagree**		**Indifferent**		**Agree**		**Strongly Agree**	
Customer satisfaction	0%	0	5%	1	0%	0	14%	3	82%	18
Product quality	0%	0	0%	0	5%	1	19%	4	76%	16
Level of customer perceived value of product	0%	0	5%	1	14%	3	9%	2	73%	16
Quality of delivery goods	0%	0	0%	0	0%	0	24%	5	76%	16
Delivery performance	0%	0	0%	0	0%	0	14%	3	86%	18
Delivery reliability	0%	0	0%	0	0%	0	18%	4	82%	18
Level of supplier’s defect free deliveries	5%	1	0%	0	5%	1	18%	4	73%	16
Supplier rejection rate	0%	0	5%	1	5%	1	29%	6	62%	13
Accuracy of forecasting techniques	0%	0	5%	1	18%	4	23%	5	55%	12
Effectiveness of distribution planning schedule	0%	0	0%	0	19%	4	19%	4	62%	13
Buyer–supplier partnership level	0%	0	5%	1	14%	3	27%	6	55%	12
Level of information sharing	5%	1	0%	0	9%	2	27%	6	59%	13
Trust with partners	5%	1	0%	0	5%	1	33%	7	57%	12
Supplier assistance in solving technical problems	0%	0	0%	0	5%	1	27%	6	68%	15
Order entry methods	5%	1	0%	0	29%	6	29%	6	38%	8
Quality of delivery documentation	0%	0	0%	0	14%	3	43%	9	43%	9
Effectiveness on delivery invoice methods	0%	0	0%	0	33%	7	33%	7	33%	7

Number of retained customers	5%	1	5%	1	18%	4	23%	5	50%	11

Source: the author, 2017

The 'Flexibility to meet particular customer needs' measure was considered relevant by all the panelists and the other measures were considered relevant for almost all of group, as shown in Table 13.

Table 13 - Flexibility measures

Measure	Strongly Disagree		Disagree		Indifferent		Agree		Strongly Agree	
Responsiveness to urgent deliveries	0%	0	0%	0	5%	1	42%	8	53%	10
Delivery flexibility	0%	0	0%	0	11%	2	21%	4	68%	13
Flexibility to meet particular customer needs	0%	0	0%	0	0%	0	47%	9	53%	10
Flexibility of service systems to meet particular customer needs	0%	0	6%	1	18%	3	24%	4	53%	9
Responsiveness to product changes	0%	0	0%	0	11%	2	33%	6	56%	10
Responsiveness to changing processes	0%	0	5%	1	0%	0	26%	5	68%	13
Materials variety (number of materials available)	6%	1	6%	1	17%	3	44%	8	28%	5
Range of products and services	5%	1	5%	1	16%	3	26%	5	47%	9
Supplier ability to respond to quality problems	0%	0	0%	0	11%	2	11%	2	78%	14
Adaptability of the upstream and downstream chain	0%	0	5%	1	5%	1	37%	7	53%	10

Source: the author, 2017

The 12 measures associated with the cost dimension were considered relevant for interviewees. The 'Supplier cost saving initiatives' and 'Total Transportation cost' were considered relevant by all respondents, as shown in Table 14.

Table 14 - Cost measures

Measure	Strongly Disagree		Disagree		Indifferent		Agree		Strongly Agree	
Supplier cost saving initiatives	0%	0	0%	0	0%	0	33%	6	67%	12
Variations against budget	0%	0	6%	1	12%	2	41%	7	41%	7
Manufacturing cost	0%	0	6%	1	6%	1	29%	5	59%	10
Cost per operation hour	0%	0	6%	1	12%	2	24%	4	59%	10
Inventory cost	0%	0	0%	0	0%	0	28%	5	72%	13
Total Transportation cost	0%	0	0%	0	0%	0	12%	2	88%	15
Emergency transportation cost	0%	0	6%	1	0%	0	18%	3	76%	13
Information carrying cost	0%	0	6%	1	6%	1	41%	7	47%	8
Inventory carrying cost	0%	0	0%	0	6%	1	41%	7	53%	9
Machine downtime	0%	0	0%	0	12%	2	41%	7	47%	8

Effectiveness of master production schedule	0%	0	6%	1	11%	2	39%	7	44%	8
Capacity utilization	0%	0	6%	1	12%	2	29%	5	53%	9

Source: the author, 2017

As shown in Table 15, except for the 'Demand forecast accuracy' measure, all reliability measures were considered relevant by 100% of respondents.

Table 15 - Reliability measures

Measure	Strongly Disagree		Disagree		Indifferent		Agree		Strongly Agree	
Perfect order fulfillment	0%	0	0%	0	0%	0	17%	3	83%	15
Inventory accuracy	0%	0	0%	0	0%	0	28%	5	72%	13
On-time delivery	0%	0	0%	0	0%	0	6%	1	94%	17
Demand forecast accuracy	0%	0	0%	0	6%	1	22%	4	72%	13

Source: the author, 2017

Table 16 presents the relevance degree considered by the specialists for the responsiveness dimension. All measures were considered relevant and the 'Delivery lead time' measure was considered relevant by all the interviewees.

Table 16 - Responsiveness measures

Measure	Strongly Disagree		Disagree		Indifferent		Agree		Strongly Agree	
Delivery lead time	0%	0	0%	0	0%	0	22%	4	78%	14
Total supply chain cycle time	0%	0	0%	0	6%	1	11%	2	83%	15
Product development cycle time	0%	0	18%	3	29%	5	18%	3	35%	6
Supplier lead time against industry norms	0%	0	6%	1	12%	2	35%	6	47%	8
Planning process cycle time	0%	0	0%	0	18%	3	47%	8	35%	6
Efficiency of purchase order cycle time	0%	0	0%	0	6%	1	47%	8	47%	8
Order lead time	0%	0	0%	0	0%	0	17%	3	83%	15
Order fulfillment cycle time	0%	0	0%	0	6%	1	18%	3	76%	13
Customer query time	0%	0	6%	1	0%	0	22%	4	72%	13

Source: the author, 2017

The 'Product development cycle time' measure, related to Responsiveness, was the least considered by the interviewees, only 53% of respondents considered this measure, but when related to the innovation dimension, it was considered relevant for 65% of respondents.

The relevance of the innovation measures, according to the interviewees' opinion is shown in Table 17 and all measures were considered relevant by experts.

Table 17 - Innovation measures

Measure	Strongly Disagree		Disagree		Indifferent		Agree		Strongly Agree	
Number of new products launched	0%	0	18%	3	24%	4	35%	6	24%	4
Product/ Project development cycle time	0%	0	24%	4	12%	2	24%	4	41%	7
Chain involvement in the development of the new project	0%	0	6%	1	0%	0	28%	5	67%	12
Use of new technology	6%	1	6%	1	11%	2	28%	5	50%	9
New processes implemented per year	0%	0	12%	2	6%	1	47%	8	35%	6
Sales ratio of existing products X new products	0%	0	12%	2	12%	2	59%	10	18%	3
Investment in R&D	0%	0	11%	2	6%	1	22%	4	61%	11
Revenue from new projects	0%	0	12%	2	24%	4	18%	3	47%	8

Source: the author, 2017

In general, respondents consider all measures to be important for measuring the supply chains performance. However, in specific terms, its importance depends on the sector in which the chain is embedded. The results of the first round confirm the proposed model based on the literature review.

Based on the experts' suggestions, the questionnaire was redefined for the second round. Among the panelists who participated in the second round, 18% are supply chain specialists, 27% are management and performance measurement specialists, 45% are specialists in both supply chains and management and performance measurement, and 9% of the panelists are specialists in Operations Strategy. These results are present in Table 8.

As shown in Table 9, 33% of respondents acting in the industrial area, 40% are academic and 27% acting in consulting. It is possible to notice that 4 panelists operate in more than one area. In relation to the interviewees' acting time, it is possible to conclude that 91% the panelists of the second round have between 10 and 30 years of experience, as shown in the Table 10.

In this phase, the experts were questioned to indicate whether the presented measure is context-dependent to the supply chain which it belongs, or it is nondependent, that is, applicable to any supply chain (generalist). Table 18 shows the measures considered non-dependent to the supply chain by more than 50% of respondents.

Table 18 – Contex-nondependent measures

Economic and financial		**Responsiveness**	
Market share	55%	Product development cycle time	73%
Rate of return on investment	70%	Planning process cycle time	55%
Quality		**Cost**	
Delivery reliability	55%	Manufacturing cost	55%
Accuracy of forecasting techniques	64%	Cost per operation hour	64%
Effectiveness of distribution planning schedule	64%	Inventory cost	64%
Order entry methods	64%	Information carrying cost	64%
Quality of delivery documentation	55%	Machine downtime	64%
Effectiveness on delivery invoice methods	70%	Capacity utilization	55%
Number of retained customers	55%		
Flexibility		**Reliability**	
Responsiveness to changing processes	50%	Inventory accuracy	55%
Materials variety (number of materials available)	55%	On-time delivery	55%
Range of products and services	55%	Demand forecast accuracy	64%
Supplier ability to respond to quality problems	55%		

Source: the author, 2017

4.5.3 Model refined

The Delphi study conduction allowed the refinement and validation of the model proposed based on the systematic literature review. The performance dimensions and the initially proposed measures were all considered as relevant and besides these, measures suggested by the experts between the rounds were added.

The refined model will be presented in the Table 19 to Table 22. The performance measures with (*) are considered non-dependent by the experts, that is, their relevance does not depend on the context in which the supply chain is inserted.

According to Bhagwat and Sharma (2007a), financial performance measures indicate whether the company's strategy, implementation and execution are effectively contributing to the bottom line improvement of a firm, in other words, financial goals are to survive, succeed and prosper. Financial performance indicators are shown in Table 19.

Table 19 – The financial perspective measures

The financial perspective	Strategic	Tactical	Operational	Financial	N Financial
Economic/financial					
Market share*	x			x	
Net profit vs productivity ratio	x			x	
Rate of return on investment*	x			x	
Total cash flow time	x			x	x
Cost					
Manufacturing cost*			x	x	
Inventory carrying cost			x	x	
Information carrying cost*			x	x	x
Variations against budget	x			x	
Supplier cost saving initiatives		x		x	
Cost per operation hour*			x	x	
Quality					
Buyer–supplier partnership level	x			x	x
Delivery reliability*		x		x	x
Supplier rejection rate			x	x	x
Delivery performance		x			x
Responsiveness					
Customer query time	x			x	x
Innovation					
Sales ratio of existing products X new products	x			x	
Investment in R&D	x			x	
Revenue from new projects	x			x	

Source: the author, 2017

The organization needs to translate their general mission statement on customer service into specific measures that reflect the factors that really matter to the customers (BHAGWAT; SHARMA, 2007a; NAJMI; MAKUI, 2012).The customer perspective performance indicators are shown in Table 20.

Table 20 – The customer perspective measures

The customer perspective	Strategic	Tactical	Operational	Financial	N Financial
Quality					
Customer satisfaction	x				x
Product quality			x		x
Delivery performance		x			x
Delivery reliability*		x		x	x
Level of customer perceived value of product	x				x
Effectiveness on delivery invoice methods*		x			x
Effectiveness of distribution planning schedule*		x			x
Quality of delivery documentation*			x		x
Quality of delivery goods			x		x
Number of retained customers*	x				x
Flexibility					
Responsiveness to urgent deliveries		x			x
Flexibility of service systems to meet particular customer needs	x				x
Flexibility to meet particular customer needs	x				x
Range of products and services*	x				x
Delivery flexibility		x			x
Cost					
Information carrying cost*			x	x	x
Responsiveness					
Order fulfillment cycle time			x		x
Delivery lead time	x				x
Customer query time	x			x	x
Order lead time		x			x
Reliability					
On-time delivery*			x		x
Perfect order fulfillment		x			x

Source: the author, 2017

According to Bhagwat and Sharma (2007a), the internal measures stem from the business process that has the greatest impact on customer's satisfaction. Firms should decide what processes and competencies they must excel at and specify measures for each of them. Performance metrics for the internal business perspective are shown in Table 21.

Table 21 – The internal process perspective measures

The internal process perspective	Strategic	Tactical	Operational	Financial	N Financial
Quality					
Level of supplier's defect free deliveries	x				x
Trust with partners	x				x
Accuracy of forecasting techniques*		x			x
Flexibility					
Flexibility of service systems to meet particular customer needs	x				x
Adaptability of the upstream and downstream chain	x				x
Responsiveness to product changes		x			x
Responsiveness to changing processes*		x			x
Materials variety (number of materials available) *			x		x
Responsiveness					
Product development cycle time*		x			x
Efficiency of purchase order cycle time		x			
Supplier lead time against industry norms	x				x
Total supply chain cycle time	x				x
Planning process cycle time*		x			x
Reliability					
On-time delivery*			x		x
Inventory accuracy *			x	x	
Demand forecast accuracy*			x		x
Cost					
Capacity utilization			x		x
Total Transportation cost		x		x	
Effectiveness of master production schedule		x			x
Inventory cost*			x	x	
Capacity utilization*			x	x	
Emergency transportation cost			x	x	
Machine downtime*			x	x	x
Innovation					
Number of new products launched	x				x
Use of new technology		x			x
Chain involvement in the development of the new project		x		x	x
New processes implemented per year			x		x

Source: the author, 2017

Bhagwat and Sharma (2007a) claim that a company's ability to innovate, improve and learn lies directly to company's value. Innovation and continuous learning process can bring about efficiency in operating domain of the business. Moreover, it ensures cost reduction and product differentiation to meet the varied requirements of the customers. Performance metrics for the learning and growth perspective are shown in Table 22.

Table 22 – The learning and growth perspective measures

The learning and growth perspective	Strategic	Tactical	Operational	Financial	N Financial
Quality					
Level of customer perceived value of product	x				x
Supplier assistance in solving technical problems		x			x
Buyer–supplier partnership level	x				x
Order entry methods*		x			x
Accuracy of forecasting techniques*		x			
Level of information sharing	x				x
Flexibility					
Flexibility of service systems to meet particular customer needs	x				x
Supplier ability to respond to quality problems*		x			x
Innovation					
Product development time		x			x
Cost					
Supplier cost saving initiatives		x		x	
Capacity utilization*			x		x

Source: the author, 2017

The proposed model responds to some of the main problems cited by the researchers in the studies on performance evaluation of supply chains: (i) Lack of a balanced approach. For a balanced approach, companies should bear in mind that, while financial performance measurements are important for strategic decisions and external reporting, day-to-day control of manufacturing and distribution operations is better handled with non-financial measures. (BEAMON, 1999; CHAN et al., 2003; CHAN; QI, 2003b; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; MASKELL, 1991; NAJMI; MAKUI, 2012; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006); (ii) Focus on the cost to the

detriment of non-cost indicators (BEAMON, 1999; DE TONI; TONCHIA, 2001) and (iii) Lack of a clear distinction between metrics at strategic, tactical, and operational levels. Using a classification based on these three levels, each metric can be assigned to a level where it would be most appropriate (GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; NAJMI; MAKUI, 2012).

It's worth pointing out that this model is based largely on metrics discussed in the literature and should be regarded as a starting point for an assessment of the need for supply chain performance measurement. It is hoped that this framework will assist practitioners in their efforts to assess supply chain performance.

5 CONCLUSION

This work addressed the following research question: What are the generally applicable measures for measuring supply chain performance? In this way, the main objective was to propose a model for supply chain performance measurement.

Three specific objectives were derived to achieve the main objective of the research. The first objective intended to identify and organize from the supply chain literature a set of research trends related to supply chain performance. To achieve this goal, a systematic literature review was conducted. The used research protocol contained information about the search strings, the search strategy, and the criteria for inclusion and exclusion of studies in the review. The search for articles was carried out between December 2015 and January 2016. All papers abstracts were reviewed in order to exclude works not pertinent to the research. As a result, a dataset of 816 papers were classified according to its central theme and were classified in five main groups: i) Supply chain integration and collaboration; ii) IT and information sharing in supply chains; iii) Supply chain management practices; iv) Green supply chain; and v) Supply chain performance measurement and management. The discussion on these common subjects addressed in the supply chain literature provide an overall comprehension upon the context in which the present research work is positioned, especially to the extent that these themes involve issues and aspects that impact on supply chain performance.

Then, a bibliometric analysis of the 185 papers related to performance measurement models in the supply chain was conducted in order to understand the evolution of the theme under various perspectives (the main methodology applied, the principal authors in this area, the years and journals of publication and keywords of each paper).

The second objective intended to select from the literature the measures for a supply chain performance measurement and propose a model. Four layers of filtering was applied to the 185 articles: publication impact factor, publication year, recurrence of citations and the authors' h-index factor resulting in a final data set of 76 papers to base the content analysis to be carried out. These papers analysis allowed to identify the main limitations and characteristics of the systems

of measurement of performance of the supply chains, which were used as a reference for the model proposition.

The basic concepts of the model are taken from BSC and SCOR models and the Operations Strategy concepts. The proposed model is a hierarchical one with a top–down view to performance measurement via three levels. The strategic objectives of organizations and supply chains lie at the first level of the model and they are represented by the BSC perspectives. The criteria which a SC must encompass to achieve strategic objectives are placed at level 2. In the proposed model, those criteria are based on SCOR model attributes and the traditional performance dimensions from operations strategy. The measures for monitoring the supply chain performance, are defined in level 3. The most relevant measures that have been proposed in the literature has been chosen to compose this model. It should be noted that the measures cover the three levels of strategic, tactical and operational and are classified as both financial and non-financial. It's worth pointing out that this model is based on the literature discussions about supply chain performance measurement.

Refine the proposal model from an empirical-based approach was the third specific objective. A Delphi study was conducted to refine and validate the proposed model. Two rounds were performed and the performance dimensions and measures proposed in the model were completely validated and new measures were added according to the indications of the respondents.

Research relevance is founded on the use of systematic literature review to summarize the findings of the supply chain performance measurement area and the identification of factors that influence the performance of supply chains, along with the models for measuring performance in supply chains. The contribution to the theoretical field is in terms of mapping and reviewing the field of supply chain performance measurement, as well as in terms of creating conditions for academics to identify future research opportunities. For practitioners, the model is intended to support supply chain performance measurement initiatives.

Amongst the main limitations of the research approach, stand out the fact that the study is limited to the selected scientific databases, document type, search period, language and search strings. Thus, it is possible that some important papers have not been selected for the study. However, although these

non-selected articles may be pertinent to the field, it can be argued that it is not likely that such articles would significantly change the results of the study, because of the robustness provided by the systematic literature review and the content analysis approaches. This research delineated itself in not addressing the sustainable supply chain management issue. The respondent's selection and the number of participants in the Delphi study are also limiting.

For future works, it is suggested to include the sustainability dimension and other relevant dimensions, for example, corporate governance, as suggested by the panelists. The continuity of the Delphi study is also suggested to evaluate the relationships between the BSC's perspectives and the performance dimensions/measures and the characteristics of measures (i. e. financial/ non-financial; operational/ tactical/ strategic). Also, further research should be carried out so as to validate the model with a supply chain real data through interviews with specialists or case study to verify the model applicability in the supply chains.

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ANNEXES

Annex 1 - Supply chain performance measurement models

Models/characteristics	1-ABC: Activity-Based Costing	2-FLR: Framework for Logistics Research	3-BSC: Balanced ScoreCard	4-SCOR: Supply Chain Operation Reference Model
References	(Kaplan and Johnson, 1987; Kaplan, 1983; Comellia et al., 2008)	(Chow et al., 1995)	(Kaplan and Norton, 1996)	(SCOR, 2010)
Origin of model	• Created in the 1980s	• Developed in the 1990s.	• Developed in the 1990s.	• Developed in 1996 by the Supply Chain Council (SCC).
Type of analysis used	• Analyzes costs and margins • Variant of full costs, but goes beyond simple calculation of return costs	• Describes dependency between level of performance achieved, logistics organisation and competitive strategy • Emphasizes relative nature of performance evaluation	• Seeks balanced measures to buttress company strategy • Proposes four analytical axes: customers, finance, internal processes and innovation-growth • Incorporates human dimension in performance measurement	• Analyzes four dimensions: reliability of commercial performance, flexibility/ responsiveness, cost of supply chain and turnover of committed capital
Conditions and constraints	• In-depth knowledge of company along with its activities and processes	• Applies at organisational and strategic levels	• Traditional top–down approach • Specifically geared towards general management • Applies from the strategic through the organisational level	• Applies to all industrial and service sector companies • Applies at tactical and operational level for implementation of decisions relating to the company's strategic planning • Contributes to operations integrating different actors in the chain
Degree of conceptualisation	• Interweaves accounting data into the concept of "activity" • Groups activities by their process logic	• Structures logistics function into several dimensions: centralisation, formalisation, integration, and areas of control	• Approach establishing causalities between the performance of each analytical axis • Details causalities between customers and financial axes	• Models processes: planning, sourcing, manufacturing delivery and returns • Standardised common language for different actors in the chain • Definition of basic concepts: processes, typology of processes, management modes
Established indicators	• Financial piloting indicators coherent with the strategy • Performance improvement internal benchmarking approach	• Does not define indicators, but enables internal benchmarking	• Indicators chosen depending on the company's objectives • Measurements must be balanced to accommodate demands emanating from all internal corporate functions and from external environment	• Indicators' definition explained using calculation modes • Association of indicators with each process • Enables internal and external comparisons of measurements • Suggests "best-in-class"

Models/characteristics	5-GSCF framework	6-ASLOG audit	7-SASC: Strategic Audit Supply Chain	8-Global EVALOG (Global MMOG/LE)
References	(Cooper et al., 1997)	(Pimor, 1998)	(Gilmour, 1999)	(Odette, 2010; AIAG, 2010)
Origin of model	• Created by the Ohio State University in 1994	• Created in 1997 by ASLOG • Based on models used in the automobile sector	• Developed in 1999	• Created in 1999 • Developed with Odette International Limited and Automobile Industry Action Group
Type of analysis used	• Describes three levels: strategic, tactical and operational • Highlights links between supply chain process and structure	• Model comprised of 200 performance measurement questions • Assesses logistics procedures by analysing strengths and weaknesses • Transversal tool seeking to achieve given level of excellence and implement good practice	• Analyszs supply chain in terms of processes, information technologies and organisation	• Assesses partner site processes and performance, pursues continuous improvement approach
Conditions and constraints	• Adapted to all types of companies	• Model geared towards small companies • Targets companies with low or medium levels of maturity	• Applied at the organisational level	• Developed for automobile industry, but also used for associated sectors (metalworks, chemicals)
Degree of conceptualisation	• Focuses on seven processes: customer relationship management, customer service management, demand management, order fulfillment, manufacturing flow management, supplier relationship management, product development and commercialisation, returns management	• Analyzes range of areas: management, strategy and planning, design and projects, sourcing, production, transportation, stocks, sales, returns and after-sales, piloting and permanent progress indicator	• Breaks logistics chain down into six competencies: customer orientation, distribution, sales planning, lean production, supplier partnerships and integrated management of chain • Links competencies to information technology and organisation of chain	• Structured into six areas: strategy and improvement, work organisation, production planning, customer interface, process control and supplier interface
Established indicators	• Enables internal benchmarking	• Internal benchmarking	• Internal benchmarking	• Six standard indicators • Model assessing operational performance in terms of supplier–customer relationship

Models/characteristics	9-WCL: World Class Logistics Model	10-AFNOR FD X50-605	11-SCM/SME	12-APICS: Association for Operations Management
References	(Bowersox et al., 1999)	(AFNOR, 2010)	(Jouenne, 2008)	(Lamouri and Thomas, 2000; APICS (2010))
Origin of model	• Developed by Michigan State University in the 1990s	• Developed in 2008	• Developed in 2007 within an SME context	• Developed by professional association APICS
Type of analysis used	• Evaluates company's performance in terms of its ability to account for inter-organisational relationships • Model comprised of 68 questions	• Offers general framework for strategic reflection• Defines different logistics processes • Identifies performance levers associated with each process	• Questionnaire featuring 25 modules: corporate strategy, organisation and development of logistic competencies, performance processes and measurements and information system	• Analyzes innovation and customer service management, efficiency drivers, agility, risk control and sustainability
Conditions and constraints	• Applies at strategic and organisational level	No constraints	• Mainly targets industrial SMEs in fast moving consumer goods sector	• Mainly applies to industrial firms
Degree of conceptualisation	• Revolves around four areas of competency: positioning, integration, agility and performance measurement	• Model featuring six area: identification of needs and setting of objectives, logistics system design and development, production, sales and distribution, logistics support and control over global logistics process	• Structured around demand management, distribution, import/ export flows, stocks, production, sourcing, returns and after-sales support and tracability	• Processes structured via model that is mainly geared towards production planning
Established indicators	• Assesses actors' degree of an integration • Assesses an extent of control over supply concepts	• Proposes logistics performance measurement approach based on performance levers and indicators	• Enables internal benchmarking	• Grouped into multiple performance management indicators

Models/characteristics	13-ECR: Efficient Customer Response	14-EFQM: Excellence Model	15-SCALE: Supply Chain Advisor Level Evaluation	16-SPM: Strategic Profit Model
References	(ECR, 2010)	(EFQM, 2010)	(Favre Bertin and Estampe, 2004)	(Stapleton et al., 2002)
Origin of model	• Created in 1994 by an ECR Association of manufacturers and retailers	• Introduced in 1992	• Created in early 2000s by the Institute for Supply Chain Excellence (ISLI)	• Derived from the DuPont model
Type of analysis used	• Evaluates good inter-organisational practices • Uses maturity-based evaluation tool: global mapping	• Questionnaire with 50 questions; respondents positioned along the scale of excellence • Covers areas relating to process efficiency, continuous improvement in products and services, personnel management and progression	• Revolves around questionaire that assesses strategic and tactical dimensions, elements of value creation	• Displays existing interactions between strategic and operational levels by means of financial ratios
Conditions and constraints	• Focuses on collaboration between industrialists and distributors in fast moving consumer goods sector	• Suitable for all types of companies	• Developed for all sectors of activity	• Strategic and financial implementation based on cost drivers • Based on return on an asset or return on net value measurements
Degree of conceptualisation	• Establishes common language based on joint evaluation of performance by actors in the chain • 45 Criteria structured into four areas: consumer demand management, supply chain management, technological platforms and integration	• Based on eight principles: customer focus, leadership, definition of objectives, process-based management, staff involvement, continuous innovation process, development of partnerships and civic responsibility	• 58 Processes classified into seven categories of activities: definition of strategic objectives, establishment of procedures, needs planning, coordination of phases, performance evaluation and monitoring and supply chain optimisation	• Based on the DuPont model
Established indicators	• 13 Performance measurement indicators enabling inter-sectorial comparisons	• General indicators (margins, cash flow, stock turnover, etc.) • Indicators relating to satisfaction of customers and staff, and to the company's integration into the rest of the society	• Evaluates the creation of value	• Financial ratios

Source: Estampe *et al*., (2013).

Annex 2 - Gunasekaran's framework on metrics for supply chain performance evaluation

Level	Performance metrics	Financial	Non-financial
Strategic	Total supply chain cycle time		◆
	Total cash flow time	◆	◆
	Customer query time	◆	◆
	Level of customer perceived value of product		◆
	Net profit vs. productivity ratio	◆	
	Rate of return on investment	◆	
	Range of product and services		◆
	Variations against budget	◆	
	Order lead time		◆
	Flexibility of service systems to meet particular customer needs		◆
	Buyer-supplier partnership level	◆	◆
	Supplier lead time against industry norm		◆
	Level of supplier's defect free deliverires		◆
	Delivery lead time		◆
	Delivery performance	◆	◆
Tactical	Accuracy of forecasting techniques		◆
	Product development cycle time		◆
	Order entry methods		◆
	Effectiveness of delivery invoice methods		◆
	Purchase order cycle time		◆
	Planned process cycle time		◆
	Effectiveness of master production schedule		◆
	Supplier assistance in solving technical problems		◆
	Supplier ability to respond to quality problems		◆
	Supplier cost saving initiatives	◆	
	Supplier's booking in procedures		◆
	Delivery reliability	◆	◆
	Responsiveness to urgent deliveries		◆
	Effectiveness of distribution planning schedule		◆
Operational	Cost per operation hour	◆	
	Information carrying cost	◆	◆
	Capacity utilisation		◆
	Total inventory as: – Incoming stock level – Work-in-progress – Scrap level – Finished goods in transit	◆	
	Supplier rejection rate	◆	◆
	Quality of delivery documentation		◆
	Efficiency of purchase order cycle time		◆
	Frequency of delivery		◆
	Driver reliability for performance		◆
	Quality of delivered goods		◆
	Achievement of defect free deliveries		◆

Source: Gunasekaran, Patel and Tirtiroglu (2001).

Annex 3 - Gunasekaran's supply chain performance metrics

Supply chain activity/ process	Strategic	Tactical	Operational
Plan	Level of customer perceived value of product, Variances against budget, Order lead time, Information processing cost, Net profit Vs productivity ratio, Total cycle time, Total cash flow time, Product development cycle time	Customer query time, Product development cycle time, Accuracy of forecasting techniques, Planning process cycle time, Order entry methods, Human resource productivity	Order entry methods, Human resource productivity
Source		Supplier delivery performance, supplier leadtime against industry norm, supplier pricing against market, Efficiency of purchase order cycle time, Efficiency of cash flow method, Supplier booking in procedures	Efficiency of purchase order cycle time, Supplier pricing against market
Make/ Assemble	Range of products and services	Percentage of defects, Cost per operation hour, Capacity utilization, Utilization of economic order quantity	Percentage of Defects, Cost per operation hour, Human resource productivity index
Deliver	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule, Effectiveness of delivery invoice methods, Percentage of finished goods in transit, Delivery reliability performance	Quality of delivered goods, On time delivery of goods, Effectiveness of delivery invoice methods, Number of faultless delivery notes invoiced, Percentage of urgent deliveries, Information richness in carrying out delivery, Delivery reliability performance

Source: gunasekaran; Patel and Mcgaughey (2004).

Annex 4 - Chan's framework on performance measurements

	Subcriteria level 1	Subcriteria level 2	Performance measurements
A. Quantitative			
Cost		Distribution cost	The transportation and handling cost, safety stock cost and duty.
		Manufacturing cost	Labour, maintenance and re-work costs. Also, there are purchased materials, equipment charges and supplier's margin.
		Inventory cost	The work-in-process and finished goods inventories.
		Warehouse cost	Associated with allocation from one tier to another.
		Incentive cost and subsidies	Taxes and subsidies.
		Intangible cost	Quality costs, product adaptation or performance costs and coordination.
		Overhead cost	Total current landed costs.
		Sensitivity to long-term cost	Productivity and wage changes, exchange rate changes, product design and core competence.
Resource Utilisation		Labour, machine, capacity, energy	Investigate the percentage of excess or lack of that particular resource within a period.
B. Qualitative			
Quality		Customer dissatisfaction	The number of customer complaints registered.
	Time	Customer response time	The amount of time between an order and its corresponding delivery.
		Lead time	The time required once the product began its manufacture until the time it is completely processed
		On-time delivery	The percentage of orders delivered on or before the due date.
		Fill rate	The proportion of orders that can be filled immediately.
		Stockout probability	The instantaneous probability that a requested item is out of stock while number of backorders is the number of items backordered due to stockout.
		Accuracy	Percentage of accurate goods delivered to clients.
Flexibility	Input	Labour	The number of tasks a worker can perform.
		Machine	The efficiency by using a more flexible machine to the traditional switching over machine. Both time and cost saved can be used to express its efficiency.
	Process	Material handling	The number of existing paths between processing centres and the variety of material which can be transported along those paths without incurring high transition penalties or large changes in performance outcomes.
		Routeing	The number of products which have alternative routes and the extent of variation among the routes used without incurring other high costs in performance outcome.
		Operation	The number of products which have alternative sequencing plans without incurring high costs or large changes in performance outcome.
	Output	Volume	The extent of change and the degree of fluctuation in aggregate output level which the system can accommodate without incurring high costs or large changes in performance outcome OR The demand which can be profitably sustained.
		Mix	The number and variety of products which can be produced without incurring high costs or large changes in performance outcomes. OR The time required to produce a new product mix.
		Delivery	The percentage of slack time by which the delivery time can be reduced.
	Improvement	Modification	The number and variety of product modifications which are accomplished without incurring high transition penalties or large changes in performance outcomes.
		New product	Time or cost required to add new products to the existing production operation OR The number and heterogeneity or products which can be produced without involving high transition penalties or large changes in performance outcomes.
		Expansion	The number and variety of expansions which can be accommodated without involving high cost or large changes in performance outcomes.
Visibility		Time	Time required from when the designer changes his idea to when the product starts being processed in the new way.
		Accuracy	The percentage waste of wrong products made after the new design is launched.
Trust		Consistency	The percentage of late or wrong delivery to the next tier which led to an inconsistent supply. For late delivery, it is the percentage of time delayed whereas for wrong delivery, it is the percentage of returned goods.
Innovativeness		New launch of product	Compare the number of products launched by a particular company within a period. OR The percentage sales of a new product to the whole sales within a period for a company.
		New use of technology	The percentage decrease in time necessary for producing the same product.

Source: Chan (2003)

Annex 5 - Shepherd and Günter 's framework

Stages in supply chain	Measure	Cost (C) Time (T) Quality (Q) Flexibility (F) Innovativeness (I)	Quantitative (QN) or qualitative (QL)
Plan	Sales[b]	C	QN
	Profit[b]	C	QN
	Return on investment (ratio of net profits to total assets)[b]	C	QN
	Rate of return on investment[a]	C	QN
	Net profit vs productivity ratio[a]	C	QN
	Information carrying cost[a]	C	QN
	Variations against budget[a]	C	QN
	Total supply chain management costs[d]	C	QN
	Cost of goods sold[d]	C	QN
	Asset turns[d]	C	QN
	Value added productivity[d]	C	QN
	Overhead cost[n]	C	QN
	Intangible cost[n]	C	QN
	Incentive cost and subsides[n]	C	QN
	Sensitivity to long-term costs[n]	C	QN
	Percentage sales of new product compared with whole sales for a period[n]	C	QN
	Expansion capability[n]	C	QN
	Capital tie-up costs[o]	C	QN
	Total supply chain response time[c]	T	QN
	Total supply chain cycle time[a]	T	QN
	Order lead time[a,o]	T	QN
	Order fulfilment lead time[d]	T	QN
	Customer response time[b]	T	QN
	Product development cycle time[a]	T	QN
	Total cash flow time[a]	T	QN
	Cash-to-cash cycle time[d]	T	QN
	Horizon of business relationship[e]	T	QL
	Percentage decrease in time to produce a product[n]	T	QN
	Fill rate (target fill rate achievement & average item fill rate)[b,c,m,n]	Q	QN
	Order entry methods[a]	Q	QN
	Accuracy of forecasting techniques[a]	Q	QN
	Autonomy of planning[e]	Q	QL
	Perceived effectiveness of departmental relations[f]	Q	QL
	Order flexibility[m]	Q	QN
	Perfect order fulfilment	Q	QN
	Mix flexibility[b,n]	F	QN
	New product flexibility[b]	F	QN
	Number of new products launched[n]	I	QN
	Use of new technology[n]	I	QN

(*continued*)

Stages in supply chain	Measure	Cost (C) Time (T) Quality (Q) Flexibility (F) Innovativeness (I)	Quantitative (QN) or qualitative (QL)
Source	Supplier cost-saving initiatives[a]	C	QN
	Percentage of late or wrong supplier delivery	C	QN
	Supplier lead time against industry norm[a]	T	QN
	Supplier's booking-in procedures[a]	T	QN
	Purchase order cycle time[a]	T	QN
	Efficiency of purchase order cycle time[a]	T	QN
	Buyer-supplier partnership level[a]	Q	QL
	Level of supplier's defect-free deliveries[a]	Q	QN
	Supplier rejection rate[a]	Q	QN
	Mutual trust[e]	Q	QL
	Satisfaction with knowledge transfer[g]	Q	QL
	Satisfaction with supplier relationship[h]	Q	QL
	Supplier assistance in solving technical problems[a]	Q	QL
	Extent of mutual planning cooperation leading to improved quality[j]	Q	QL
	Extent of mutual assistance leading in problem-solving efforts[k]	Q	QL
	Distribution of decision competences between supplier and customer[i]	Q	QL
	Quality and frequency of exchange of logistics information between supplier and customer[i]	Q	QL
	Quality of perspective taking in supply networks[l]	Q	QL
	Information accuracy[p]	Q	QL
	Information timeliness[p]	Q	QL
	Information availability[p]	Q	QL
	Supplier ability to respond to quality problems[a]	F	QL
Make	Total cost of resources[b]	C	QN
	Manufacturing cost[b,n]	C	QN
	Inventory investment[b]	C	QN
	Inventory obsolescence[b]	C	QN
	Work in process[b]	C	QN
	Cost per operation hour[a]	C	QN
	Capacity utilization as incoming stock level, work-in-progress, scrap level, finished goods in transit[a,c]	C	QN
	Inventory cost[n]	C	QN
	Inventory turnover ratio[c]	C	QN
	Inventory flow rate[m]	C	QN
	Inventory days of supply[d]	C	QN
	Economic order quantity[a]	C	QN

(*continued*)

Stages in supply chain	Measure	Cost (C) Time (T) Quality (Q) Flexibility (F) Innovativeness (I)	Quantitative (QN) or qualitative (QL)
	Effectiveness of master production schedule[a]	C	QN
	Number of items produced[b]	C	QN
	Warehouse costs[m,n]	C	QN
	Stock capacity[m]	C	QN
	Inventory utilization[m]	C	QN
	Stockout probability[b,n]	C	QN
	Number of backorders[b]	C	QN
	Number of stockouts[b]	C	QN
	Average backorder level[b]	C	QN
	Percentage of excess/lack of resource within a period[n]	C	QN
	Storage costs per unit of volume[o]	C	QN
	Disposal costs[o]	C	QN
	Planned process cycle time[a]	T	QN
	Manufacturing lead time[b]	T	QN
	Time required to produce a particular item or set of items[b]	T	QN
	Time required to produce new product mix[n]	T	QN
	Inventory accuracy[m]	Q	QN
	Inventory range[o]	F	QN
	Percentage of wrong products manufactured[n]	Q	QN
	Production flexibility[d]	F	QN
	Capacity flexibility[c]	F	QN
	Volume flexibility[b,n]	F	QN
	Number of tasks worker can perform[n]	F	QN
Deliver	Total logistics costs[o]	C	QN
	Distribution costs[b,n]	C	QN
	Delivery costs[m]	C	QN
	Transport costs[m]	C	QN
	Transport costs per unit of volume[o]	C	QN
	Personnel costs per unit of volume moved[o]	C	QN
	Transport productivity[m]	C	QN
	Shipping errors[b]	C	QN
	Delivery efficiency[o]	C	QN
	Percentage accuracy of delivery[n]	C	QN
	Delivery lead time[a]	T	QN
	Frequency of delivery[a]	T	QN
	Product lateness[b]	T	QN
	Average lateness of orders[b]	T	QN
	Average earliness of orders[b]	T	QN
	Percent of on-time deliveries[b,n]	T	QN
	Delivery performance[a,d]	Q	QN
	Delivery reliability[a,c,d,m]	Q	QN
	Number of on-time deliveries[b]	Q	QN

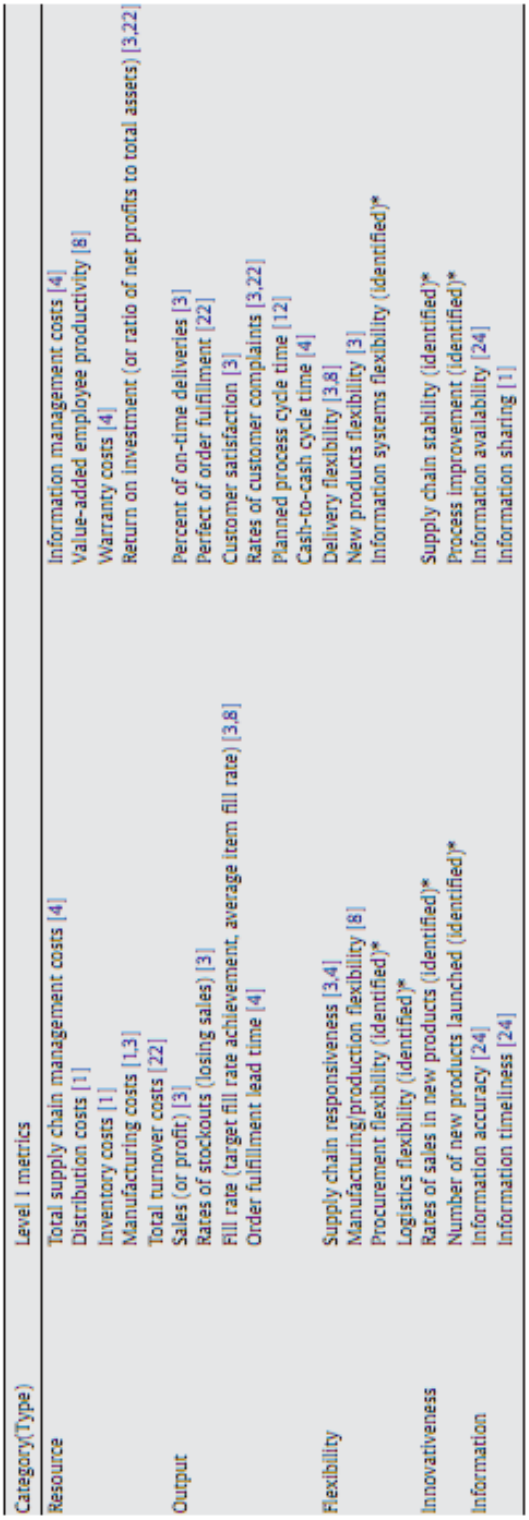
(*continued*)

Stages in supply chain	Measure	Cost (C) Time (T) Quality (Q) Flexibility (F) Innovativeness (I)	Quantitative (QN) or qualitative (QL)
	Effectiveness of distribution planning schedule[a]	Q	QL
	Effectiveness of delivery invoice methods[a]	Q	QN
	Driver reliability for performance[a]	Q	QN
	Quality of delivered goods[a]	Q	QL
	Achievement of defect-free deliveries[a]	Q	QN
	Quality of delivery documentation[a]	Q	QL
	Delivery flexibility[b,m]	F	QN
	Responsiveness to urgent deliveries[a,m]	F	QN
	Transport flexibility[m]	F	QN
Return (customer satisfaction)	Warranty/returns processing costs[d]	C	QN
	Customer query time[a]	T	QN
	Customer satisfaction (or dissatisfaction)[b,n]	Q	QL
	Level of customer perceived value of product[a]	Q	QL
	Customer complaints[b]	Q	QN
	Rate of complaint[c]	Q	QN
	Product quality[b,m]	Q	QL
	Flexibility of service systems to meet particular customer needs[a]	F	QL

Notes: [a] = Gunasekaran *et al.* (2001); [b] = Beamon (1999); [c] = Schonsleben (2004); [d] = SCOR level 1 metrics; [e] = Hieber (2002); [f] = Ellinger; [g] = Sperka (1997): [h] = Artz (1999); [i] = Windischer and Grote (2003); [j] = Graham *et al.* (1994); [k] = Maloni and Benton (1997); [l] = Parker and Axtell (2001); [m] = Chan and Qi (2003); [n] = Chan (2003); [o] = VDI guidelines (association of engineers); [p] = Van der Vorst and Beulens (2001)

Source: Shepherd and Günter (2006).

Annex 6 - Level I metrics of supply chain performance based on Cai *et al*. supply chain processes



Category(Type)	Level I metrics	
Resource	Total supply chain management costs [4]	Information management costs [4]
	Distribution costs [1]	Value-added employee productivity [8]
	Inventory costs [1]	Warranty costs [4]
	Manufacturing costs [1,3]	Return on investment (or ratio of net profits to total assets) [3,22]
	Total turnover costs [22]	
Output	Sales (or profit) [3]	Percent of on-time deliveries [3]
	Rates of stockouts (losing sales) [3]	Perfect of order fulfillment [22]
	Fill rate (target fill rate achievement, average item fill rate) [3,8]	Customer satisfaction [3]
	Order fulfillment lead time [4]	Rates of customer complaints [3,22]
		Planned process cycle time [12]
		Cash-to-cash cycle time [4]
Flexibility	Supply chain responsiveness [3,4]	Delivery flexibility [3,8]
	Manufacturing/production flexibility [8]	New products flexibility [3]
	Procurement flexibility (identified)*	Information systems flexibility (identified)*
	Logistics flexibility (identified)*	
Innovativeness	Rates of sales in new products (identified)*	Supply chain stability (identified)*
	Number of new products launched (identified)*	Process improvement (identified)*
Information	Information accuracy [24]	Information availability [24]
	Information timeliness [24]	Information sharing [1]

Note: *KPIs identified in this paper, by interviews or surveys of companies in China.

Source: Cai *et al.*, (2009b)

Annex 7 - Measures ofthe supply chain performance evaluation based on BSC approach

The internal process perspective measures	The customer perspective measures
Total supply chain cycle time [12,16]	Customer query time [12,16,13]
Total cash flow time [12,16]	Level of customer perceived value of product [12,16]
Flexibility of service systems to meet particular customer needs [12,16]	Range of products and services [12,16]
Supplier lead time against industry norms [12,16]	Order lead time [12,16,13]
Level of supplier's defect free deliveries [12,16]	Flexibility of service systems to meet particular customer needs [12,16]
Accuracy of forecasting techniques [12,16,13]	Buyer–supplier partnership level [12,16]
Product development cycle time [12,16]	Delivery lead time [12,16]
Purchase order cycle time [12,16,13]	Delivery performance [12,16]
Planned process cycle time [12,16,13]	Effectiveness of delivery invoice methods [12,16]
Effectiveness of master production schedule [12,16,13]	Delivery reliability [12,16]
Capacity utilization [12,16]	Responsiveness to urgent deliveries [12,16]
Total inventory cost as: [13]	Effectiveness of distribution planning schedule [12,16]
Incoming stock level [12,16]	Information carrying cost [12,16]
Work-in-progress [12,16]	Quality of delivery documentation [12,16]
Scrap value [12,16]	Driver reliability for performance [12,16]
Finished goods in transit [12,16]	Quality of delivered goods [12,16]
Supplier rejection rate [12,16,13]	Achievement of defect free deliveries [12,16]
Efficiency of purchase order cycle time [12,16]	Product quality[15]
Frequency of delivery [12,16,13]	Product price[15]
Manufacturing lead time[15]	Range of products and services[15]
Yield[15]	Customer's product return rate[15]
Perished inventory [15]	Customer response time [15]
Obsolete inventory [15]	On-time delivery [15]
Inventory accuracy [15]	Finished goods inventory [15]
Material inventory [15]	Finished goods stock-out [15]
Material stock-out[15]	Repeat vs new customer sales [15]
Delivery flexibility[15]	Order fill rate [15]
Truck cube utilization[15]	Order tracking performance [15]
Responsiveness to urgent order[15]	Percentage of resolving customer's first call[15]
Adherence to schedule[15]	Image[15]
Forecast accuracy[15]	Reputation[15]
Volume flexibility[15]	Purity of product[17]
Mix flexibility[15]	Steady supply of finished product[17]
New product time to market[15]	Distribution lead time [13]
Percentage of sales from new products[15]	Distribution performance [13]
Steady supply of raw material[17]	Delivery reliability [13]
Transportation costs[17]	Effectiveness of distribution planning schedule [13]
Inventory costs[17]	Quality of delivery goods [13]
Integration with supply chain partners[17]	Customer perceived value of product [13]
Optimization of enterprise[17]	Flexibility of service system to meet particular customer needs [13]
Volume flexibility[17]	Responsiveness to urgent delivery [13]
Quality of purchased goods[15]	Market share [14]
Procurement administration cost[15]	Number of customer retained[14]
Price of purchased cost[15]	Customer satisfaction[14]
Time for successful bids[15]	•••••• to be continued••••••••
Material return rate[15]	
Supplier on-time delivery[15]	
Inventory information sharing[15]	
Order information sharing[15]	
Forecast information sharing[15]	
Trust with partners[15]	
Percentage of online purchase[15]	
Order processing[15]	
Purchase order fill rate [15]	
Quality services[14]	
New services implemented per year[14]	
On time delivery[14]	
Waste reduction[14]	
•••••• to be continued••••••••	
The financial perspective measures	**The learning and growth perspective measures**
Net profit vs. productivity ratio [12,16]	Supplier assistance in solving technical problems [12,16,13]
Rate of return on investment [12,16,14]	Supplier ability to respond to quality problems [12,16,13]
Variations against budget [12,16,13]	Supplier cost saving initiatives [12,16]
Buyer–supplier partnership level [12,16]	Supplier's booking in procedures [12,16]
Delivery performance [12,16]	Capacity utilization [12,16]
Supplier cost saving initiatives [12,16,13]	Order entry methods [12,16,13]
Delivery reliability [12,16]	Accuracy of forecasting techniques [12,16]

The internal process perspective measures	The customer perspective measures
Cost per operation hour [12,16,13]	Product development cycle time [12,16]
Information carrying cost [12,16]	Flexibility of service systems to meet particular customer needs [12,16]
Supplier rejection rate [12,16]	Buyer–supplier partnership level [12,16]
Total Profit[15]	Range of products and services [12,16]
Total revenue[15]	Level of customer perceived value of product [12,16]
Sales growth[15]	Human capital[15]
Total cost[15]	Information capital[15]
Cost per unit produced[15]	Organizational capital[15]
Inventory carrying cost[15]	Use of IT [17]
Delivery cost[15]	Postponement [17]
Setup/change-over cost[15]	Level of information sharing [13]
Cash flows[15]	Buyer–supplier collaboration in problem solving [13]
Customer query time; [16]	Employee satisfaction [14]
Raw material prices[17]	Employee turnover per year [14]
Length of supply chain[17]	Number of suggestions implemented per employee yearly [14]
Physical risks[17]	Money invested in employee training yearly [14]
Market share[17]	•••••• to be continued••••••••
Information carrying cost [13]	
Supplier cost saving activities [13]	
Variations against budget [13]	
Cost per operation hour [13]	
Return on investment [13]	
Gross revenue [14]	
Profit before tax[14]	
Cost reduction[14]	
•••••• to be continued••••••	

Source: Shafiee, Lotfi and Saleh (2014)

APPENDIX A – A MODEL FOR SUPPLY CHAIN PERFORMANCE MEASUREMENT – QUESTIONNAIRE – 1ST ROUND

Dear Specialist,

The Industrial and Systems Engineering Graduate Program at PUCPR is carrying out a research whose objective is to develop a model for measuring the supply chains performance based on the operations strategy. The present questionnaire will be used to evaluate some characteristics of a proposed model after a systematic literature review on supply chains performance measurement.

Q1 Full name

Q2 Interviewee specialty

- ○ Supply chain Management
- ○ Performance Management and Measurement
- ○ Both
- ○ Another specialty (please specify): _____

Q3 Area of activity

- ☐ Industry
- ☐ Consulting
- ☐ Academy
- ☐ Another area (please specify): _____

Q4 Interviewee's action time (years)

_____

Q5 In your opinion, what performance dimensions listed below are related to supply chain performance management and measurement?

( ) Quality
( ) Trust
( ) Responsiveness
( ) Cost
( ) Assets
( ) Reliability
( ) Polyvalence
( )Flexibility
( ) Resource utilization
( ) Visibility
( ) Security Resilience

Any comments? Any other dimension to be considered?

Q6 For each measure assigned to performance dimensions indicate your agreement level:

The financial economic indicators, listed below, are relevant for supply chain management:

	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Market share	○	○	○	○	○
Rate of return on investment	○	○	○	○	○
Net profit vs productivity ratio	○	○	○	○	○
Total cash flow time	○	○	○	○	○

Any comments? Any other measure to be considered?

Q7 The measures related to Quality, listed below, are relevant for supply chain management:	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Customer satisfaction	○	○	○	○	○
Product quality	○	○	○	○	○
Level of customer perceived value of product	○	○	○	○	○
Quality of delivery goods	○	○	○	○	○
Delivery performance	○	○	○	○	○
Delivery reliability	○	○	○	○	○
Level of supplier’s defect free deliveries	○	○	○	○	○
Supplier rejection rate	○	○	○	○	○
Accuracy of forecasting techniques	○	○	○	○	○
Effectiveness of distribution planning schedule	○	○	○	○	○
Buyer–supplier partnership level	○	○	○	○	○
Level of information sharing	○	○	○	○	○
Trust with partners	○	○	○	○	○
Supplier assistance in solving technical problems	○	○	○	○	○
Order entry methods	○	○	○	○	○
Quality of delivery documentation	○	○	○	○	○

Effectiveness on delivery invoice methods	○	○	○	○	○
Number of retained customers	○	○	○	○	○

Any comments? Any other measure to be considered?

Q8 The measures related to Flexibility, listed below, are relevant for supply chain management:

	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Responsiveness to urgent deliveries	○	○	○	○	○
Delivery flexibility	○	○	○	○	○
Flexibility to meet particular customer needs	○	○	○	○	○
Flexibility of service systems to meet particular customer needs	○	○	○	○	○
Responsiveness to product changes	○	○	○	○	○
Responsiveness to changing processes	○	○	○	○	○
Materials variety (number of materials available)	○	○	○	○	○
Range of products and services	○	○	○	○	○
Supplier ability to respond to quality problems	○	○	○	○	○
Adaptability of the upstream and downstream chain	○	○	○	○	○

Any comments? Any other measure to be considered?

Q9 The measures related to Cost, listed below, are relevant for supply chain management:

	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Supplier cost saving initiatives	○	○	○	○	○
Variations against budget	○	○	○	○	○
Manufacturing cost	○	○	○	○	○
Cost per operation hour	○	○	○	○	○
Inventory cost	○	○	○	○	○
Total Transportation cost	○	○	○	○	○
Emergency transportation cost	○	○	○	○	○
Information carrying cost	○	○	○	○	○
Inventory carrying cost	○	○	○	○	○
Machine downtime	○	○	○	○	○
Effectiveness of master production schedule	○	○	○	○	○
Capacity utilization as incoming stock level, work-in-progress, scrap level, finished goods in transit	○	○	○	○	○

Any comments? Any other measure to be considered?

Q10 The measures related to Reliability, listed below, are relevant for supply chain management:

	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Perfect order fulfillment	○	○	○	○	○
Inventory accuracy	○	○	○	○	○
On-time delivery	○	○	○	○	○
Demand forecast accuracy	○	○	○	○	○

Any comments? Any other measure to be considered?

Q11The measures related to Responsiveness, listed below, are relevant to supply chain management:

	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Delivery lead time	○	○	○	○	○
Total supply chain cycle time	○	○	○	○	○
Product development cycle time	○	○	○	○	○
Supplier lead time against industry norms	○	○	○	○	○
Planning process cycle time	○	○	○	○	○
Efficiency of purchase order cycle time	○	○	○	○	○
Order lead time	○	○	○	○	○
Order fulfillment cycle time	○	○	○	○	○
Customer query time	○	○	○	○	○

Any comments? Any other measure to be considered?

Q12 The measures related to Innovation, listed below, are relevant to supply chain management:

	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
Number of new products launched	○	○	○	○	○
Product/ Project development time	○	○	○	○	○
Chain involvement in the development of the new project	○	○	○	○	○
Use of new technology	○	○	○	○	○
New processes implemented per year	○	○	○	○	○
Sales ratio of existing products X new products	○	○	○	○	○
Investment in R&D	○	○	○	○	○
Revenue from new projects	○	○	○	○	○

Any comments? Any other measure to be considered?

APPENDIX B – A MODEL FOR SUPPLY CHAIN PERFORMANCE MEASUREMENT – QUESTIONNAIRE – 2ND ROUND

Q1 Dear Specialist,

The Industrial and Systems Engineering Graduate Program at PUCPR is carrying out a research whose objective is to develop a model for measuring the supply chains performance based on the operations strategy. The present questionnaire composes the second round of the Delphi study to evaluate some characteristics of a proposed model after a systematic literature review on supply chains performance measurement.

Q2 Full name

Q3 For each measure assigned to the performance dimensions, indicate whether the measure is context-dependent to which it belongs, or it is non-dependent, that is, applicable to any supply chain (generalist): The financial economic indicators:

	Dependent	Generalist
Market share	○	○
Rate of return on investment	○	○
Net profit vs productivity ratio	○	○
Total cash flow time	○	○

Q4 Any comments?

Q5 The measures related to Quality:

	Dependent	Generalist
Customer satisfaction	○	○
Product quality	○	○

Level of customer perceived value of product	○	○
Quality of delivery goods	○	○
Delivery performance	○	○
Delivery reliability	○	○
Level of supplier's defect free deliveries	○	○
Supplier rejection rate	○	○
Accuracy of forecasting techniques	○	○
Effectiveness of distribution planning schedule	○	○
Buyer–supplier partnership level	○	○
Level of information sharing	○	○
Trust with partners	○	○
Supplier assistance in solving technical problems	○	○
Order entry methods	○	○
Quality of delivery documentation	○	○
Effectiveness on delivery invoice methods	○	○
Number of retained customers	○	○

Q6 Any comments?

Q7 The measures related to Flexibility:

	Dependent	Generalist
Responsiveness to urgent deliveries	○	○
Delivery flexibility	○	○
Flexibility to meet particular customer needs	○	○
Flexibility of service systems to meet particular customer needs	○	○
Responsiveness to product changes	○	○
Responsiveness to changing processes	○	○
Materials variety (number of materials available)	○	○
Range of products and services	○	○
Supplier ability to respond to quality problems	○	○
Adaptability of the upstream and downstream chain	○	○

Q8 Any comments?

Q9 The measures related to Cost:

	Dependent	Generalist
Supplier cost saving initiatives	○	○
Variations against budget	○	○
Manufacturing cost	○	○
Cost per operation hour	○	○
Inventory cost	○	○

Total Transportation cost	○	○
Emergency transportation cost	○	○
Information carrying cost	○	○
Inventory carrying cost	○	○
Machine downtime	○	○
Effectiveness of master production schedule	○	○
Capacity utilization	○	○

Q10 Any comments?

Q11 The measures related to Reliability:

	Dependent	Generalist
Perfect order fulfillment	○	○
Inventory accuracy	○	○
On-time delivery	○	○
Demand forecast accuracy	○	○

Q12 Any comments?

Q13 The measures related to Responsiveness:

	Dependent	Generalist
Delivery lead time	○	○
Total supply chain cycle time	○	○

Product development cycle time	○	○
Supplier lead time against industry norms	○	○
Planning process cycle time	○	○
Efficiency of purchase order cycle time	○	○
Order lead time	○	○
Order fulfillment cycle time	○	○
Customer query time	○	○

Q14 Any comments?

Q15 The measures related to Innovation:

	Dependent	Generalist
Number of new products launched	○	○
Product/ Project development time	○	○
Chain involvement in the development of the new project	○	○
Use of new technology	○	○
New processes implemented per year	○	○
Sales ratio of existing products X new products	○	○
Investment in R&D	○	○
Revenue from new projects	○	○

Q16 Any comments?

APPENDIX C - APPROVED ARTICLE ISPE 2016

Performance measurement for Supply Chain management: A systematic literature review

Amanda O. VOLTOLINI[a,2], Edson PINHEIRO DE LIMA[b] and Sérgio E. GOUVEA DA COSTA[b]
[a] *Industrial and Systems Engineering Graduate Program, Pontifical Catholic University of Parana, Brazil*
[b] *Industrial and Systems Engineering Graduate Program, Pontifical Catholic University of Parana and Federal University of Technology - Parana, Brazil*

Abstract. Performance measurement models are evolving fast in recent years, many research studies have been done regarding the nature and the methodologies of measuring performance in organizations. The present global economic environment of continuous change is demanding new business models and competitive strategies. These new models are being characterized by integration, and new technologies adoption, their operations are being forced to look not only in individual company, but also in their entire set of operations networks. The present challenge is to extend the performance management and measurement models developed for isolated companies to supply chains. This article aims to systematically review the literature on supply chain performance management and measurement in order to map the trends and behavior of scientific production developed in the field.

Keywords. Performance measurement, Supply chain management, Supply chain performance measurement systems, Systematic literature review.

1. Introduction

The concept of performance measurement is progressing and in recent years, many research studies have been done regarding the nature and the methodologies of measuring performance in organisations [1]. This field developed over a number of phases, so ordered: productivity management; budgetary control; integrated performance measurement and integrated performance management [2].

With continuous changes happening in the world, in the new business environment, such as integration, and new technologies like the Internet, many organisations are forced to focus on the supply chain (SC) rather than their internal operations. Like this, the next step is to extend the performance management and measurement from isolated companies to supply chains. Aramyan *et al.* [3] put that an adequate performance measurement system needs to be developed in order to assess the success of supply chains.

Therefore, measuring supply chain performance plays an important role in supply chain management and improvement, and has received a lot of attention from the research community so that measuring it can improve the understanding and the cooperation between SC partners [4], increases SC integration [5] and can reveal the gap between planning and execution, helping companies to identify potential problems and areas for improvement [6]

This article aims to systematically review the literature on supply chain performance management and measurement from the perspective of operations management, highlighting the factors that affect the supply chain performance, performance dimensions and decision areas. A bibliometric analysis was conducted in order to show the research evolution on this theme. This paper is organized into the following sections: description of the systematic review methodology used research trands based on the literature; findings and conclusions.

2. Systematic review of performance measurement and management in the supply chain

This paper undertakes a systematic literature review in seeking all the relevant papers about supply chain performance management e measurement and the factors that influence the SC performance.

A systematic review has many advantages over other types of reviews such as traditional reviews as a systematic review requires an extensive review of articles following a list of specific steps to ensure the most relevant information with regard to a specific topic (subject) is obtained in an unbiased manner. Eventually, this ensures the fidelity, completeness and rigorous nature of the review [7]–[9].

The systematic literature review was conducted by creating a dataset constructed based on six different databases: Web of Science, Scopus, Science Direct, Emerald, Taylor & Francis, and Wiley. These databases have important journals in the field of supply chain. Search was made for papers written in english and portuguese, at all times. The search criteria are as follows: The search expressions were divided into three

[2] Corresponding Author. [amanda.voltolini@pucpr.br]

groups: The first group of expressions related to SC (Supply Chain, SCOR, Operations Network, Collaboration Network, Extended enterprise, Supplier, Interorganizational). The second group consists of expressions that represent the measurement and performance management (Performance, Indicator, Metric, Measure, KPI, Performance Measurement, Performance Management). The third group was set up with the intention to find references about models and performance measurement practices in the supply chain referenced in the literature (Model; Framework, Process, Method, Technique, Tool, System). The expressions were used as search engine in the title, abstract and keywords. Papers related to humanitarian chains and services were not considered in the analysis.

In total 1252 papers were founnded in the six bases. All papers abstracts were reviewed in order to exclude not pertinent works to the research and to identify the main methodology of each article. Repeated papers among the databases were also excluded, resulting in a dataset of 816 papers. Then, an bibliometric analysis was to perform within the filtered set of papers in order to understand the evolution of the theme under various perspectives. Bibliometric studies were used as techniques for supporting SLR strategy and, the study applies them as a set of research methods to map the structure of knowledge in the researched theme. Thus, from the processing of information relating to the authors of the research, the publication of vehicles, research institutions and keywords can be evaluated trends and behavior of scientific production developed in a specific field [10], [11].

3. Research Trends

For performance measurement and management (PMM) companies to be effective, it has to fit the environment in which it operates. The environmental changes should be reflected in the strategies developed and deployed, and these strategic changes should affect the PMM system. One of the most important changes now a days is the increasing importance of the supply chain [12].

Wong *et al.* [13] wrote "A supply chain consists of a chain of suppliers and customers aiming to provide a product or service to the end customers", and the alignment within a SC is an emerging and important issue. Chae [6] wrote that supply chain performance measurement (SCPM) means a set of metrics and processes related to assessing and evaluating how accurate the planning is and how well the execution is carried out. Acording to Chen and Paulraj [14], measuring SC performance can facilitate a better understanding of the SC, positively influencing SC players' behaviour and improving its overall performance.

Literature reviews were conducted regarding SC in different contexts. Many researchers have suggested different measurement systems using the metrics of performance from different aspects. Arzu Akyuz and Erman Erkan [15] reviewed 24 articles from 1999 to 2009, and concluded the frameworks and models were still immature. Bhagwat and Sharma [16] determined the required performance measures and developed a model for performance evaluation, based on these selected measures using analytical hierarchy process (AHP) methodology. Gunasekaran, Patel and Mcgaughey [17] develop a framework for SCPM that provides a detailed 'measurement and metrics classification' and uses a survey aiming at assessing importance within each metric group. Gunasekaran and Kobu [18] offer a comprehensive review and classification for SC measurement and metrics. Arzu Akyuz and Erman Erkan [15] present some characteristics and requirements that new era performance measurement metrics should have. Beamon [19] categorised performance measures in the literature into two groups of qualitative and quantitative measures.

Some other researchers reviewed supply chain management within the context of sustainability. The study of Ahi and Searcy [20] identifyed and analyzed the metrics that have been published in the literature on green supply chain management (GSCM) and sustainable supply chain management (SSCM). Bhattacharya *et al.* [21] delineated a green supply chain (GSC) performance measurement framework using an intra-organisational collaborative decision-making (CDM) approach. Chin, Tat and Sulaiman [22] reviewed the extant literature on the relationship between GSCM, environmental collaboration and sustainability performance and propose a plausible conceptual model to elucidate the relationship between these three variables in the context of Malaysian manufacturing companies. Olugu, Wong and Shaharoun [23] reviewed various literatures on green supply chain performance measurement, environmental management, traditional supply chain performance measurement, and automobile supply chain management.

The influence of information technology (IT), information and knowledge sharing in the performance of the supply chain is also targeted by investigators. In their study, Byrd and Davidson [24] examined the impact of information technology (IT) on the supply chain through a survey of 225 large for-profit US firms. Based on the dynamic capabilities perspective and the view of a hierarchy of capabilities, Liu *et al.* [25] proposed a model to examine how IT capabilities affect firm performance through absorptive capacity and supply chain agility in the SC context. In their study, Baihaqi and Sohal [26] conceptualised and assessed several factors that influence the degree of information sharing in supply chains.

Melnyk et al. [37] suggest that SC operating in the current working environment should have the ability to provide one or more (blend) of the six basic outcomes depending on the customer/market requirements,

which are cost, responsiveness, resilience, security, innovation and sustainability. The findings of a survey conducted by Ambe [27] revealed that quality, final product delivery reliability and cost were highly rated and the most important indicators for the South African automotive market. Terpend and Ashenbaum [28] examines the intersecting effects of power, trust and supplier network size on 5 dimensions of supplier performance (delivery, quality, cost, innovation and flexibility). Other authors developed their studies with a focus on delivery [29]–[31] and SC flexibility [32], [33].

Several authors based their studies on the Supply Chain Operations Reference (SCOR) model and Balanced Scorecrd [15], [34]–[43]. The SCOR model is a framework, being developed and maintained by the SC council, for examining the SC in detail through defining and categorizing the processes that make up the chain, assigning metrics to these processes and reviewing comparable benchmarks [34]. It is a flexible framework and a common language that can help companies improve their SC internally and externally [35]. Hwang, Wen and Chen [36] explored the relationship between the plan-do-study-act (PDSA) cycle of green purchasing and the SCOR purchasing/sourcing process and its performance indices/metrics. Ganga and Carpinetti [37] proposed a SC performance model based on fuzzy logic to predict performance based on causal relationships between metrics of the SCOR model. Based on the survey data from 232 companies that have obtained ISO 9000 certification, Li, Su and Chen [38] studied the five decision areas of the SCOR model by integrating quality assurance measures in the SC process. Collectively, 'Plan' and 'Source' decisions are more important to customer-facing supply chain performance (reliability, response, and flexibility), and 'Make' decisions positively affect internal-facing performance metrics (cost and asset).

Sellitto *et al.* [39] presented a SCOR-based model for performance measurement in supply chains (SC) and apply it in the context of Brazilian footwear industry. The model has two dimensions: SCOR processes (source, make, deliver and return) and performance standards adapted from original SCOR (cost, quality, delivery and flexibility). And Thunberg and Persson [40] evaluated construction material supplier and construction site performance according to the SCOR model.

Kaplan and Norton [44] BSC concept reflects an intent to keep score of a set of items that maintain a balance ''between short term and long term objectives, between financial and non-financial measures, between lagging and leading indicators, and between internal and external performance perspectives'' [45]. The importance of the balanced scorecard approach for SCPM is beyond discussion [15]. The BSC holds the potential to facilitate performance measurement for SC [46]. Although extensive studies have been recorded in the evaluation of SC efficiency through balanced scorecard (BSC), these studies do not focus on the relationships between the four perspectives of the BSC. Kim and Rhee [41] examined the impact of green supply chain management CSFs (critical success factors) on the BSC (balanced scorecard) performance by the structural equation modelling metodology. Jalali Naini *et al.* [42] proposed a mixed performance measurement system using a combination of evolutionary game theory and the balanced scorecard (BSC) in environmental supply chain management (ESCM). Kusrini, Subagyo and Masruroh [43] has developed an integrated model that combines the BSC with the SCOR to identify key indicators of SC performance based on strategic objectives of supply chain actors and for the government (regulator) especially with regard to public sector policy.

4. Findings

This section presents the bibliometric analysis results, including time distribution, publishing country, journals, authors, methodologies and keywords analysis.

3.1. Time distribution and publishing country

83% of the papers were published during the last ten years, almost 40% during the last three years. Figure 1 represents the the publications evolution over the years. The analyzed publications are from 55 different countries. The nine most representative countries are shown in Figure 2.

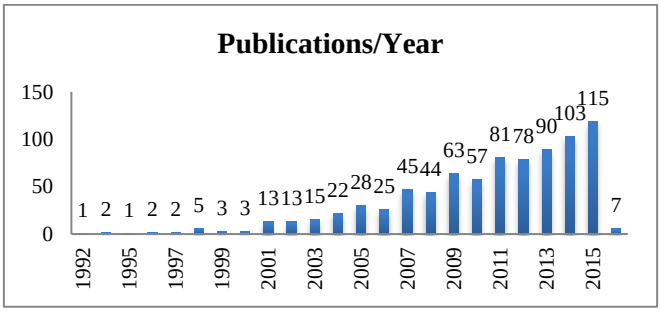


Figure 1 - Amount of publications per year.

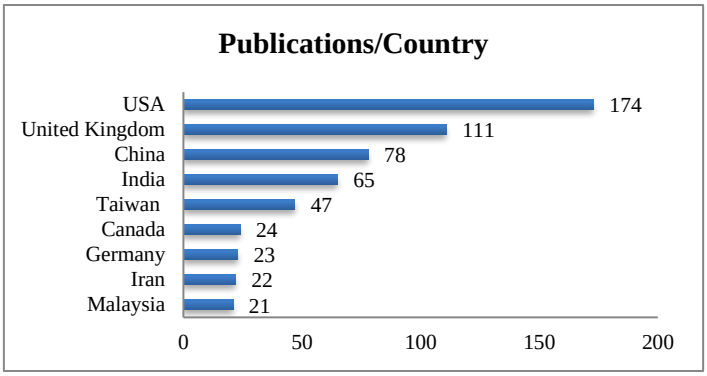


Figure 2 - Amount of papers per Country

The fast growth of research may be justified not only by the strengthening of academic communities in general, but also by the increasing importance given to the supply chains management, which generates the need to develop ways to measure and manage the performance of companies working together.

Once the development of performance measurement went through the phases of productivity in the 50s, financial indicators until the 70s, measuring new dimensions from 80s, a change from measuring to managing performance in 90s, and only then aroused need for research in supply chain performance measurement and management, it was expected that the bulk of studies in the area had started to occur after 2005, with faster growth in recent years.

3.2. Journals

The 816 identified papers were published in 241 different journals. The ten most expressive journals, listed in Table 1, represented together 39% of all the papers.

Table 1 - Papers distribution by journals

Supply Chain Management: An international Journal	**63**
International Journal of Production Economics	58
International Journal of Production Research	48
International Journal of Operations and Production Management	37
Industrial Management and Data Systems	22
Benchmarking: An International Journal	21
International Journal of Physical Distribution and Logistics Management	20
Production Planning and Control	20
International Journal of Productivity and Performance Management	19
Journal of Operations Management	16

According to the databases, the subject area of the publications varies a lot. The most important fields interested in performance measurement and management of supply chain are (based on the amount of papers published): Business, Management and Accounting, Engineering, Decision Sciences, Computer Science, Economics, Econometrics and Finance, Social Sciences, Environmental Science and others.

3.3. Authors

Were considered for this analysis all authors of each identified paper, not just the correspondinng author. Were listed a total of 1.698 different authors, of which 80,6% are present in only one article. These data show a wide range of researchers interested in the topic, but points to a situation in which few of them use this theme as the main focus of their studies or research groups. Table 2 shows informations about tewelve authors who participated in six or more papers.

Table 2 - Principal authors

Authors	Number of papers	University/ Departament	Country	h-index
Sarkis, Joseph	11	Worcester Polytechnic Institute, School of Business	United States	54
Chan, Felix T.S.	11	Hong Kong Polytechnic University, Department of Industrial and Systems Engineering	China	42

Lai, Kee-hung	9	Hong Kong Polytechnic University, Faculty of Business	China	35
Fynes, Brian	8	National University of Ireland, Michael Smurfit Graduate Business School	Ireland	16
Huo, Baofeng	7	Zhejiang University, School of Management	China	10
Forslund, Helena	7	Linnaeus University, Department of Accounting and Logistics	Sweden	8
Tan, Keah-Choon	6	University of Nevada, Lee Business School	United States	22
Wiengarten, Frank	6	Universitat Ramon Llull, ESADE Business School	Spain	10
Zhao, Xiande	6	China Europe International Business School	China	25
Govindan, Kannan	6	Syddansk Universitet, Department of Technology and Innovation	Denmark	22
Green Jr., Kenneth W.	6	Southern Arkansas University, Department of Management	United States	23
Koh, S.C. Lenny	6	University of Sheffield, Management School	United Kingdom	27

3.4. Methodologies and Keywords

All papers on the dataset were classified by its most important methodological approach, based on the authors' description of their works. The following Figure 3 presents the amount of papers identified for each of these categories. presents the amount of papers identified for each of these categories.

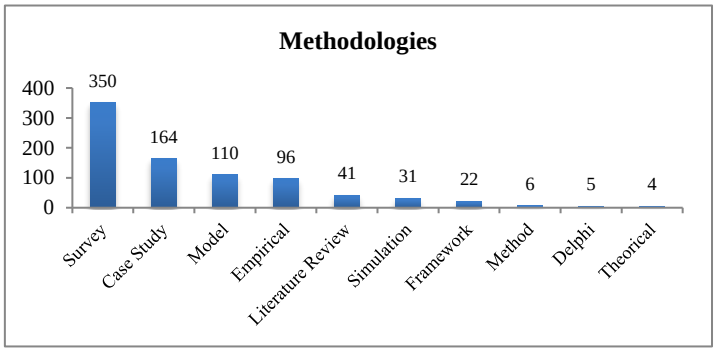


Figure 3 - Amount of papers per methodological approach.

The most addressed keywords used for represent the studies in supply chain performance management, presented in the analyzed papers, were identified. Figure 4 lists the amount of papers studied that used the most cited keywords.

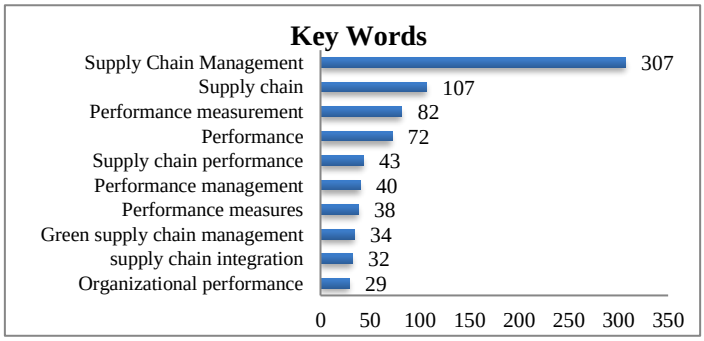


Figure 4 - Principal keywords and number of publications.

5. Conclusion

The initial literature review showed many authors in the performance measurement and management field were pointing the need to extend the researches from companies to the SC context. Aiming to check if this calls for research were being answered, a Systematic literature review and bibliometric analysis, were conducted to map the search field.

The findings showed a greater amount of papers started to appear only in the last five years, publications are from journals from various areas and researchers from several countries. The diversity of research origins shows the importance of the theme and indicates it is continuing to grow in the future, but, in the other hand, hinders the search process maturity. Many papers have been conducted with the purpose of identifying the issues involved in supply chain performance measurement and management or proposing frameworks, models, and methods to solve them, but few studies have been made about application and validation of these proposals.

This paper contributes for theory in terms of mapping and reviewing the present research in the theme of Supply Chain Performance Measurement, and it creates conditions for academics to identify research opportunities in topics and research problems not fully addressed.

The main limitations of the approach are related to the selected scientific databases, document type (ie articles), language (i.e. English or Portuguese) and search phrases, which can delete items. The papers are not included in the data set may be pertinent to the field, but it is not likely that they would change the results of this evaluation. As future work, we propose an in-depth analysis on performance measurement models and indicators of the supply chain and consolidate in a conceptual framework, the supply chain performance measurement systems requirements proposed in the literature.

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APPENDIX D - APPROVED ARTICLE P&OM 2016

Supply chain performance measurement: A systematic literature review

Amanda Oliveira Voltolini
Industrial and Systems Engineering/ Pontifical Catholic University of Parana

Edson Pinheiro de Lima (e.pinheiro@pucpr.br)
Industrial and Systems Engineering/Pontifical Catholic University of Parana and Federal University of Technology

Sérgio Eduardo Gouvêa da Costa
Industrial and Systems Engineering/Pontifical Catholic University of Parana and Federal University of Technology

Summary Abstract

One of the most important changes nowadays is the increasing importance of the supply chain performance. Therefore, measuring supply chain performance plays an important role in supply chain management and improvement, and has received a lot of attention from the research community. This article aims to systematically review the literature on supply chain performance management and measurement in order to show the research evolution on this theme and identify and analyze the PMS models proposed for SC.

Keywords: Performance measurement, Performance management, Supply chain, Systematic literature review

Introduction

The performance measurement field is being developed over a number of phases, so ordered: productivity management; budgetary control; integrated performance measurement and integrated performance management. One of the next natural steps is to extend the performance management from isolated companies to supply chains (Bititci *et al.*, 2012). The continuous changes that are happening in the world, as the new business environment is impacted by market and operations as integration, and new information and communication technologies, many organizations are forced to focus on the supply chain (SC) rather than only in their internal operations (Nudurupati *et al.*, 2016).

Supply chain management (SCM) is recognized as an organizational framework to pursue continuous improvement in the competitive market, especially because individual companies in supply chain do not maximize efficiency the attainment of their goals independently (Cho *et al*., 2012). As mentioned by Wong *et al*., 2012), "a supply chain consists of a chain of suppliers and customers aiming to provide a product or service to the end customers", and the alignment within a supply chain is an emerging and important issue. The authors suggest that performance measurement system (PMS) is one of the six main constructs for the enablers of alignment.

Therefore, measuring supply chain performance plays an important role in supply chain management and improvement, and has received a lot of attention from the research community: measuring it can improve the understanding and the cooperation between SC partners (Chan *et al.,* 2003); it increases SC integration (Gunasekaran *et al,*. 2001); and can reveal the gap between planning and execution, helping companies to identify potential problems and areas for improvement (Chae, 2009).

This article aims to systematically review the literature on supply chain performance management and measurement in order to show the research evolution on this theme and to identify and to analyze the PMS models proposed for SCM.

Systematic literature search criteria and procedure

According to Mustafa Kamal and Irani (2014) the objective of a systematic and structured literature review is to observe and understand the past trends and extant patterns/themes in the research area, evaluate contributions and summarize knowledge, thereby identifying limitations, implications and potential directions of further research.

As a systematic review requires an extensive review of articles following a list of specific steps to ensure that the most relevant information with regard to a specific topic (subject) is obtained in an unbiased manner. Eventually, this ensures the fidelity, completeness and rigorous nature of the review (González *et al*., 2010; Choong, 2014).

This paper undertakes a systematic review of the literature in seeking all the relevant articles about performance management e measurement and the factors that influence the performance of supply chain management. The systematic review carried out in this paper follows the approach delineated by Tranfield *et al*. (2003) as showed in Table 1.

Table 1 - Systematic Literature Review Phases

Phase	Steps
Define	1. Identification of need for a literature review 2. Developmente of a literature review protocol
Collect and Select	3. Identification of documents 4. Selection of relevant documents
Analyze	5. Categorization of documents 6. Data extraction
Result	7. Document findings

The systematic literature review was conducted by creating a dataset constructed based on six different databases: Web of Science, Scopus, Science Direct, Emerald, Taylor & Francis, and Wiley. These databases have important journals in the field of supply chain. Search was made for articles written in English, at all times. The search expressions were divided into three groups: The first group of expressions related to supply chain (Supply Chain, SCOR, Operations Network, Collaboration Network, Extended enterprise, Supplier, Interorganizational). The second group consists of expressions that represent the measurement and performance management (Performance, Indicator, Metric, Measure, KPI, Performance Measurement, Performance Management) and the third group was set up with the intention to find references about models and performance measurement practices in the supply chain referenced in the literature (Model, Framework, Process, Method, Technique, Tool, System).The expressions were used as search engine in the title, abstract and keywords.

In total 1252 papers were identified in the six scientific bases. All papers abstracts were reviewed in order to exclude works not pertinent to the research and identify the

main methodology of each article. Excluding repeated also, the dataset ended with a total of 816 different papers listed. Then was conducted a keywords and articles goals analysis to identify the articles related to performance measurement models in supply chain. This analysis resulted in 185 articles. Finalized the abstracts analysis stage, a bibliometric analysis was performed to extract different information to show the evolution of the theme.

Bibliometric studies were used as techniques for supporting SLR strategy and, the study applies them as a set of research methods to map the structure of knowledge in the researched theme. Thus, from the processing of information relating to the authors of the research, the publication outlets (journals), research institutions and keywords, it is possible to evaluate trends and behavior of scientific production developed in a specific field (Vanti, 2002; Treinta *et al*., 2014).

To perform the content analysis were selected articles which the journal had impact factors greater than 0.7. Besides this criteria, all articles from 2014 to 2016, were selected. It was also selected articles representing 85% of citations and representing 85% of the h- index of authors. This sequential filter/selections process resulted in a final paper set of 72 articles.

Systematic literature Review

This section presents the results of bibliometric analysis with 185 articles and a content overview of the 72 final articles.

Bibliometric analysis

The 185 identified papers were published in 91 different journals. The twelve most expressive journals, listed in Table 2, represented together 45% of all the papers.

Table 2 - Distribution of the articles with respect to journals

Benchmarking: An International Journal	**11**
International Journal of Operations and Production Management	10
International Journal of Productivity and Performance Management	10
International Journal of Production Economics	10
Supply Chain Management: An International Journal	8
International Journal of Production Research	8
Production Planning and Control	7
International Journal of Supply Chain Management	4
Journal of Intelligent Manufacturing	4
Industrial Management & Data Systems	4
International Journal of Business Performance Management	4
International Journal of Logistics Systems and Management	4

Over 80% of the papers were published during the last ten years, almost 35% during the last three years and the publications are from 39 different countries. Figure 1 represents the evolution of the number of publications over the years and the ten most representative countries are shown in Figure 2.

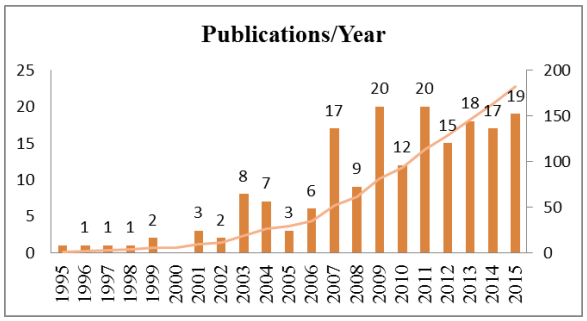

Figure 1 - Amount of publications per year

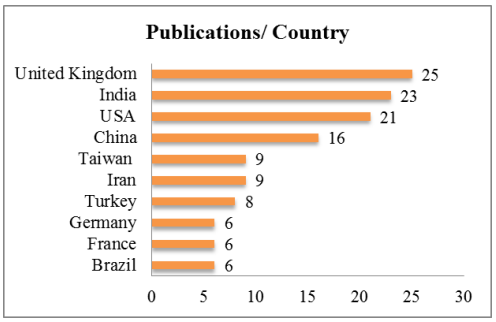

Figure 2 - Amount of papers per Country

We considered for this analysis all authors of each identified paper, not just the correspondinng author. It is listed a total of 396 different authors, of which 91% are present in only one article. Table 3 shows information about tewelve researchers who authored three or more papers.

Table 3 - Principal authors

Authors	Articles	University/Department	Country	h-index
Chan, F. T.S.	8	Hong Kong Polytechnic University, Department of Industrial and Systems Engineering	China	42
Qi, H. J.	5	The George W. Woodruff School of Mechanical Engineering	United States	21
Bhagwat, R.	4	Jai Narain Vyas University, Department of Mechanical Engineering	India	14
Gunasekaran, A.	4	University of Massachusetts Dartmouth, Decision and Information Sciences	United States	44
Sharma, M. K.	4	Jai Narain Vyas University, Department of Production and Industrial Engineering	India	12
Morgan, C.	3	Humboldt State University, Department of Chemistry	United States	24
Piotrowicz, W.	3	University of Oxford, Sad Business School	United States	5
Cuthbertson, R.	3	University of Oxford, Saïd Business School	United States	5
Deshmukh, S. G.	3	Atal Bihari Vajpayee Indian Institute of Information Technology and Management	India	32
Wong, K. Y.	3	University Technology Malaysia, Department of Manufacturing and Industrial Engineering	Malaysia	17

All papers on the dataset were classified by its most important methodological approach, based on the authors' description of their works and by their informed keywords. Figure 3 presents the methodologies used in articles and Figure 4 lists the amount of papers studied that used the most cited keywords.

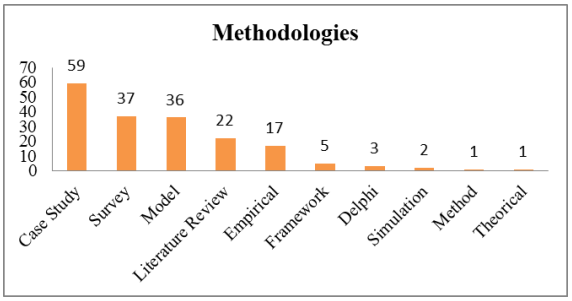

Figure 4 – Methodological approaches

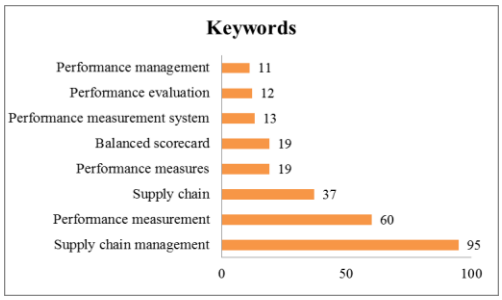

Figure 5 - Keywords

Literature Review

Table 4 presents the main topics of articles and publications related to each topic.

Table 4 - Main topics

Subject	Publications
Supply chain performance measurement and management	Akyuz & Erkan (2010); Chan & H. J. Qi (2003); Angerhofer & Angelides (2006); Min & Mentzer (2004); Park and Chang (2010); Chen & Paulraj (2004);Li & Nagurney (2015); Kim & Wemmerlöv (2015); Teimoury *et al.* (2014); Schmitz & Platts (2003); Ip *et al*. (2011); Kache & Seuring (2014); van Hoek (1998); Frederico & Martins (2014); Aramyan *et al.* (2007); Wickramatillake *et al*. (2007); Papakiriakopoulos & Pramatari (2010); Blanc *et al.* (2007); Varma *et al*. (2013); Ou *et al*. (2010); Estampe *et al*. (2013); Prajogo *et al*. (2012)
Supply chain performance measures and metrics	Lambert & Pohlen (2001); Beamon (1999); Gunasekaran *et al.* (2001); Gunasekaran *et al*. (2004); Chan (2003); Sánchez & Pérez (2005); Huang & Keskar (2007); Cai *et al.* (2009);Stewart (1995); Otto & Kotzab (2003); Mummalaneni *et al*. (1996); Appelqvist *et al*. (2013); Chae (2009); Christensen *et al*. (2007); Pettersson & Segerstedt (2013); Moreira & Tjahjono (2016); *Li et al.* (1997); Dabhilkar *et al*. (2009); Martin & Patterson (2009); Camarinha-Matos & Abreu (2007)
Balanced Scorecard approach	Rajat Bhagwat & Sharma (2007); Charkha & Jaju (2015); Thunberg & Persson (2013); Kleijnen & Smits (2003); Bititci *et al*. (2005); Halman & Voordijk (2012); Shafiee *et al*. (2014); Schmitz & Platts (2004)
SCOR model	Lockamy III & McCormack (2004); Sellitto *et al*. (2015); Jamehshooran *et al.* (2015); Li *et* al. (2011); Bai & Sarkis (2012); Gulledge & Chavusholu (2008); Folan & Browne (2005)
Multi criteria model to evaluate supply chain performance	Bac & Erkan (2011); Chan *et al.* (2003); Chan & Qi (2003); Bhagwat & Sharma (2007); Chen & Yan (2011); Tavana *et al*. (2013); Najmi & Makui (2012); Dey *et al*. (2015); Agami *et al*. (2014); Wong & Wong (2007); Bhagwat & Sharma (2009); Olugu & Wong (2012); Berrah & Clivillé (2007); Xu *et al*. (2009)

The papers included in the review can be categorized into three subgroups according to their common themes.

Supply chain performance measurement

Measuring performance in the supply chain is crucial to identify whether an organization is on target with regard to achieving supply chain objective. An innovative performance measurement method is proposed by Chan *et al.* (2003) to provide necessary assistance for performance improvement in SCM. The proposed method addresses this purpose in four aspects: a simplified supply chain model; tangible and intangible performance measures in multiple dimensions; a cross-organizational performance measurement; and fuzzy set theory and weighted average method. Gunasekaran *et al.* (2004) develop a framework for supply chain performance measurement and provide a detailed 'measurement and metrics classification' and uses a survey aiming at assessing importance within each metric group. Bititci *et al.* (2005) found that due to structural differences between traditional and extended enterprises, the systems required to measure and manage the performance of extended enterprises, whilst being based upon existing performance measurement frameworks, would be structurally and operationally different. Based on this, they propose a model for measuring and managing performance in extended enterprises which includes intrinsic and extrinsic inter-enterprise coordinating measures.

Chae (2009) recognized that developing key performance indicators (KPIs), or

metrics, is very challenging and a set of practical guidelines is not readily available for companies and supply chain management practitioners. His paper offers a practical approach to performance measurement and to present a list of essential KPIs.

Akyuz and Erkan (2010) reviewed 24 articles from 1999 to 2009, and concluded the frameworks and models were still immature. A mathematical model is proposed by Bac and Erkan (2011) to evaluate supply chain performance using some KPIs. This model can be used to evaluate the flexibility characteristics of logistic, market, supplier, machine, labor, information system, and routing of the supply chain. Frederico and Martins (2014) identify eleven PMSs for SCM, two maturity models for PMS and six dimensions which drives the maturity of PMS. Also, it was possible to verify that the PMS for SCM focus only on measurement scope, which is only one dimension to manage the maturity of the PMS. Moreira and Tjahjono (2016) develop a conceptual framework that adopts performance measures for ex-ante decision-making at an operational level within the supply chain and carried out a case study at a major global brand beverage company.

Supply chain performance measures and metrics

Lambert and Pohlen (2001) provide a framework for developing supply chain metrics that translates performance into shareholder value. The framework focuses on managing the interfacing customer relationship management and supplier relationship management processes at each link in the supply chain. Chan (2003) present the formulisation of both quantitative and qualitative performance measurements for easy representation and understanding. Apart from the common criteria such as cost and quality, five other performance measurements are defined: resource utilisation; flexibility; visibility; trust; and innovativeness. In particular, new definitions are developed for visibility, trust, and innovativeness. Angerhofer and Angelides (2006) show how the constituents, key parameters and performance indicators are modelled into the environment and through a case study illustrate how the decision support environment may be used to improve the performance of a collaborative supply chain by pinpointing areas for improvement. Cai *et al.* (2009) propose a framework using a systematic approach to improving the iterative KPIs accomplishment in a supply chain context and quantitatively analyzes the interdependent relationships among a set of KPIs. A scenario of a large retail company is also discussed to explain the application of this framework. Akyuz and Erkan (2010) present some characteristics and requirements that new era performance measurement metrics should have be. According Bai and Sarkis (2012) formal modelling tools and approaches for organisations to help evaluate the relationships between the performance measures and the desired competitive outcomes are limited, especially in logistics and supply-chain management functions. To help address this gap, they introduce a novel application of neighbourhood rough-set theory for the identification and selection of performance measures related to externally derived desired outcomes on the sourcing function.

The use of Balanced Scorecard approach and SCOR model

The Balanced Scorecard (BSC) approach was proposed by Kaplan & Norton (1992) as a framework and process for performance assessment and it was designed to complement traditional measures maintaining balances between short-term and long-term objectives, financial and non-financial measures, lagging and leading indicators, and internal and external performance perspectives (Bhagwat and Sharma 2007 b). According Shafiee *et al.* (2014) vast studies have been recorded on supply chain efficiency evaluation via BSC approach, but these studies do not focus on the relationships between the four perspectives of BSC. Then, after reviewing different tools to evaluate the performance of supply chain,

a new approach, relying on network DEA with BSC approach, was generated focusing on these relationships, especially the returnable ones. Bhagwat and Sharma (2007) propose the use of the analytical hierarchy process (AHP) methodology as aid in making SCM evaluation decisions that can help firms to prioritize and formulate viable performance measurement strategies in the volatile and complex global decision environment from different BSC perspectives. Bhagwat and Sharma (2007 b) suggests that a balanced SCM scorecard can be the foundation for a strategic SCM system provided that certain development guidelines are properly followed, appropriate metrics are evaluated, and key implementation obstacles are overcome.

The Supply Chain Operations Reference (SCOR) model is a framework for examining the supply chain in detail through defining and categorizing the processes that make up the chain, assigning metrics to these processes and reviewing comparable benchmarks (Agami *et al.*, 2012). Lockamy III and McCormack (2004) investigate the relationship between supply-chain management planning practices and supply chain performance based on the four decision areas provided in SCOR Model Version 4.0 and nine key supply-chain management planning practices derived from supply-chain management experts and practitioners. The results show that planning processes are important in all SCOR supply chain planning decision areas. Based on the survey data from 232 companies that have obtained ISO 9000 certification, Li *et al.* (2011) studied the five decision areas of the SCOR model by integrating quality assurance measures in the supply chain process. The results show that individually, each decision area has a positive impact on both customer-facing supply chain quality performance and internal-facing firm level business performance. Collectively, 'Plan' and 'Source' decisions are more important to customer-facing supply chain performance (reliability, response, and flexibility), and 'Make' decisions positively affect internal-facing performance metrics (cost and asset). Thunberg and Persson (2013) evaluated construction material supplier and construction site performance according to the SCOR model. Sellitto *et al*. (2015) present a SCOR-based model for performance measurement in supply chains and apply it in the context of Brazilian footwear industry. The model has two dimensions: SCOR processes (source, make, deliver and return) and performance standards adapted from original SCOR (cost, quality, delivery and flexibility).

Conclusion

The fast growth of the field may be justified by the increasing importance given to the management of supply chains, which generates the need to develop ways to measure and manage the performance of companies working together. This paper contributes for theory in in terms of mapping and reviewing Supply Chain Performance Measurement, and it creates conditions for researchers identify research opportunities in topics and research problems not fully addressed. Practitioners could use the results of this research to implement or improve their supply chain performance measurement system.

The main limitations of the approach are related to the selected scientific databases, document type (i.e. articles), language (i.e. English) and search phrases, which can delete items. The articles are not included in the data set may be pertinent to the field, but it is not likely that they would change the results of this evaluation. As future work, we propose an in-depth analysis on performance measurement models and indicators of the supply chain and consolidate in a conceptual framework, the supply chain performance measurement systems requirements proposed in the literature.

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APPENDIX E - SUBMITTED ARTICLE MEASURING BUSINESS EXCELLENCE 2017

SUPPLY CHAIN PERFORMANCE MEASUREMENT: A SYSTEMATIC LITERATURE REVIEW

Purpose: Supply chain management is a multidisciplinary field and it is addressed from many different perspectives. This article aims to systematically review the literature on supply chain performance management and measurement from the perspective of operations management, highlighting the factors that affect the supply chain performance.
Design/ methodology/ approach: A systematic literature review and bibliometric analysis are carried out in order to map the research trends in the supply chain field.
Findings: The research works included in the dataset can be classified in five main groups, according to their common themes. The discussion on these subjects addressed in the literature provide an overall comprehension upon the context in which the present research work is positioned, especially to the extent that these themes involve issues and aspects that impact on supply chain performance. The research trend, which is related to strategic performance measurement systems it was examined by means of the bibliometric analysis. Thus, from the processing of information relating to the papers' authors, the publication's journals, the research institutions, years and keywords, it was possible to evaluate the trends and behavior of scientific production developed in this field.
Originality/ value: Research relevance is founded on two main aspects, the first is related to identify the factors that influence the supply chains performance and the proposed models for measuring performance; and the second aspect is the use of systematic literature review to summarize the findings of the area.
Keywords: Supply chain management, Supply chain performance measurement systems, Systematic literature review.
Article classification: Literature Review.

Introduction

According to Li *et al*. (2006) effective supply chain management (SCM) has become a potentially valuable way for developing a sustainable competitive advantage and improving organizational performance since competition is no longer established by

organizations, but among supply chains. Highly competitive environments require that supply chain (SC) managers respond quickly to competitive challenges, inventory shortages, customers' requirements in product customization, quality improvement, inaccurate order processing and unreliable transport situations. On the other hand, they need to reduce production cost, shorten lead times and lower inventory levels to ensure profitability (Chithambaranathan *et al.*, 2015).

The SC modern environment calls for collaboration among SC partners, who often establish strong relationships with each other (Chithambaranathan et al., 2015). Performance analysis can provide important feedback information to enable supply chain managers to monitor implementation, review progress, enhance communication and diagnose problems. Also, the analysis on supply chain performance can provide a basis for better integration among the supply chain members and, especially, for better decision-making in SCM, particularly in redesigning business goals and strategies, and in reengineering processes (Sharma and Bhagwat, 2007).

Supply chain management is a multidisciplinary field and it is addressed from many different perspectives. This article aims to systematically review the literature on supply chain performance management and measurement from the perspective of operations management, highlighting the factors that affect the supply chain performance. A bibliometric analysis was conducted in order to show the research evolution on this theme.

In order to provide a view on the major context of supply chain performance measurement models, the paper is organized as follows. First, the main concepts of research are presented. Following the research strategy presentation, the systematic literature review and bibliometric analysis results are presented. The paper concludes with a discussion on the contribution, limitations, and prospects for future research.

Supply chain management

According to Chopra and Meindl (2007) supply chain consists of all parties involved, directly or indirectly in fulfilling a customer request. The supply chain not only includes the manufacturer and the supplier but also transporters, warehouses, retailers, wholesalers, service providers and customers themselves. Supply chain is a network of companies, which influence each other (Chen and Gong, 2013).

Supply chain management (SCM) can be defined as the management of different types of physical, informational and financial flows from the raw-materials stage through

to the finished products, connecting material suppliers, manufacturers, distributors and customers (Chithambaranathan *et al.,* 2015). According to Bagchi *et al.* (2005) the implementation of SCM requires different companies to stop attempting to improve their own processes independently, as has been done up until now, in order to achieve a global benefit.

Operations strategy

Operations strategy is the general pattern of decisions that determines the long-term competences and their contribution to the global strategy, for any kind of operation, by means of conciliating market requirements and operations capabilities. The operations strategy formulation begins with defining the business strategies for the different niche markets in which the company compete (Hayes & Wheelwright 1985; Slack & Lewis 2008).

The operations strategy content can be organized in two major layers: defining competitive objectives and relating them to performance measures. These measures set up references to the decision-making processes for each dimension of the operations. The performance measures along with the decision areas define the content of the operations strategy (Hayes & Wheelwright 1985; Slack & Lewis 2008)..

Performance measurement

According to Neely *et al.* (1995), performance measurement is the technique for quantifying the efficiency and effectiveness of business activities. The efficiency addresses the economic utilization of resources, taking into consideration a given level of expectation. The effectiveness, in turn, evaluate the result of a process in comparison to the clients' expectations.

According to Amaratunga *et al*. (2002), a strategic performance measurement system is one that utilizes information about performance to produce a positive change on the organization's culture, systems and processes. Folan *et al.* (2007) points out that the PMS is responsible for managing the implementation of operations strategy.

Measurement systems are part of a wider system, which includes the design of metrics, feedback and incentive mechanisms. Over time, the PMSs are clearly changing, decreasing their emphasis on control to become more oriented to learning. Even though the performance measurement literature recognizes that there is certainly a relationship, more and more evident it becomes that performance measurement is a social phenomenon, in which individual and organizational behaviors are shaped by the values

and perceptions of people and by the communities to which they (Bititci et al., 2012; Pinheiro de Lima et al., 2009).

Research strategy

According to Tranfield *et al.* (2003) the literature review process is a key tool used to manage the diversity of knowledge for a specific academic inquiry. The objective of a systematic and structured literature review is to observe and understand the past trends and extant patterns/ themes in the research area, evaluate contributions and summarize knowledge, thereby identifying limitations, implications and potential directions of further research (Kamal and Irani, 2014). A systematic literature review requires an extensive review of papers following a list of specific steps to ensure that the most relevant information with regard to a specific topic is obtained in an unbiased manner. Eventually, this ensures the fidelity, completeness and rigorous nature of the review (Choong, 2014).

Bibliometric studies were used in the present work as techniques for supporting SLR strategy. The bibliometric analysis is a statistical method for counting references to evaluate the trends and behavior of scientific production developed in a specific field (Treinta *et al*. 2014).

Systematic literature review

The systematic literature review was conducted to find all relevant papers about supply chain performance measurement and management and to identify the factors that influence supply chain performance. Table 1 presents the protocol, which was used in this research.

In order to comprehensively cover the literature in the search for articles, a range of keywords was considered: Group 1 refers to the search terms for supply chain, Group 2 refers to the search terms for performance measurement and Group 3 aims at searching for propositions oriented to practice – i.e. to find references about models and performance measurement practices in the supply chain literature.

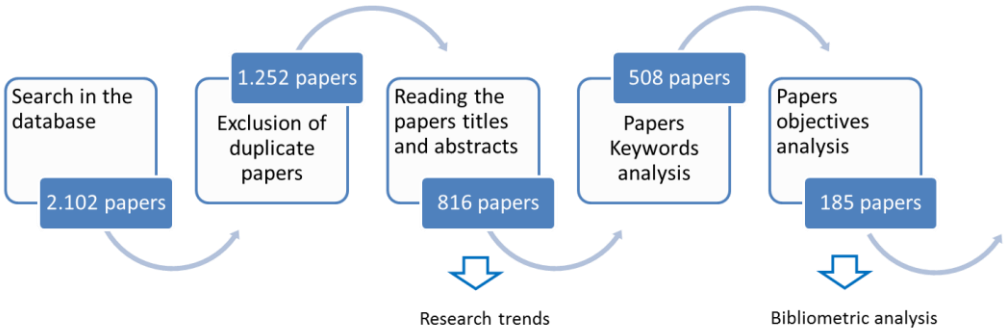
Table 1 - Literature review protocol

Keywords	Group 1 - Supply Chain; SCOR; Operations Network; Supplier; Collaboration Network; Extended enterprise; Inter-organizational Group 2 - Performance; Indicator; Metric; Measure; KPI; Performance Measurement; Performance Management

	Group 3 - Model; Framework; Process; Method; Technique; Tool; System
Boolean Operator	Title: OR between keywords; AND between groups 1 and 2 Abstract: Performance it is mandatory; OR between keywords; AND between groups Keywords: OR between keywords of groups 1 and 2.
Databases	Web of science, Scopus, Science Direct, Emerald, Taylor & Francis and Wiley
Exclusion criteria	NOT humanitarian chains NOT services
Language	English; Portuguese
Publication Type	Articles

In total 1252 papers were identified in the six scientific bases. All papers abstracts were reviewed in order to exclude works not pertinent to the research and to identify the main methodology, authors, years, journals and keywords of each paper. Repeated papers among the databases were also excluded, resulting in a dataset of 816 papers. Then, an analysis was conducted regarding the papers' keywords and goals in order to identify the ones related to performance measurement models in supply chain, which resulted in a set of 185 papers. The next step was to perform a bibliometric analysis within the filtered set of papers in order to understand the evolution of the theme under various perspectives. Figure 1 presents the whole procedure for the selection of papers.

Figure 1 - Selection paper process



Research trends

This section presents the research trends identified as the result of the systematic

literature review. During the reading of the papers' abstracts, they were classified according to its central theme. On that account, the research works included in the dataset of 816 papers can be classified in five main groups, as shown in the next sections.

The last research trend is the group that addresses the core scope of the present research work. This particular perspective will be thoroughly examined and scrutinized by means of the bibliometric analysis of the 185 papers filtered from the systematic literature review.

Supply chain integration and collaboration

Supply chain integration (SCI) has been a highly researched topic during the last 20 years. The purpose of Armistead and Mapes (1993) article is to identify the extent to which greater integration along the supply chain leads to improved operating performance. Trkman and Groznik (2006) show how the SC performance can be improved with the integration of various tiers in the chain. Their work deals with business renovation, effective utilization of information technology and the role of business process modeling in SC integration projects.

Lee *et al.* (2007) developed multivariate regression models in order to identify the characteristics of linkages determinants in the supply chain stakeholders (suppliers, internal stakeholders and customers). The purpose of their research is to present the relationship between supply chain linkages and supply chain performance.

According to Fabbe-Costes and Jahre (2008) more SCI does not always improve performance. Definitions and measures of SCI and performance are diverse to the extent that a conclusion such as “the more (SCI) the better (the performance)” cannot be drawn. Zhao *et al.* (2015), for instance, argue that supply chain integration may impair financial performance under certain conditions.

Danese and Romano (2011) analyze the impact of customer integration on efficiency, and the moderating role of supplier integration. They found that supplier integration positively moderates the relationship between customer integration and efficiency, whereas the analyses do not support the hypothesis that in general customer integration positively impacts on efficiency and when supplier integration is at a low level, customer integration can even produce a reduction in efficiency.

According to Gimenez *et al.* (2012) the SCI increases performance if supply complexity is high, while a very limited or no influence of supply chain integration can be detected in case of low supply complexity, and in high supply complexity

environments the use of structured communication means to achieve supply chain integration has a negative effect on cost performance.

Leuschner Rudolf *et al.* (2013) use a meta-analytic approach to provide a quantitative review of the empirical literature in SCI, and examine relevant design and contextual factors.

Didonet *et al.* (2014) verify the alignment between market orientation and supply chain integration practices for improving performance in small and medium-sized enterprises (SMEs). The findings suggest that the generation of information in market oriented SMEs favors their sharing information both inter-and intra-organizational.

IT and information sharing in supply chains

The influence of information technology (IT) and information and knowledge sharing in the performance of the SC is also targeted by investigators. Jayaram and Vickery (2000) found that the three dimensions of information system infrastructure (ISI) - design-manufacturing integration, manufacturing technology, and information technology - directly influenced at least one dimension of time-based performance (lead time, new product development time, customer responsiveness). The findings strongly support the idea of joint deployment of information system infrastructure and process improvement to streamline cycle time performance in a SC.

Byrd and Davidson (2003) examined the impact of IT on the SC through a survey of 225 large profit-making US firms. Specifically, it involved the determination of IT antecedents to IT impact on the supply chain and the effect that these relationships had on overall firm performance. Fawcett *et al*. (2007) carried out a large-scale survey and semi-structured interviews to understand how IT is used to enhance supply chain performance. They identified and analyzed two distinct dimensions to IT - connectivity and willingness. Both dimensions are found to impact operational performance and to be critical to the development of a real information sharing capability.

The purpose of Collins *et al*. (2010) paper is to provide a conceptual overview of the relationship between knowledge management, supply chain technology investments, and overall firm performance.

Baihaqi and Sohal (2012) conceptualized and assessed several factors that influence the degree of information sharing in SC, namely integrated information technologies, internal integration, information quality and costs–benefits sharing and then they tested the relationship between the degree of information sharing and organizational

performance. According to Tyagi *et al.* (2014) IT is the most important concern for the existence of a company in the competitive market. A model based on analytic hierarchy process (AHP) is proposed to evaluate the alternatives – namely top management support, IT advancement and supply chain integration – on the behalf of performance improvement in IT-enabled SC.

Supply chain management practices

In recent years, numerous approaches have been proposed to improve operations performance. Three in particular – Just in Time (JIT), SCM, and Total Quality Management (TQM), have received considerable attention. While the three are sometimes viewed and implemented as if it was independent and distinct, they can also be used as three prongs of an integrated operations strategy. Kannan and Tan (2005) examine the extent to which JIT, SCM and TQM are correlated, and how they impact business performance. Results demonstrate that at both strategic and operational levels, linkages exist between how JIT, TQM and SCM are viewed by organizations as part of their operations strategy. Hsu *et al*. (2009) use mediated regression analysis and structural equation modelling to test the proposition that supply chain management practices (SCMP) mediate the relationship between operations capability and firm performance. They define operations capability in terms of a firm's new product design and development, TQM and JIT capabilities.

Li *et al*. (2006) conceptualize five dimensions of SCM practice (strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement) and tests the relationships between SCM practices, competitive advantage, and organizational performance. The results indicate that higher levels of SCM practice can lead to enhanced competitive advantage and improved organizational performance. Peng Wong *et al*. (2011) investigate how SCM practices and knowledge management capabilities affect firm performance.

Chavez *et al*. (2012) examine the effect of industry clock speed on the relationship between SCM practices, from both upstream and downstream sides of the SC, and SCM performance. Gawankar *et al.* (2013) collected the data through questionnaire survey from 157 operations and supply chain heads from leading retail stores in India with the aim to design a scale with a high degree of reliability, validity and dimensionality which helps to determine appropriate supply chain practices and their interrelations.

In their paper Okongwu *et al.* (2015) purpose to empirically investigate, from a balanced scorecard strategy map perspective, the types of linkages through which SCMP impact on financial and non-financial performance, and consequently lead to the achievement of the firm's strategic objectives.

Green supply chain

The first work related to green supply chain in this review is the study of Green *et al.* (1998) that discusses the following issues: how does green purchasing change the environmental performance of the firms in a supply chain and what is the influence of SC and industry structure on that performance? Do such changes contribute to companies' overall environmental performance and to sustainability?

Hervani *et al.* (2005) introduce and provide an overview of the various issues related to environmental SC performance measurement. As a result, they provide an integrative framework for the study, design and evaluation of green supply chain management (GSCM) performance tools.

According to Vachon and Klassen (2008) the literature characterizing environmental management within the SC has been slowly building, but remains sparse. Using a survey of North American manufacturers, their work examines the impact of environmental collaborative activities on manufacturing performance.

Shaw *et al.* (2010) review extant literature and present a proposed research agenda to examine whether green performance measures can be integrated within an existing supply chain performance framework, also to explore what a meaningful industry-recognized environmental measure should look like, and to understand the direct benefits of incorporating environmental measures within a SC performance framework.

Olugu *et al.* (2011) reviewed various literatures on green supply chain performance measurement, environmental management, traditional supply chain performance measurement and automobile SCM. In order to comprehensively and effectively establish the relevant measures, a suitable framework which considered the automobile green supply chain as a two-in-one chain was adopted. The study of Ahi and Searcy (2014) identified and analyzed the metrics that have been published in the literature on GSCM and sustainable supply chain management. In a subsequent research effort, Ahi and Searcy (2015) focused on metrics used in the literature to measure social issues.

In the Uysal (2012) work the Decision-Making Trial and Evaluation Laboratory

(DEMATEL) method was applied to deal with the importance and causal relationships between the sustainable performances measurements criteria by considering the interrelationships among them and the proposed frameworks are tested using data obtained from three different manufacturing companies that take place on the same supply chain.

Bhattacharya *et al*. (2014) delineated a green supply chain performance measurement framework using an intra-organizational collaborative decision-making approach. Chin *et al.* (2015) reviewed the extant literature on the relationship between GSCM, environmental collaboration and sustainability performance and proposed a conceptual model to elucidate the relationship between these three variables in the context of Malaysian manufacturing companies.

Lean and agile supply chain

In a context of increasing competition with ever-demanding customers and ever-shorter product life cycles, SCM needs right direction for a better performance. According to Soni and Kodali (2009), a "Leagile" Supply Chain (LASC) – which refers to a taxonomy for a combination of lean and agile supply chain management – provides a competitive advantage over other models/strategies of supply chain. These authors develop a multi-attribute decision model named as Performance Value Analysis (PVA) to justify the LASC, and the usefulness of the proposed PVA is demonstrated though a case study.

Khan K. and Pillania (2008) explore the dimensions of strategic sourcing and determine its relationship with supply chain agility and organizational performance. In regard to the adoption of lean practices across the supply chain, Agus and Shukri Hajinoor (2012) develop a research effort to look for a better understanding of the extent to which lean production permeates manufacturing companies in Malaysia, by drawing on SCM managers' or production managers' perception of lean production practices and level. Sezen *et al.* (2012) develop a model for measuring adherence to lean practices for automotive part suppliers and to assess the relationship between the firm performance and the adoption of lean principles.

Sukwadi *et al.* (2013) explore how lean–agile operations and supplier–firm partnership can improve garment small and medium enterprise (SME) supply chain performance. The results show that agile supply chain and partnership strategy are critical for garment SMEs because these strategies influence their supply chain performance.

However, the leanness strategy does not necessarily influence their supply chain performance. The supply chain performance and partnership strategy have a positive influence on the SME performance.

Among the available strategies lean, green and resilient are considered as new management strategies for the SCM to achieve competitiveness. Cruz-Machado *et al*. (2015) aim to identify the critical lean, green and resilient practices on which top management should focus in order to improve the performance of automotive supply chains. Arif-uz-Zaman and Nazmul Ahsan (2014) present supply chain metrics and propose a fuzzy-based performance evaluation method for lean supply chain.

Supply chain performance measurement and management

Measuring performance in the supply chain is crucial to identify whether an organization is on 'target' with regard to achieving supply chain objectives. Gunasekaran *et al.* (2004) develop a framework for supply chain performance measurement and provide a detailed 'measurement and metrics classification' and use a survey aiming at assessing importance within each metric group. Bititci *et al.* (2005) found that due to structural differences between traditional and extended enterprises, the systems required to measure and manage the performance of extended enterprises, whilst being based upon existing performance measurement frameworks, would be structurally and operationally different. Based on this, they propose a model for measuring and managing performance in extended enterprises which includes intrinsic and extrinsic inter-enterprise coordinating measures.

Camarinha-Matos and Abreu (2007) introduced an approach for the analysis of benefits in collaborative processes for networks of enterprises. Chae (2009) recognized that developing key performance indicators (KPIs), or metrics, is very challenging and a set of practical guidelines is not readily available for companies and SCM practitioners. His paper offers a practical approach to performance measurement and present a list of essential KPIs.

In order to understand the interactions between SCM practices and firm performance, OU *et al*. (2010) considered four internal contextual factors, namely: human resource management, quality data and reporting, design management, and process management. Three levels of firm performance are also examined, including internal operational performance, external customer satisfaction, and firm financial performance.

Akyuz and Erkan (2010) reviewed 24 articles from 1999 to 2009, and concluded

that the frameworks and models of supply chain performance measurement were still immature. Anvari *et al*. (2011) discuss the relationship between performance measurement systems in SCM and lean manufacturing. Frederico and Martins (2014) identify eleven PMSs for SCM, two maturity models for PMS and six dimensions which drives the maturity of PMS. Also, it was possible to verify that the PMS for SCM focus only on the measurement scope, which is only one dimension to manage the maturity of the PMS. Moreira and Tjahjono (2016) develop a conceptual framework that adopts performance measures for ex-ante decision-making at an operational level within the supply chain and carried out a case study at a major global brand beverage company.

Supply chain performance measures and metrics

Lambert and Pohlen (2001) provide a framework for developing supply chain metrics that translates performance into shareholder value. The framework focuses on managing the interfacing of customer relationship management and supplier relationship management processes at each link in the supply chain.

Chan (2003) present the formulisation of both quantitative and qualitative performance measurements for easy representation and understanding. Apart from the common criteria such as cost and quality, five other performance measurements are defined: resource utilisation; flexibility; visibility; trust; and innovativeness. In particular, new definitions are developed for visibility, trust, and innovativeness.

Angerhofer and Angelides (2006) show how the constituents, key parameters and performance indicators are modelled into the environment and through a case study illustrate how the decision support environment may be used to improve the performance of a collaborative supply chain by pinpointing areas for improvement.

Cai *et al.* (2009) propose a framework using a systematic approach to improving the iterative KPIs accomplishment in a supply chain context and quantitatively analyzes the interdependent relationships among a set of KPIs.

Akyuz and Erkan (2010) present some characteristics and requirements that the new era performance measurement metrics should have. Lin and Li (2010) propose an integrated framework for SC performance measurement that adopts the six-sigma metrics and includes three components (i.e., team structure measurement, supply chain process measurement, and output measurement) to provide a more complete coverage of performance requisites, which had not been adequately addressed in relevant literatures before.

According to Bai and Sarkis (2012) formal modelling tools and approaches for organisations to help evaluate the relationships between the performance measures and the desired competitive outcomes are limited, especially in logistics and SCM functions. To help address this gap, they introduce a novel application of neighbourhood rough-set theory for the identification and selection of performance measures related to externally derived desired outcomes on the sourcing function.

Anand and Grover (2015) identify key indicators for performance measurement for retail industry and classified them into four major categories: transport optimization, information technology optimization, inventory optimization and resource optimization, while Piotrowicz and Cuthbertson (2015) explore the approaches and metrics used to measure SC performance and to understand the relative perceived importance of such measures.

The use of balanced scorecard approach

The Balanced Scorecard (BSC) approach was proposed by Kaplan and Norton (1992) as a framework and process for performance assessment and it was designed to complement traditional measures maintaining a balance between short-term and long-term objectives, financial and non-financial measures, lagging and leading indicators, and internal and external performance perspectives.

Folan and Browne (2005) discuss the development of a performance measurement system specifically designed for the requirements of the extended enterprise, via two performance measurement frameworks: the structural extended enterprise BSC and the procedural framework for the selection and implementation of measures.

Bhagwat and Sharma (2007) propose the use of the AHP methodology as aid in making SCM evaluation decisions that can help firms to prioritize and formulate viable performance measurement strategies in the volatile and complex global decision environment from different BSC perspectives.

Bhagwat and Sharma (2007 b) suggest that a balanced SCM scorecard can be the foundation for a strategic SCM system provided that certain development guidelines are properly followed, appropriate metrics are evaluated, and key implementation obstacles are overcome.

According to Shafiee *et al.* (2014), vast studies have been recorded on supply chain efficiency evaluation via BSC approach, but these studies do not focus on the relationships between the four perspectives of BSC. Then, after reviewing different tools

to evaluate the performance of supply chain, a new approach, relying on network data envelopment analysis (DEA) with BSC approach, was generated focusing on these relationships, especially the returnable ones.

SCOR model

The Supply Chain Operations Reference (SCOR) model is a framework for examining the supply chain in detail through defining and categorizing the processes that make up the chain, assigning metrics to these processes and reviewing comparable benchmarks (AGAMI *et al*., 2012).

Lockamy III and McCormack (2004) investigate the relationship between SCM planning practices and supply chain performance based on the four decision areas provided in SCOR Model Version 4.0 and nine key SCM planning practices derived from SCM experts and practitioners. The results show that planning processes are important in all SCOR supply chain planning decision areas.

Based on the survey data from 232 companies that have obtained ISO 9000 certification, Li *et al.* (2011) studied the five decision areas of the SCOR model by integrating quality assurance measures in the supply chain process. Thunberg and Persson (2013) evaluated construction material supplier and construction site performance according to the SCOR model. Sellitto *et al*. (2015) present a SCOR-based model for performance measurement in supply chains and apply it in the context of Brazilian footwear industry. The model has two dimensions: SCOR processes (source, make, deliver and return) and performance standards adapted from original SCOR (cost, quality, delivery and flexibility).

Multi criteria model to evaluate supply chain performance

An innovative performance measurement method was proposed by Chan *et al.* (2003) to provide necessary assistance for performance improvement in SCM. The proposed method addresses this purpose in four aspects: a simplified supply chain model; tangible and intangible performance measures in multiple dimensions; a cross-organizational performance measurement; and fuzzy set theory and weighted average method.

Wong and Wong (2007) illustrated the use of DEA in measuring internal supply chain performance. Two DEA models were developed – the technical efficiency model and the cost efficiency model. The information obtained from the DEA models helps managers to identify the inefficient operations and take the right remedial actions for

continuous improvement.

A mathematical model is proposed by Bac and Erkan (2011) to evaluate supply chain performance using some KPIs. This model can be used to evaluate the flexibility characteristics of logistic, market, supplier, machine, labor, information system, and routing of the SC. Chen and Yan (2011) constructed an alternative network DEA model that embodies the internal structure for SC performance evaluation. Three different network DEA models are introduced under the concept of centralized, decentralized and mixed organization mechanisms, respectively.

A conceptual model for measuring SC performance which can be used for most organizations with the same class at various industries is proposed by Najmi and Makui (2012). The model has been developed according to performance metrics interdependencies and some existing shortcomings in the available literature of performance models. The methodology which was used for solving and integrating the model is a combination of the AHP and DEMATEL methods.

Arif-Uz-Zaman and Nazmul Ahsan (2014) present SC metrics and propose a fuzzy-based performance evaluation method for lean supply chain and Chithambaranathan *et al.* (2015) develop a conceptual model for the task of analyzing the performance of members of supply chains.

Bibliometric analysis

This section presents the bibliometric analysis with 185 papers related to performance measurement models in supply chains in order to identify the theme evolution. Table 2 presents the main themes and the number of publications related to each theme.

Table 2 - Publications by theme

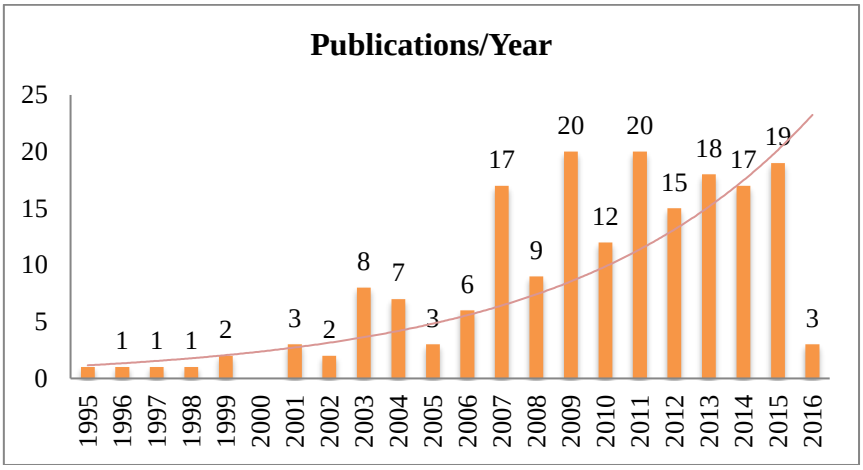
Subject	Publications
SC performance measurement and management	72
SC performance measures and metrics	39
Balanced Scorecard approach	18
SCOR model	15
Multi criteria model to evaluate supply chain performance	40

Publications over time

The first analysis is related to publications distribution over the years. Research on performance measurement in the SC have begun in the 90s, but more than 80% of the

papers were published during the last ten years of which 35% of the publications were carried out in the last three years. Figure 2 exhibits the publications evolution over the years.

Figure 2 - Amount of publications per year



The fast growth of research in this particular field may be justified not only by the strengthening of academic communities in general, but also by the increasing importance given to the supply chains management leading to the need of developing ways to measure and manage performance of companies working together.

It is possible to verify that the performance measurement development field experienced different phases over time. In the 50s, a focus on efficiency; then a focus on financial indicators until the 70s; from the 80s emerged a concern with measuring and balancing new dimensions; by the time the SCM field arose, in the 90s, the performance measurement field was changing its focus from measuring to managing performance, and then began the need for researching supply chain performance measurement and management. On that account, it is not surprising that the bulk of studies in this particular field has begun to take place after 2003, with faster growth in recent years.

Journals

The 185 identified papers were published in 91 different journals. The ten most expressive journals, listed in the Table 3, represent 41% of all publications.

Table 3 – Papers distribution by journals

Journal	JCR	SJR	Publications
Benchmarking: An International Journal	-	Q1	11
International Journal of Operations and Production Management	1,736	Q1	10
International Journal of Productivity and Performance Management	-	Q1	10
International Journal of Production Economics	2,752	Q1	10
Supply Chain Management: An International Journal	3,500	Q3	8
International Journal of Production Research	1,477	Q1	8
Production Planning and Control	1,466	Q1	7
International Journal of Supply Chain Management	-	Q3	4
International Journal of Business Performance Management	0,204	Q3	4
International Journal of Logistics Systems and Management	-	Q3	4

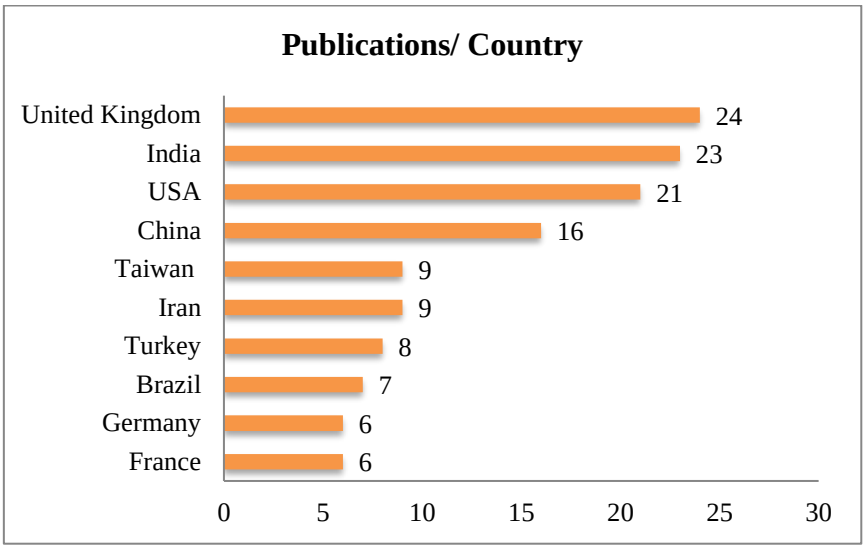
According to the databases, the subject area of the publications varies widely. The fields that seem to be more interested in supply chain performance measurement and management are Business, Management and Accounting; Engineering; Decision Sciences; Computer Science; Economics, Econometrics and Finance; Social Sciences and Environmental Science.

Important journals of the Performance Measurement field stand out with a representative number of articles, such as *International Journal of Operations and Production Management*, *International Journal of Productivity and Performance Management* and *International Journal of Production Economics.* Also, one can note that sustainability issues are already being explored in the performance measurement field, as Bititci *et al.* (2012) point out in their literature review.

Publishing countries

The analyzed publications are from 39 different countries. The ten most representative countries are shown in Figure 3.

Figure 3 - Amount of papers per country



There is certainly a growth of publications from the emerging Asian countries, which seems to be an effect of a natural trend in recent years in the overall context of global economics and education. The rates of investment in science, technology and education in countries such as China and India has significantly increased over the last decades (LOWREY, 2014).

In this panorama, the first publication from China was in 2002, and Chan F.T.S is the author with more participation in publications, with 8 publications from 2002 to 2006. The most representative article is "Performance Measurement in the Supply Chain" from Chan (2003) with 217 citations. As to India, the first publication within the dataset is from 2004. The most representative authors of this country are listed in Table 7, and the most cited article is "Performance measurement of supply chain management: The Balanced Scorecard approach" from Bhagwat and Sharma (2007a) with 216 citations.

Brazil also appears among the countries with more publications in this field, although the amount of publications can still be considered small. The papers from Brazil are related to the use of performance measurement systems in supply chains, especially the BSC approach and the SCOR model.

Leading authors

Were considered for this analysis all authors of each identified paper, not just the corresponding author. As a result, 396 different authors are listed, of which 91% are present in only one paper. Table 4 shows information about five researchers who authored four or more papers, and their correspondent h-index.

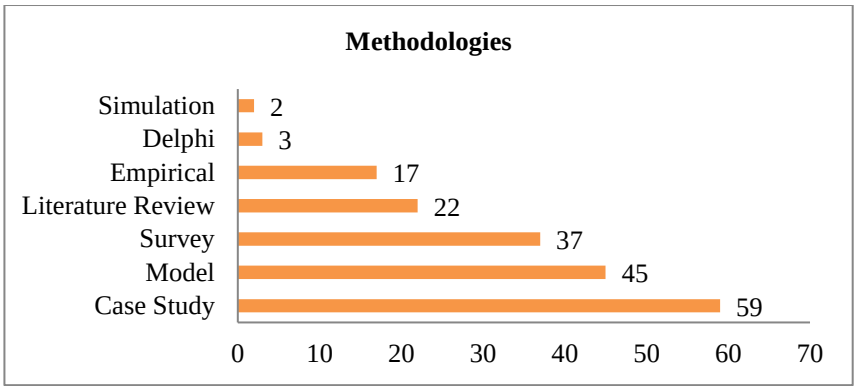
Table 4 - Leading authors

Authors	Papers	University/Department	Country	h-index
Chan, F. T.S.	8	Hong Kong Polytechnic University, Department of Industrial and Systems Engineering	China	42
Qi, H. J.	5	The George W. Woodruff School of Mechanical Engineering	US	21
Bhagwat, R.	4	Jai Narain Vyas University, Department of Mechanical Engineering	India	14
Gunasekaran, A.	4	University of Massachusetts Dartmouth, Decision and Information Sciences	US	44
Sharma, M. K.	4	Jai Narain Vyas University, Department of Production and Industrial Engineering	India	12

Methodologies

All papers on the dataset were classified by its most important methodological approach, based on the authors' description of their works. The following Figure 4 presents the amount of papers identified for each of these categories.

Figure 4 - Methodological approach

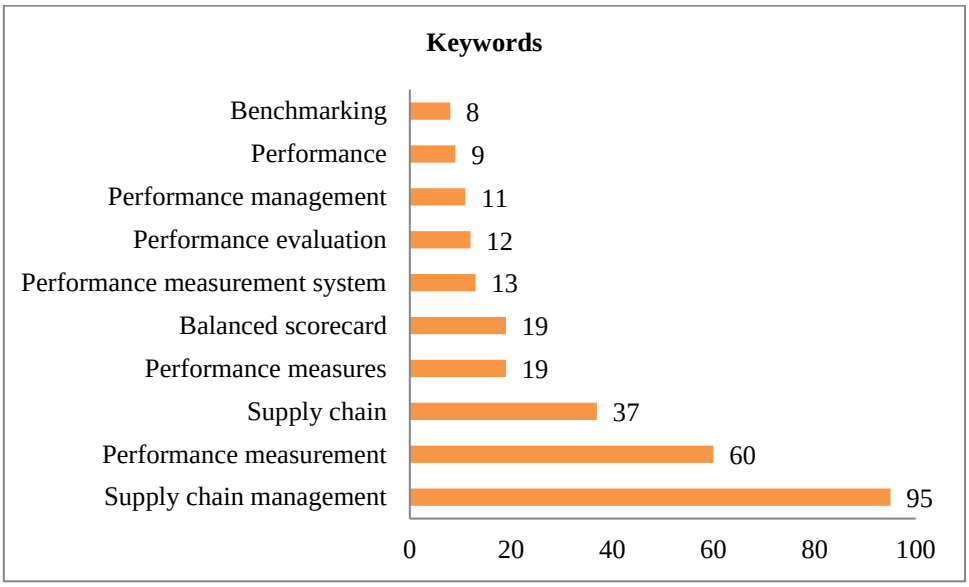


It is notable that the authors are concerned with carrying out practical investigations in case studies, from which we can infer that there is a variety of models/systems/frameworks being implemented and tested in the real SC context. The development of models also stands out in this bibliometric analysis, which comprises use of both quantitative and quantitative methods. The use of survey is also highlighted and gives a clue on the concern with conducting studies in broader samples of data collection.

Keywords

The most recurring keywords used for represent the studies in supply chain performance management were identified. Figure 5 lists the amount of papers studied that used the ten most expressive.

Figure 5 - Principal keywords



Interestingly, among the most frequent keywords in papers, only the words "benchmarking" and "performance evaluation" were not applied in the search string. As to the other keywords found, they are either a word present in the groups described earlier in this document or a word that represents an intersection between the groups. The latter is the case of "supply chain management", for instance, which is an intersection between words from groups 1 and 2, and also "performance measurement system", which is an intersection between words from groups 2 and 3.

By observing the ten most recurring keywords, one can infer that the academic community indeed considers performance measurement in supply chains as an important topic.

Conclusion

A systematic literature review was conducted so as to identify research trends in the supply chain performance field. The relevance of this research is grounded on two main aspects. First, the identification of factors that influence the performance of supply chains, along with the identification of models for measuring performance in supply chains. This is achieved through literature review. Second, the use of systematic literature review to summarize the findings of the supply chain performance measurement area.

The contribution to the theoretical field is in terms of mapping and reviewing the field of supply chain performance measurement, as well as in terms of creating conditions for academics to identify future research opportunities.

Amongst the main limitations of the research approach, stand out the fact that the study is limited to the selected scientific databases, document type, language and search strings. Thus, it is possible that some important papers have not been selected for the study. However, although these non-selected articles may be pertinent to the field, it can be argued that it is not likely that such articles would significantly change the results of the study, because of the robustness provided by the systematic literature review and the content analysis approaches.

As future work, we propose an in-depth content analysis to complete the content analysis to identify the literature recommendations and propose the supply chain performance measurement meta-model.

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APPENDIX F - SUBMITTED ARTICLE INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS 2017

Developing a model for supply chain performance measurement based on operations strategy

Abstract

Inadequate supply chain performance measurement systems are still amongst the major barriers to successful supply chain collaboration. This article aims to review supply chain performance literature and propose a model for a supply chain performance measurement. The research design strategy is based on the application of bibliographic procedures for the model construction. A systematic literature review is carried out in order to map the research trends in the supply chain field and to propose a consolidated model, the content analysis of each article will be conducted by a procedure of critically reading and scrutinizing the article, identifying relevant information to compose a model. A supply chains performance measurement model based on BSC, SCOR model, and operations strategy is proposed. Research relevance is founded on two main aspects, the first is related to identify the factors that influence the supply chains performance and the important elements for supply chain performance measurement, and the second aspect is the use of systematic literature review to propose a model for supply chain performance measurement.

Keywords: Supply chain management, Supply chain performance measurement systems, Systematic literature review.

Article classification: Research paper.

1. Introduction

In order to survive under the modern business environments pressures, the advancements in information technology, globalization of markets, decentralized operations, and increased consciousness towards environmental concerns, more and more enterprises are striving to develop long-term strategic partnerships with a few competent supply chain partners and have the need to rethink their productivity and quality strategies and techniques, including the overall operations management (OM) approach. (Chan and Qi, 2003; Chithambaranathan et al., 2015; Maestrini et al., 2017).

According to Sharma and Bhagwat (2007) the analysis of supply chain performance can provide an important feedback for better integration among the supply chain members and, especially, for better decision-making in supply chain management, particularly to monitor implementation, review progress, enhance communication and diagnose problems, redesigning business goals and strategies, and in re-engineering processes.

The field of performance measurement in a supply chain context is maturing. However, many critical drawbacks prevent the existing performance analysis methods from making a significant contribution to the development and improvement of supply chains. Lack of valid measurement criteria and inadequate methodologies to aggregate different performance measures into a single index is one of the limitations. None of the current strategic models and frameworks for performance measurement, such as balanced scorecard, performance prism, IPMS, smart pyramid etc., consider performance measurement and management from an extended enterprise perspective. Inter-enterprise coordinating (or partnership) measures are essential to ensure that various partners within an extended enterprise coordinate effectively and efficiently to ensure that the performance of the extended enterprise is maximized. Some works specify a range of performance measures, which should be used in managing supply chains but fail to integrate these within a strategic performance measurement framework (Bititci et al., 2005; Chalyvidis et al., 2013; Shafiee et al., 2014; Shepherd and Günter, 2006)

Although the study of supply chain performance measurement was enriched by different researchers and findings, some gaps still exist (Gunasekaran et al., 2004; Najmi and Makui, 2012; Shafiee et al., 2014). While there are many ongoing research efforts on various aspects and areas of SCM, so far little attention has been given to the performance evaluation, and hence, to the measures and metrics of supply chains (Gunasekaran et al., 2001). According to Bai and Sarkis (2012), the barriers to effective PMS can derive from too many and poorly fitting performance measures. According to (Neely) 1998, one of the main problems with PMSs is that often there are too many data. This excess of data may make the PMS less effective (Gunasekaran et al., 2004; Najmi and Makui, 2012).

Some of the major drawbacks with the existing methods are: inability to capture holistic aspects; lack of suitability to the different levels of measurement; lack of a clear distinction between metrics at strategic, tactical, and operational levels; lack of a balanced approach; Focus on cost to the detriment of non-cost indicators; complexity in methods; requirement of intricate details; lack of connection with the strategy; insufficient focus on

customer and competitors; loss of supply chain context, thus encouraging local optimization; failure to provide adequate information on what competitors are doing through benchmarking; and inadequacy to capture vagueness in human judgement. These obstacles characterize the need for a suitable framework which can take into account the commonalities of practical supply chains when analyzing performance (Beamon, 1999; Chan et al., 2003; Chan and Qi, 2003; Chithambaranathan et al., 2015; De Toni and Tonchia, 2001; Gunasekaran et al., 2004, 2001; Humphreys et al., 2003; Maskell, 1991; Najmi and Makui, 2012; Piotrowicz and Cuthbertson, 2015; Shafiee et al., 2014; Shepherd and Günter, 2006)

In order to bridge this gap, this research project derives and organizes from the literature a set of indicators and propose a model for a supply chain performance measurement. The purpose of this research is to (i) review supply chain performance measurement literature and (ii) propose a model for a supply chain performance measurement.

The research design strategy is based on the application of bibliographic procedures for the model construction. A systematic literature review is carried out in order to map the research trends in the supply chain field and to propose a consolidated model, the content analysis technique will be applied. According to Tranfield *et al.* (2003), a literature review process is a key tool used to manage the diversity of knowledge for a specific academic inquiry. The literature review is a process which is conducted to provide a map of the body of knowledge in a specific field (Tranfield et al., 2003). According to Bardin (2011), "the content analysis is a set of methodological instruments constantly improving, which apply to extremely diverse discourses". For this reason, the content analysis appears as a set of communication analysis techniques that make use of systematic and objective procedures for the description of messages' content (Bardin, 2011). The content analysis of each article will be conducted by a procedure of critically reading and scrutinizing the article, identifying relevant information to compose a model.

2. Systematic Literature Review

A method adapted from Tranfield *et al.* (2003) was applied to produce a robust and comprehensive knowledge base in supply chain performance measurement. The systematic literature review was conducted to find all relevant papers about supply chain performance measurement and management and to identify the factors that influence supply chain performance.

In order to comprehensively cover the literature in the search for articles, a range of keywords was considered: Group 1 refers to the search terms for supply chain (Supply Chain; SCOR; Operations Network; Supplier; Collaboration Network; Extended enterprise; Inter-organizational), Group 2 refers to the search terms for performance measurement (Performance; Indicator; Metric; Measure; KPI; Performance Measurement; Performance Management) and Group 3 aims at searching for propositions oriented to practice – i.e. to find references about models and performance measurement practices in the supply chain literature (Model; Framework; Process; Method; Technique; Tool; System). Both groups 1 and 2 were considered mandatory in the articles' title and abstract, that is, both the title and the abstract would have to have one of the terms from Group 1 and one from Group 2. The term 'performance' was applied as mandatory in the articles' abstract and one of the terms from Group 3 should also be included in the abstract. At least one of the search terms from Group 1 or Group 2 should be present in the keywords. Papers addressing humanitarian chains or services were excluded from the sample.

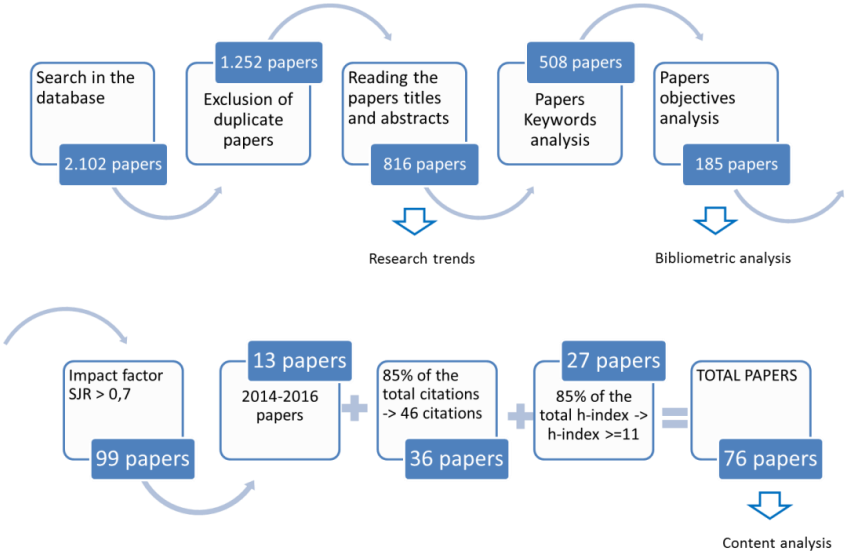
The search for the articles considered six different databases that contain important journals in the field of the supply chain - Web of science, Scopus, Science Direct, Emerald, Taylor & Francis, and Wiley. The search for articles was carried out between December 2015 and January 2016. In total 1252 papers were identified in the six scientific bases. All papers abstracts were reviewed in order to exclude works not pertinent to the research and to identify the main methodology, authors, years, journals and keywords of each paper. Repeated papers among the databases were also excluded, resulting in a dataset of 816 papers.

During the reading of the papers' abstracts, they were classified according to its central theme. On that account, the research works included in the dataset of 816 papers can be classified in five main groups, according to their common themes: i) Supply chain integration and collaboration; ii) IT and information sharing in supply chains; iii) Supply chain management practices; iv) Green supply chain; and v) Supply chain performance measurement and management. The discussion on these common subjects addressed in the supply chain literature provides an overall comprehension upon the context in which the present research work is positioned, especially to the extent that these themes involve issues and aspects that impact on supply chain performance.

The last research trend, which is related to strategic performance measurement systems, is the group that addresses the core scope of the present research work. This

particular perspective was thoroughly examined and scrutinized by means of the bibliometric analysis of the 185 papers filtered from the systematic literature review and in the content analysis upon the final selected dataset of 76 papers, as it is presented later in this document. Then, an analysis was conducted regarding the papers' keywords and goals in order to identify the ones related to performance measurement models in the supply chain, which resulted in a set of 185 papers. The next step was to perform a bibliometric analysis within the filtered set of papers in order to understand the evolution of the theme from various perspectives. Figure 1 presents the whole procedure for the selection of papers.

Figure 1 - Selection paper process



Source: the author, 2017.

The last filtering procedure considered four layers: publication impact factor, publication year, recurrence of citations and the authors' h-index factor. First, all papers published in journals with impact factors (SJR) greater than 0.7 were selected, resulting in a sample of 99 papers. Then, the three other layers were applied, but now with an inclusive function, that is, to include the papers in the final dataset, rather than to exclude. All of the most recent publications were selected – a set of 13 papers from 2014 to 2016. Another set of 36 papers representing 85% of the total of citations was selected to be included in the final data set. Finally, a set of 27 papers representing 85% of the total of authors h-index was also included. The sum of the 13 recent papers, the 36 often cited and the other 27 papers with high h-index resulted in a final data set of 76 papers to base the content analysis to be carried out, i.e., the content analysis considers these 76 papers.

3. Supply chain performance measurement models and characteristics

In this section, the most important supply chain performance measurement characteristics and models identified in the content analysis are mentioned.

In the 1990s the identification of performance measurement systems was a key concern, having as its main objective the planning of measurement systems whose dimensions would be broadly aligned with the corporate strategy (Neely et al., 1995). There have been a wide variety of measurement systems mainly oriented to a measurement of autonomous entities (companies, subsidiaries, business units, etc.) and these models did not take into account the complexity of value-creating company chains (Estampe et al., 2013). In the 2000s was defined a number of measurement models that helped to analyze supply chains in terms of some of their components (collaboration, human resource management, sustainability, etc.) (Beamon, 1999; Estampe et al., 2013; Gunasekaran et al., 2004, 2001). Estampe *et al.* (2013) summarized the 16 best-known models of supply chain performance measurement and their particularities.

The operations strategy literature suggests that a supplier's operational competences can enhance the value of its products on the following dimensions: quality, cost, delivery, flexibility, and new product development (Kaplan, 1984; Kim and Wemmerlöv, 2015; Skinner, 1969; Slack and Lewis, 2015).

In 1999, Beamon (1999) identified three types of performance measure as vital components for the supply chain performance measurement system including resource, output and flexibility. The author also mentioned that the result of each one affects the others and supply chain performance measurement system must contain at least one individual measure from each of the identified types (Beamon, 1999; Frederico and Martins, 2014; Gunasekaran et al., 2004). She divided performance measures into two groups, quantitative and qualitative, to discuss customer satisfaction and responsiveness, flexibility, supplier performance, cost and other elements of supply chain efficiency modeling. Extending these measures leads to providing a new framework for supply chain evaluation that measures the strategic, tactical, and operational level of performance (Beamon, 1999; Bititci et al., 2005; Shafiee et al., 2014).

Gunasekaran, Patel and Tirtiroglu (2001) proposed a framework for determining the performance of supply chain according to the strategic, tactical and operational levels and along the five elements of an integrated supply chain: plan performance, source performance, production performance, deliver performance and customer satisfaction. This has been done so as to assign them where they can be best dealt with by the appropriate management level, and for fair decisions to be made (Gunasekaran et al.,

2004, 2001). This framework deals with supplier delivery, customer service, inventory and logistic cost. The metrics are also distinguished as financial and non-financial so that a suitable costing method based on activity analysis can be applied. In some cases, a metric is classified as both financial and non-financial. According to Gunasekaran, Patel and Tirtiroglu (2001), taken together, these three representations of metrics can give a clear picture of which metric should be used for the performance assessment study, where it can be used, and who will be responsible for that. Such a representation is a step closer to bridging the gap between the need for a model with which supply chain performance can be assessed, and the potential areas of improvement that can be identified.(Bititci et al., 2005; Gunasekaran et al., 2004, 2001; Shafiee et al., 2014).

In 2002, Hausman (2002) claimed that a supply chain needs to be evaluated by three criteria including service, asset and speed. He also emphasises that the metrics must be suitable for the value proposition of the SC (Najmi and Makui, 2012; Shafiee et al., 2014).

Apart from the common criteria such as cost and quality, Chan (2003) proposed five other performance measurements: resource utilisation - to measure the resource utilization, a company can directly investigate the percentage of surplus or deficit of that resource within a period. Resource utilization also shows the efficiency of that company, flexibility, visibility - for a supply chain is important for accurate and fast delivery of information. It is clear that measurement of visibility is the time and accuracy of information transfer, trust - it is the reliability and consistency between different levels of the supply chain and enhances the long-term relationship between them, and innovativeness. Of the seven attributes identified as important measures for the performance of the supply chain, two of them are direct quantitative measures (i.e. cost, and resource utilization), and the other five are qualitative (i.e. quality, flexibility, visibility, trust, and innovativeness) (Chan, 2003).

Agarwal, Shankar and Tiwari (2006) applied a framework in which the market sensitiveness, process integration, information driver and flexibility are used for determining the performance of the supply chain. They explored the relationship among lead-time, cost, quality and service level with the leanness and agility of an SC in the fast-moving consumer goods business. Lead- time, cost, quality and service level are the major determinants of the proposed framework. (Agarwal et al., 2006; Najmi and Makui, 2012; Shafiee et al., 2014).

A framework in which the reliability, responsiveness, flexibility, reconfigurability and cost criteria have been proposed by Xia *et al.* (2007) for measuring SC performance. They also used analytical hierarchy process (AHP) to link the company performance measures to SC strategy, and identify some important attributes and metrics in the SC.

Melnyk *et al*. (2010) suggest that supply chains operating in the current working environment should have the ability to provide one or more of the six basic outcomes depending on the customer/market requirements, which are cost, responsiveness, resilience, security, innovation and sustainability. Cost: Traditional supply chain outcome which combines criteria for a monetary cost along with delivery and quality measures. Responsiveness: Ability to respond quickly to volume, mix, and location demand changes. Security: Ability to protect product integrity and consistency while ensuring a supply chain's products will be otherwise safe. Sustainability: Environmental responsibility through a reduction in waste, pollution and carbon footprint and ensuring minimal resource impact. Resilience: Ability to identify and monitor supply chain risks and recover quickly and effectively from both external and internal disruptions. Innovation: Develop new products and services, or new ways to produce and deliver products (Melnyk et al., 2010).

Soni and Kodali (2010) argue that the categories of measurement proposed by Chopra and Meindl (2007), referred as "drivers" of supply chain performance, are found to be most suitable for comparing performance of various supply chains and pointing out the poorly performing functions, as the idea behind performance measurement is to assess all the levels of management from strategic level to operational level and spanning all the practices in a supply chain. These drivers of SCM are: facilities, transportation, information, inventory, sourcing, and pricing (Chopra and Meindl, 2007; Shafiee et al., 2014; Soni and Kodali, 2010).

Najmi and Makui (2012) too defend that the coordination between performance measures and metrics can be evaluated from two viewpoints. In the first view, levels of strategic, tactical and operational, are hierarchical based tasks in which the policies and trade-offs are distinctive and appropriate control is applicable (Ballou, 1992). The second view includes financial and non-financial metrics, that is the main difference between the new performance measurement models and traditional ones. According to the authors for performance measurement, measurement goals should be set in accordance with the organisational strategy, they must show the organisation objectives. Performance criteria should be coordinated and evaluated based on the organisation's strategy and selected

metrics should reflect coordination between financial and non-financial measures and capable of being related to strategic, tactical and operational levels (Najmi and Makui, 2012).

Shafiee, Lotfi and Saleh (2014) work's has focused on a comprehensive method to study the measures of the supply chain performance and efficiency with the end-to-end approach. To do so, it is clear that to have effective SCM, it should represent a balanced approach and should be classified as strategic, tactical and operational levels and be financial and non financial measures as well. Taking into account the above factors, a balanced SCM scorecard has been proposed and developed to discuss several measures and metrics of SCM. According to the authors a balanced performance evaluation of SCM not only helps organizations in faster and wider monitoring of their operations, but can also help them in improving their internal and external function of business such as engineering and design applications, production, quality improvement, material management, quick response, gaining lost market shares, and proper implementation of business strategies (Shafiee et al., 2014).

The Supply Chain Operations Reference (SCOR) model it has been developed in 1996 by the Supply Chain Council (SCC) and AMR Research, now Gartner, has become a benchmark by its pioneering spirit. The SCOR model it was launched to help supply chains to conduct systematic analysis and promote communication among its members (Hwang et al., 2008; Supply Chain Council, 2012).

The SCOR model provides a unified framework that relates business processes, terminology, metrics, best practices, and technology capabilities to support communication and integration among business partners and a systemic approach for identifying, evaluating and monitoring supply chain performance. The model provides not only an opportunity to see how the firm is doing, but also a common frame of reference and language across the supply chain (Bolstorff, 2004; Hwang et al., 2008; Jamehshooran et al., 2015; Naslund and Williamson, 2010). The SCOR model is a management tool, spanning from customer to supplier, that enables companies to benchmark of the whole supply chain (and not just on internal processes) and influence future application development to improve business processes in six distinct functional areas: plan, source, make, delivery, return and enable (Jamehshooran et al., 2015; Najmi and Makui, 2012; Supply Chain Council, 2012; Thunberg and Persson, 2013).

Based on the Supply Chain Council (2012), the SCOR performance section consists of two types of elements: performance attributes and metrics. A performance

attribute is a grouping of metrics used to express a strategy. An attribute it is used to set strategic direction. The metrics are categorized into five performance attributes: reliability, responsiveness, agility/flexibility, costs and asset management efficiency. The first three attributes are considered customer-focused; the latter two are internally focused. This structure can be applied to all industrial and service sector companies, at strategic, tactical and operational levels for an implementation of decisions relating to the company's strategic planning (Estampe et al., 2013; Najmi and Makui, 2012; Supply Chain Council, 2012).

Shepherd and Günter (2006) summarize the taxonomy of supply chain performance measures, delineated according to: the processes identified in the SCOR model (plan, source, make, deliver or return); whether they measure cost, time, quality, flexibility or innovativeness; and, whether they are quantitative or qualitative shows this framework.

Cai *et al*. (2009) developed a methodology which used a process-oriented SCOR model to identify basic performance measures and key performance indicators. Their proposed measurement system includes five categories of measures: resource, output, flexibility, innovativeness, and information (Cai et al., 2009; Najmi and Makui, 2012; Xia et al., 2007). Ganga and Carpinetti (2011) bridge an important gap using standardized and benchmarking metrics such as the SCOR model metrics to evaluate the application of fuzzy logic to develop a model to predict the performance of supply chain lagging metrics based on leading metrics and inference rules. Their findings reinforce the proposition that the adoption of a predictive model based on fuzzy logic and on metrics of the SCOR model seems to be a feasible approach to predict the supply chains performance so as to help managers in the decision making the process of managing of supply chains performance (Ganga and Carpinetti, 2011).

In their paper, Sellitto *et al.* (2015) develop and applies a model for Supply Chain Performance Measurement (SCPM) based on SCOR model. The model includes a multivariate structure, relating SCOR processes except plan (source, make, deliver, return), and performance standards (reliability, responsiveness, agility, cost, assets). For purposes of their model, such performance standards were translated as quality (understood as reliability or perfect order fulfilment, and return as assets for clients satisfaction), delivery time (taken as responsiveness or order fulfilment cycle time), flexibility (or agility), and costs (total costs to serve, including inventory budget and level

of sales) as proposed by Slack and Lewis, (2008b) and Ward *et al.*, (1998) (Sellitto et al., 2015).

One of the main limitations of this model is that it does not offer a systematic method for prioritizing measures. Also, due to the importance of the quality criterion for evaluating SC performance which has been given in the literature, the SCOR model shown the weakness in this regard (Najmi and Makui, 2012; Shepherd and Günter, 2006).

The Balanced scorecard (BSC) from Kaplan and Norton (1992) is one of the best-known performance measurement frameworks. In observing and working with many companies, the authors realize that no single measure can provide a clear performance target or focus attention on the critical areas of the business. It is necessary a balanced of both financial and operational measures (Kaplan and Norton, 1992). According to its idealizers, the principles of BSC are: to clarify and translate vision and strategy, and to communicate and associate strategic objectives and measures (Kaplan and Norton, 1992; Maia and Martins, 2008).

The BSC allows managers to look at the business from four important perspectives: (i) Financial perspective: Identifies how the companies wish to be viewed by its shareholders; (ii) Customer perspective: Shows how the companies would be seen by customers; (iii) Internal processes perspective: Explains the processes that the company should be particularly adept in order to satisfy its shareholders and customers; and (iv) Learning and growth perspective: Includes changes and improvements which the company needs to understand to achieve its vision (Kaplan and Norton, 1992; Najmi and Makui, 2012).

Based on the basic concepts from BSC and SCOR, Najmi and Makui (2012) proposed a hierarchical model with a top–down view to performance measurement via four levels. In the first level, the strategic aspects of the organisation are defined as the main goals and frameworks of the performance measurement model. This level was determined according to BSC concepts, the only difference is that the environmental determinant has also been added. In the second level, the SC performance criteria and their importance for accessing the strategic objectives are defined according to SCOR attributes, with the difference that the cost attribute has been replaced with the quality attribute. For monitoring the state of each criterion obtained in level 2, we must choose and define suitable metrics, level 3, having the potential of converting the criterion's states to measurable values. And finally, in level 4, the performance of the considered SC

can be evaluated in comparison with an ideal one, based on metrics defined in level 3 (Najmi and Makui, 2012).

According to Shafiee *et al.* (2014), the strongest point of BSC is its ability to illustrate the cause and effect relations between strategies and processes through the four perspectives. Based on this reasoning, to achieve its financial benefits, an organization has to take its customers' needs and expectations into account, initially. To do this, organizations should take on a process approach when developing and implementing a quality management system (Kaplan and Norton, 1992; Shafiee et al., 2014).

4. Proposed supply chain performance measurement model

The basic concepts of the model are taken from BSC and SCOR models and the Operations Strategy concepts. Like the model proposed by Najmi and Makui (2012), the proposed model is a hierarchical one with a top–down view to performance measurement via three levels. The strategic objectives of organizations and supply chains lie at the first level of the model and they are represented by the BSC perspectives - Financial, Customer, Internal business processes and Learning and growth.

Supply chains performance is measured by criteria which are specific to the SC, and achieving them will help the chain to achieve goals (Najmi and Makui, 2012). Thereby, the criteria which a SC must encompass to achieve strategic objectives, are placed at level 2. In the proposed model, those criteria are the same as SCOR model attributes, with the difference that the 'Asset Management Efficiency' attribute has been replaced for quality and innovation attribute. Due to the importance which has been given in the literature of the quality and innovation criterion for evaluating SC performance. Description of the given criteria in this level is as following: (i) Quality: Offering products and services in compliance with design specifications and in conformance to customers' expectations, in other words, 'doing things right'(Chan, 2003; Slack et al., 2013; Slack and Lewis, 2008); (ii) Reliability: Delivery the correct product to the correct place at the correct time in the correct condition and packaging in the correct quantity with the correct documentation to the correct customer, ie to meet the deadline promises and other conditions agreed with the customers (Najmi and Makui, 2012; Slack et al., 2013); (iii) Responsiveness: The elapsed time between customers requesting products or services and them receiving them. It can also be considered in the development of new products (development speed or launch speed) (Moreira, 1996; Najmi and Makui, 2012; Slack et al., 2013); (iv) Flexibility: It is about the ability or the adaptability of the company to respond to diversity or change, ie., to adapt the operations to changes in the customers'

requirements as needed and with the demanded quickness. This may mean changing what the operation does, how it is doing it, or when it is doing it (Chan, 2003; Moreira, 1996; Slack et al., 2013); (v) Cost: To offer products and service with lower prices than those of the competitors. To the companies which compete directly on price, the cost will clearly be their major operations objective. The lower the cost of producing their goods and services, the lower can be the price to their customers. Even those companies which do not compete on price will be interested in keeping costs low (Slack et al., 2013; Slack and Lewis, 2008); and (vi) Innovation: refers to the competence of rapidly designing and launching new products and services – and doing that quicker than the competitors (Kim and Wemmerlöv, 2015; Slack and Lewis, 2008). Innovations in product and process technology, management systems and structure are particularly important (Moreira, 1996).

For monitoring the supply chain performance, it's necessary to choose and define suitable measures for which criteria. Therefore, the measures are defined in level 3. The most relevant measures that have been proposed in the literature has been chosen to compose this model. It should be noted that the measures should be selected in a balanced manner, cover the three levels of strategic, tactical and operational and are classified as both financial and non-financial. In addition to measures related to the model dimensions, relevant economic and financial measures were selected. The Table to Table 4 present the most representative measures in the literature, organized according to the dimensions and perspectives to which they belong.

According to Bhagwat and Sharma (2007), financial performance measures indicate whether the company's strategy, implementation and execution are effectively contributing to the bottom line improvement of a firm, in other words, financial goals are to survive, succeed and prosper. Financial performance indicators are shown in Table 1.

Table 1 – The financial perspective measures

The financial perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Economic/financial						
Market share	x			x		(Bai and Sarkis, 2012; Beamon, 1999; Berrah and Clivillé, 2007; Bhagwat and Sharma, 2009, 2007; Charkha and Jaju, 2015; Gunasekaran et al., 2004, 2001;
Net profit vs productivity ratio	x			x		
Rate of return on investment	x			x		
Total cash flow time	x			x	x	
Cost						
Manufacturing cost			x	x		
Inventory carrying cost			x	x		
Information carrying cost			x	x	x	
Variations against budget	x			x		
Supplier cost saving initiatives		x		x		
Cost per operation hour			x	x		

Quality						Shafiee et al., 2014; Shepherd and Günter, 2006; Tajbakhsh and Hassini, 2015)
Buyer–supplier partnership level	x			x	x	
Delivery reliability		x		x	x	
Supplier rejection rate			x	x	x	
Delivery performance		x			x	
Responsiveness						
Customer query time	x			x	x	

Source: the author, 2017.

The organization needs to translate their general mission statement on customer service into specific measures that reflect the factors that really matter to the customers (Najmi and Makui, 2012; Sharma and Bhagwat, 2007).The customer perspective performance indicators are shown in Table 2.

Table 2 – The customer perspective measures

The customer perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Quality						
Customer satisfaction	x				x	(Bai and Sarkis, 2012; Berrah and Clivillé, 2007; Bhagwat and Sharma, 2009, 2007; Charkha and Jaju, 2015; Gunasekaran et al., 2004, 2001; Shafiee et al., 2014; Shepherd and Günter, 2006; Tajbakhsh and Hassini, 2015; Thunberg and Persson, 2013)
Product quality			x		x	
Delivery performance		x			x	
Delivery reliability		x		x	x	
Level of customer perceived value of product	x				x	
Effectiveness on delivery invoice methods		x			x	
Effectiveness of distribution planning schedule		x			x	
Quality of delivery documentation			x		x	
Quality of delivery goods			x		x	
Flexibility						
Responsiveness to urgent deliveries		x			x	
Flexibility of service systems to meet particular customer needs	x				x	
Flexibility to meet particular customer needs	x				x	
Range of products and services	x				x	
Cost						
Information carrying cost			x	x	x	
Responsiveness						
Order fulfillment cycle time			x		x	
Delivery lead time	x				x	
Customer query time	x			x	x	
Order lead time	x				x	
Reliability						
On-time delivery			x		x	
Perfect order fulfillment		x			x	

Source: the author, 2017.

According to Bhagwat and Sharma (2007), the internal measures stem from the business process that has the greatest impact on customer's satisfaction. Firms should decide what processes and competencies they must excel at and specify measures for each of them. Performance metrics for the internal business perspective are shown in Table 3.

Table 3 - The internal process perspective measures

The internal process perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Quality						(Bai and Sarkis, 2012; Beamon, 1999; Berrah and Clivillé, 2007; Bhagwat and Sharma, 2009, 2007; Charkha and Jaju, 2015; Gunasekaran et al., 2004, 2001; Shafiee et al., 2014; Shepherd and Günter, 2006; Tajbakhsh and Hassini, 2015)
Level of supplier's defect free deliveries	x				x	
Trust with partners	x				x	
Accuracy of forecasting techniques		x			x	
Flexibility						
Flexibility of service systems to meet particular customer needs	x				x	
Responsiveness						
Product development cycle time		x			x	
Efficiency of purchase order cycle time		x	x			
Supplier lead time against industry norms	x				x	
Total supply chain cycle time	x				x	
Planning process cycle time		x			x	
Reliability						
On-time delivery			x		x	
Inventory accuracy			x		x	
Cost						
Total Transportation cost		x		x		
Effectiveness of master production schedule		x			x	
Inventory cost			x	x		
Capacity utilization			x		x	
Innovation						
Number of new products launched		x			x	
Use of new technology		x			x	

Source: the author, 2017.

Bhagwat and Sharma (2007) claim that a company's ability to innovate, improve and learn lies directly to company's value. Innovation and continuous learning process can bring about efficiency in operating domain of the business. Moreover, it ensures cost reduction and product differentiation to meet the varied requirements of the customers. Performance metrics for the learning and growth perspective are shown in Table 4.

Table 4 – The learning and growth perspective measures

The learning and growth perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Quality						(Bai and Sarkis, 2012; Beamon, 1999; Bhagwat and Sharma, 2009, 2007; Charkha and Jaju, 2015; Gunasekaran et al., 2004, 2001; Shafiee et al., 2014; Shepherd and Günter, 2006; Tajbakhsh and Hassini, 2015)
Level of customer perceived value of product	x				x	
Supplier assistance in solving technical problems		x			x	
Buyer–supplier partnership level	x			x	x	
Order entry methods		x	x		x	
Accuracy of forecasting techniques		x				
Level of information sharing	x				x	
Flexibility						
Flexibility of service systems to meet particular customer needs	x				x	
Supplier ability to respond to quality problems		x			x	
Innovation						
Product development time						
Cost						
Supplier cost saving initiatives		x		x		
Capacity utilization			x		x	

Source: the author, 2017

The proposed model responds to some of the main problems cited by the researchers in the studies on performance evaluation of supply chains: (i) Lack of a balanced approach. For a balanced approach, companies should bear in mind that, while financial performance measurements are important for strategic decisions and external reporting, day-to-day control of manufacturing and distribution operations is better handled with non-financial measures. (Beamon, 1999; Chan et al., 2003; Chan and Qi, 2003; Gunasekaran et al., 2004; Maskell, 1991; Najmi and Makui, 2012; Shafiee et al., 2014; Shepherd and Günter, 2006); (ii) Focus on the cost to the detriment of non-cost indicators (Beamon, 1999; De Toni and Tonchia, 2001) and (iii) Lack of a clear distinction between metrics at strategic, tactical, and operational levels. Using a classification based on these three levels, each metric can be assigned to a level where it would be most appropriate (Gunasekaran et al., 2004, 2001; Najmi and Makui, 2012).

The model enables the monitoring of supply chain performance in a balanced and comprehensive manner and can be tailored according to the characteristics of the supply chain. It's worth pointing out that this model is based largely on metrics discussed in the literature and should be regarded as a starting point for an assessment of the need for

supply chain performance measurement. It is hoped that this framework will assist practitioners in their efforts to assess supply chain performance.

5. Conclusion

This work presents a model for supply chain performance measurement. First, a systematic literature review was conducted so as to identify research trends in the supply chain performance field and select the dataset of research papers from which to derived and organized, through content analysis procedures, a set of indicators for supply chain performance measurement systems and proposed the supply chain performance measurement model.

The basic concepts of the model are taken from BSC and SCOR models and the Operations Strategy concepts. The proposed model is a hierarchical one with a top–down view to performance measurement via three levels. The strategic objectives of organizations and supply chains lie at the first level of the model and they are represented by the BSC perspectives. The criteria which a SC must encompass to achieve strategic objectives are placed at level 2. In the proposed model, those criteria are based on SCOR model attributes and the traditional performance dimensions from operations strategy. The measures for monitoring the supply chain performance, are defined in level 3. The most relevant measures that have been proposed in the literature has been chosen to compose this model. It should be noted that the measures cover the three levels of strategic, tactical and operational and are classified as both financial and non-financial. It's worth pointing out that this model is based on the literature discussions about supply chain performance measurement.

Research relevance is founded on two main aspects, the first is related to identify the factors that influence the supply chains performance and the important elements for supply chain performance measurement, and the second aspect is the use of systematic literature review to propose a model for supply chain performance measurement. The contribution to the theoretical field is in terms of mapping and reviewing the field of supply chain performance measurement and for practitioners, the model is intended to support supply chain performance measurement initiatives.

Amongst the main limitations of the research approach, stand out the fact that the study is limited to the selected scientific databases, document type, search period, language and search strings. Thus, it is possible that some important papers have not been selected for the study. However, although these non-selected articles may be pertinent to the field, it can be argued that it is not likely that such articles would significantly change

the results of the study, because of the robustness provided by the systematic literature review and the content analysis approaches. This research delineated itself in not addressing the sustainable supply chain management issue.

For future work, it is suggested to include the sustainability dimension and other relevant dimensions, for example, corporate governance. Also, further research should be carried out so as to validate the model with a supply chain real data through interviews with specialists or case study to verify the model applicability in the supply chains.

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APPENDIX G - SUBMITTED ARTICLE OPERATIONS MANAGEMENT RESEARCH 2017

Developing a model for supply chain performace measurement - A delphi study

Abstract

Supply chain management (SCM) is a key element for improving companies' competitiveness. The issue of performance measurement plays an essential role in SCM and has received increasing attention from the research community. However, literature and practice indicate that inadequate supply chain performance measurement systems are still amongst the major barriers to successful supply chain collaboration. In order to face this gap, this work aims at developing a model for supply chain performance measurement. A systematic literature review is conducted so as to identify research trends in the supply chain performance field. Then, the research seeks to derive and organize from the literature a set of recommendations and indicators for supply chain performance measurement systems, by means of applying content analysis procedures. The literature recommendations and indicators base the model development, and a Delphi study is designed to refine and confirm the model through an empirical-based approach. This research contributes to the theoretical field in terms of mapping and reviewing supply chain performance measurement recommendations, and by creating conditions for academics to identify future research opportunities. For practitioners, the model may contribute to the challenges of designing, implementing and enhancing supply chain performance measurement systems.

Keywords: Supply chain performance measurement model; Performance measurement system; Supply chain management; Delphi Study.

1. Introduction

Highly competitive environments require that supply chain managers respond quickly to competitive challenges, inventory shortages, customers' requirements in product customization, quality improvement, inaccurate order processing and unreliable transport situations. On the other hand, they need to reduce production cost, shorten lead times and lower inventory levels to ensure profitability (CHITHAMBARANATHAN; SUBRAMANIAN; PALANIAPPAN, 2015; SMITH; LANCIONI; OLIVA, 2005).

According to Sharma and Bhagwat (2007), performance analysis can provide important feedback information to enable supply chain managers to monitor implementation, review progress, enhance communication and diagnose problems. It can also provide insights into the effectiveness of the systems in place and procedures practiced, and it can help in identifying potential opportunities for improvement. Also, the analysis on supply chain performance can provide a basis for better integration among the supply chain members and, especially, for better decision-making in supply chain management, particularly in redesigning business goals and strategies, and in reengineering processes (SHARMA; BHAGWAT, 2007).

The idea of a common performance measurement system (PMS) for the whole SC was suggested by Holmberg (2000), who identified the fragmented measurement activities of a Swedish home furnishing business supply chain and proposed the use of systems thinking when developing PMSs. Moreover, the importance of the topic has been recognized by Busi and Bititci (2006) who have indicated collaborative performance measurement as an issue for further research. Other research works addressing performance measurement in supply chains, extended enterprises and virtual enterprises specify a range of performance measures, which should be used in managing supply chains and virtual organizations but fail to integrate these within a strategic performance measurement framework (BITITCI *et al.*, 2005). The existence of different perspectives blurs the decision regarding what it is (or not) significant to measure in a supply chain, thus a growing, yet important, number of performance measures has been suggested in the literature (BAI; SARKIS, 2012; NEELY, 1998; PAPAKIRIAKOPOULOS; PRAMATARI, 2010)

Many critical drawbacks prevent the existing performance analysis methods from making a significant contribution to the development and improvement of supply chains. Some of the major drawbacks with the existing methods are: inability to capture holistic aspects; lack of suitability to the different levels of measurement; complexity in methods; requirement of intricate details; and inadequacy to capture vagueness in human judgement. These obstacles characterize the need for a suitable framework which can take into account the commonalities of practical supply chains when analyzing performance (CHITHAMBARANATHAN *et al.*, 2015; PIOTROWICZ and CUTHBERTSON, 2015).

Lack of valid measurement criteria and inadequate methodologies to aggregate different performance measures into a single index is one of the limitations. None of the current strategic models and frameworks for performance measurement, such as balanced scorecard, performance prism, IPMS, smart pyramid etc., consider performance measurement and management from an extended enterprise perspective. Inter-enterprise coordinating (or partnership) measures are essential to ensure that various partners within an extended enterprise coordinate effectively and efficiently to ensure that the performance of the extended enterprise is maximized. Some works specify a range of performance measures, which should be used in managing supply chains but fail to integrate these within a strategic performance measurement framework (BITITCI *et al.*, 2005; SHAFIEE; LOTFI; SALEH, 2014).

Based on this context it is possible to establish that the research objective is to identify what are the generally applicable indicators for measuring supply chain performance. The result is the proposition of a model proposition for supply chain performance measurement, which is refined and confirmed by means of an empirical-based approach.

The research design strategy is based on the application of bibliographic procedures for the model construction and empirical studies for its refinement and for the assessment of its applicability against its objectives. A systematic literature review is carried out in order to map the research trends in the supply chain field. To identify recommendations for the design, implementation, and use (and reconfiguration) of a supply chain performance measurement system and to propose a consolidated model. To refine the model and compare the literature recommendations with practice, a Delphi Study will be conducted.

2. Supply chain performance measurement

In the 1990s the identification of performance measurement systems was a key concern, having as its main objective the planning of measurement systems whose dimensions would be broadly aligned with the corporate strategy (NEELY; GREGORY; PLATTS, 2005). There have been a wide variety of measurement systems mainly oriented to a measurement of autonomous entities (companies, subsidiaries, business units, etc.) and these models did not take into account the complexity of value-creating company chains (ESTAMPE *et al*., 2013). In the 2000s was defined a number of measurement models that helped to analyze supply chains in terms of some of their components (collaboration, human resource management, sustainability, etc.) (BEAMON, 1999; ESTAMPE *et al*., 2013; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001). The operations strategy literature suggests that a supplier's operational competences can enhance the value of its products on the following dimensions: quality, cost, delivery, flexibility, and new product development (KAPLAN, 1984; KIM; WEMMERLÖV, 2015; SKINNER, 1969; SLACK; LEWIS, 2015).

In 1999, Beamon (1999) identified three types of performance measure as vital components for the supply chain performance measurement system including resource, output, and flexibility. The author also mentioned that the result of each one affects the others and supply chain performance measurement system must contain at least one individual measure from each of the identified types (BEAMON, 1999; FREDERICO; MARTINS, 2014; GUNASEKARAN; PATEL; MCGAUGHEY, 2004). She divided performance measures into two groups, quantitative and qualitative, to discuss customer satisfaction and responsiveness, flexibility, supplier performance, cost and other elements of supply chain efficiency modeling. Extending these measures leads to providing a new framework for supply chain evaluation that measures the strategic, tactical, and operational level of performance (BEAMON, 1999; BITITCI *et al*., 2005; SHAFIEE; LOTFI; SALEH, 2014).

Apart from the common criteria such as cost and quality, Chan (2003) proposed five other performance measurements: resource utilisation - to measure the resource utilization, a company can directly investigate the percentage of surplus or deficit of that resource within a period - flexibility, visibility - for a supply chain is important for accurate and fast delivery of information - trust - it is the reliability and consistency between different levels of the supply chain and enhances the long-term relationship between them, and innovativeness. Of the seven attributes identified as important measures for the performance of the supply chain, two of them are direct quantitative measures (i.e. cost, and resource utilization), and the other five are qualitative (i.e. quality, flexibility, visibility, trust, and innovativeness) (CHAN, 2003).

Melnyk *et al*. (2010) suggest that supply chains operating in the current working environment should have the ability to provide one or more of the six basic outcomes depending on the customer/market requirements, which are cost, responsiveness, resilience, security, innovation, and sustainability. Najmi and Makui (2012) defend that the coordination between performance measures and metrics can be evaluated from two viewpoints. In the first view, levels of strategic, tactical and operational, are hierarchical based tasks in which the policies and trade-offs are distinctive and appropriate control is applicable (BALLOU, 1992). The second view includes financial and non-financial metrics, that is the main difference between the new performance measurement models and traditional ones. According to the authors for performance measurement, measurement goals should be set in accordance with the organisational strategy, they must show the organisation objectives. Performance criteria should be coordinated and evaluated based on the

organisation's strategy and selected metrics should reflect coordination between financial and non-financial measures and capable of being related to strategic, tactical and operational levels (NAJMI; MAKUI, 2012).

Shafiee, Lotfi and Saleh (2014) work's has focused on a comprehensive method to study the measures of the supply chain performance and efficiency with the end-to-end approach. To do so, it is clear that to have effective SCM, it should represent a balanced approach and should be classified as strategic, tactical and operational levels and be financial and non financial measures as well. According to the authors a balanced performance evaluation of SCM not only helps organizations in faster and wider monitoring of their operations, but can also help them in improving their internal and external function of business such as engineering and design applications, production, quality improvement, material management, quick response, gaining lost market shares, and proper implementation of business strategies (SHAFIEE; LOTFI; SALEH, 2014).

The Supply Chain Operations Reference (SCOR) model it has been developed in 1996 by the Supply Chain Council (SCC) and AMR Research, now Gartner, has become a benchmark by its pioneering spirit. The SCOR model it was launched to help supply chains to conduct systematic analysis and promote communication among its members (HWANG; LIN; LYU, 2008; SUPPLY CHAIN COUNCIL, 2012).

The SCOR model provides a unified framework that relates business processes, terminology, metrics, best practices, and technology capabilities to support communication and integration among business partners and a systemic approach for identifying, evaluating and monitoring supply chain performance. The model provides not only an opportunity to see how the firm is doing, but also a common frame of reference and language across the supply chain (HWANG; LIN; LYU, 2008; JAMEHSHOORAN; SHAHAROUN; HARON, 2015; NASLUND; WILLIAMSON, 2010). Based on the Supply Chain Council (2012), the SCOR performance section consists of two types of elements: performance attributes and metrics. A performance attribute is a grouping of metrics used to express a strategy. An attribute it is used to set strategic direction. The metrics are categorized into five performance attributes: reliability, responsiveness, agility/flexibility, costs and asset management efficiency. The first three attributes are considered customer-focused; the latter two are internally focused. This structure can be applied to all industrial and service sector companies, at strategic, tactical and operational levels for an implementation of decisions relating to the company's strategic planning (ESTAMPE et al., 2013; NAJMI; MAKUI, 2012; SUPPLY CHAIN COUNCIL, 2012).

Shepherd and Günter (2006) summarize the taxonomy of supply chain performance measures, delineated according to: the processes identified in the SCOR model (plan, source, make, deliver or return); whether they measure cost, time, quality, flexibility or innovativeness; and, whether they are quantitative or qualitative shows this framework.

In their paper, Sellitto *et al.* (2015) develop and applies a model for Supply Chain Performance Measurement (SCPM) based on SCOR model. The model includes a multivariate structure, relating SCOR processes except for plan (source, make, deliver, return), and performance standards (reliability, responsiveness, agility, cost, assets). For purposes of their model, such performance standards were translated as quality (understood as reliability or perfect order fulfilment, and return on assets for clients satisfaction), delivery time (taken as responsiveness or order fulfilment cycle time), flexibility (or agility),

and costs (total costs to serve, including inventory budget and level of sales) as proposed by Slack and Lewis, (2008b) and Ward *et al.*, (1998) (SELLITTO *et al*., 2015).

One of the main limitations of this model is that it does not offer a systematic method for prioritizing measures. Also, due to the importance of the quality criterion for evaluating SC performance which has been given in the literature, the SCOR model shown the weakness in this regard (NAJMI; MAKUI, 2012; SHEPHERD; GÜNTER, 2006).

The Balanced scorecard (BSC) from Kaplan and Norton (1992) is one of the best-known performance measurement frameworks. In observing and working with many companies, the authors realize that no single measure can provide a clear performance target or focus attention on the critical areas of the business. It is necessary a balanced of both financial and operational measures (KAPLAN; NORTON, 1992). According to its idealizers, the principles of BSC are: to clarify and translate vision and strategy and to communicate and associate strategic objectives and measures (KAPLAN; NORTON, 1992; MAIA; MARTINS, 2008).

The BSC allows managers to look at the business from four important perspectives: (i) Financial perspective: Identifies how the companies wish to be viewed by its shareholders; (ii) Customer perspective: Shows how the companies would be seen by customers; (iii) Internal processes perspective: Explains the processes that the company should be particularly adept in order to satisfy its shareholders and customers; and (iv) Learning and growth perspective: Includes changes and improvements which the company needs to understand to achieve its vision (KAPLAN; NORTON, 1992; NAJMI; MAKUI, 2012).

According to Shafiee *et al.* (2014), the strongest point of BSC is its ability to illustrate the cause and effect relations between strategies and processes through the four perspectives. Based on this reasoning, to achieve its financial benefits, an organization has to take its customers' needs and expectations into account, initially. To do this, organizations should take on a process approach when developing and implementing a quality management system (KAPLAN; NORTON, 1992; SHAFIEE; LOTFI; SALEH, 2014).

3. Research design

According to Britto Júnior and Feres Júnior (2011), the scientific research starting point should be based on a data collection. For this collection, it is necessary, first of all, to do a literature search. The search for the articles for this research considered six different databases that contain important journals in the field of supply chain. The search for articles was carried out between December 2015 and January 2016. In total 1252 papers were identified in the six scientific bases. All papers abstracts were reviewed in order to exclude works not pertinent to the research and to identify the main methodology, authors, years, journals and keywords of each paper. Repeated papers among the databases were also excluded, resulting in a dataset of 816 papers. Then, an analysis was conducted regarding the papers' keywords and goals in order to identify the ones related to performance measurement models in the supply chain, which resulted in a set of 185 papers. The last filtering procedure considered four layers: publication impact factor, publication year, recurrence of citations and the authors' h-index that resulted in a final data set of 76 papers to base the content analysis to be carried out.

In the second phase, the researcher should perform an observation of facts or phenomena so that it gets more information and, in a third stage of the research, the researcher aim is to get information or collect data that would not be possible only through literature research and observation. The Delphi Study is one of the techniques used by researchers to collect data in this third stage.

A Delphi study is a systematic, iterative process to elicit a consensus view from a panel of experts. By nature, Delphi can fall into the category of both quantitative and qualitative study (FLYNN, 1990; LAAKSO; RUBIN; LINTURI, 2012; MCKENNA, 1994; SCHMIDT, 1997).

The Delphi technique embodies the following key characteristics (CHOCHOLIK *et al.*, 1999; MELNYK *et al.*, 2007; WHITMAN, 1990): (i) the use of a panel of "experts" for obtaining data; (ii) participants do not meet in face-to-face discussions; (iii) the use of sequential questionnaires and/or interviews; (iv) the systematic emergence of a concurrence of judgment/opinion; (v) the guarantee of anonymity for subjects' responses; (vi) the use of frequency distributions to identify patterns of agreement; and (vii) the use of two or more rounds between which a summary of the results of the previous round is communicated to and evaluated by panel members.

The procedure for conducting the Delphi study is derived from the work of Silveira (2014), who conducted a study with similar characteristics of the present work. His workflow for refinement studies through expert interviews was considered to be suitable for the refinement of the supply chain performance measurement recommendations because it provides a structured procedure for a proper planning, design, implementation and use of data from Delphi study.

The first step in the process will be the general planning of the study. This involves, firstly, the selection of the range of experts to be invited for the study. The selection of possible experts will be based on their profile, taking into account mostly the experience factor. Naturally, the feasibility of getting the interview with the expert is also a factor to be considered. After the possible experts' invitation, an overall schedule will be planned and managed, especially for the study to be properly carried out in the deadline.
In the design phase, the procedures and formularies will be developed, which should involve, specifically: (i) the procedure for conducting the interviews and collecting the necessary data; (ii) the procedure for analyzing and synthesizing the data collected; (iii) design of the formularies applied in the process (questionnaire and interview report); and (iv) upgrading of the questionnaire to each new iteration.

The implementation phase consists of carrying out the Delphi study procedures, i.e. it is the phase in which the distribution and collection of responses will be conducted. The collected data involves not only the refinement of the model itself, but also the discussion underlying it. Thus, following round, the collected data should be registered and organized in such a manner that enables the researcher to critically analyze the round's results.

4. Supply chain performance measurement model

The basic concepts of the model are taken from BSC and SCOR models and the Operations Strategy concepts. Like the model proposed by Najmi and Makui (2012), the proposed model is a hierarchical one with a top–down view to performance measurement via three levels. The strategic objectives of organizations and supply chains lie at the first level of the model and they are represented by

the BSC perspectives - Financial, Customer, Internal business processes and Learning and growth (defined in section 0).

Supply chains performance is measured by criteria which are specific to the SC, and achieving them will help the chain to achieve goals (NAJMI; MAKUI, 2012). Thereby, the criteria which an SC must encompass to achieve strategic objectives, are placed at level 2. In the proposed model, those criteria are the same as SCOR model attributes, with the difference that the 'Asset Management Efficiency' attribute has been replaced for quality and innovation attribute. Due to the importance which has been given in the literature of the quality and innovation criterion for evaluating SC performance. Description of the given criteria in this level is as follows:

- Quality: Offering products and services in compliance with design specifications and in conformance to customers' expectations, in other words, 'doing things right'(CHAN, 2003; SLACK; BRANDON-JONES; JOHNSTON, 2013; SLACK; LEWIS, 2008).
- Reliability: Delivery the correct product to the correct place at the correct time in the correct condition and packaging in the correct quantity with the correct documentation to the correct customer, ie to meet the deadline promises and other conditions agreed with the customers (NAJMI; MAKUI, 2012; SLACK; BRANDON-JONES; JOHNSTON, 2013).
- Responsiveness: The elapsed time between customers requesting products or services and them receiving them. It can also be considered in the development of new products (development speed or launch speed) (MOREIRA, 1996; NAJMI; MAKUI, 2012; SLACK; BRANDON-JONES; JOHNSTON, 2013).
- Flexibility: It is about the ability or the adaptability of the company to respond to diversity or change, ie., to adapt the operations to changes in the customers' requirements as needed and with the demanded quickness. This may mean changing what the operation does, how it is doing it, or when it is doing it (CHAN, 2003; MOREIRA, 1996; SLACK; BRANDON-JONES; JOHNSTON, 2013).
- Cost: To offer products and service at lower prices than those of the competitors. To the companies which compete directly on price, the cost will clearly be their major operations objective. The lower the cost of producing their goods and services, the lower can be the price to their customers. Even those companies which do not compete on price will be interested in keeping costs low (SLACK; BRANDON-JONES; JOHNSTON, 2013; SLACK; LEWIS, 2008).
- Innovation: refers to the competence of rapidly designing and launching new products and services – and doing that quicker than the competitors (KIM; WEMMERLÖV, 2015; SLACK; LEWIS, 2008). Innovations in product and process technology, management systems and structure are particularly important (MOREIRA, 1996).

For monitoring the supply chain performance, it's necessary to choose and define suitable measures for which criteria. Therefore, the measures are defined in level 3. The most relevant measures that have been proposed in the literature has been chosen to compose this model. It should be noted that the measures should be selected in a balanced manner, cover the three levels of strategic, tactical and operational and are classified as both financial and non-financial. In addition to measures related to the model dimensions,

relevant economic and financial measures were selected. Table 7 to Table presents the most representative measures in the literature, organized according to the dimensions and perspectives to which they belong.

According to Bhagwat and Sharma (2007), financial performance measures indicate whether the company's strategy, implementation and execution are effectively contributing to the bottom line improvement of a firm, in other words, financial goals are to survive, succeed and prosper. Financial performance indicators are shown in Table 1.

Table 1 – The financial perspective measures

The financial perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Economic/financial						
Market share	x			x		(BAI; SARKIS, 2012; BEAMON, 1999; BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
Net profit vs productivity ratio	x			x		
Rate of return on investment	x			x		
Total cash flow time	x			x	x	
Cost						
Manufacturing cost			x	x		
Inventory carrying cost			x	x		
Information carrying cost			x	x	x	
Variations against budget	x			x		
Supplier cost saving initiatives		x		x		
Cost per operation hour			x	x		
Quality						
Buyer–supplier partnership level	x			x	x	
Delivery reliability		x		x	x	
Supplier rejection rate			x	x	x	
Delivery performance		x			x	
Responsiveness						
Customer query time	x			x	x	

Source: the author, 2017.

The organization needs to translate their general mission statement on customer service into specific measures that reflect the factors that really matter to the customers (NAJMI; MAKUI, 2012; SHARMA; BHAGWAT, 2007).The customer perspective performance indicators are shown in Table 2.

Table 2 – The customer perspective measures

The customer perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Quality						
Customer satisfaction	x				x	(BAI; SARKIS, 2012; BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL;
Product quality			x		x	
Delivery performance		x			x	
Delivery reliability		x		x	x	
Level of customer perceived value of product	x				x	
Effectiveness on delivery invoice methods		x			x	
Effectiveness of distribution planning schedule		x			x	
Quality of delivery documentation			x		x	
Quality of delivery goods			x		x	

Flexibility						TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015; THUNBERG; PERSSON, 2013)
Responsiveness to urgent deliveries		x			x	
Flexibility of service systems to meet particular customer needs	x				x	
Flexibility to meet particular customer needs	x				x	
Range of products and services	x				x	
Cost						
Information carrying cost			x	x	x	
Responsiveness						
Order fulfillment cycle time			x		x	
Delivery lead time	x				x	
Customer query time	x			x	x	
Order lead time	x				x	
Reliability						
On-time delivery			x		x	
Perfect order fulfillment		x			x	

Source: the author, 2017.

According to Bhagwat and Sharma (2007), the internal measures stem from the business process that has the greatest impact on customer's satisfaction. Firms should decide what processes and competencies they must excel at and specify measures for each of them. Performance metrics for the internal business perspective are shown in Table 3.

Table 3 – The internal process perspective measures

The internal process perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Quality						(BAI; SARKIS, 2012; BEAMON, 1999; BERRAH; CLIVILLÉ, 2007; BHAGWAT; SHARMA, 2007, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
Level of supplier's defect free deliveries	x				x	
Trust with partners	x				x	
Accuracy of forecasting techniques		x			x	
Flexibility						
Flexibility of service systems to meet particular customer needs	x				x	
Responsiveness						
Product development cycle time		x			x	
Efficiency of purchase order cycle time		x	x			
Supplier lead time against industry norms	x				x	
Total supply chain cycle time	x				x	
Planning process cycle time		x			x	
Reliability						
On-time delivery			x		x	
Inventory accuracy			x		x	
Cost						
Total Transportation cost		x		x		
Effectiveness of master production schedule		x			x	
Inventory cost			x	x		
Capacity utilization			x		x	
Innovation						
Number of new products launched		x			x	
Use of new technology		x			x	

Source: the author, 2017.

Bhagwat and Sharma (2007) claim that a company's ability to innovate, improve and learn lies directly to company's value. Innovation and continuous learning process can bring about efficiency in operating domain of the business. Moreover, it ensures cost reduction and product differentiation to meet the varied requirements of the customers. Performance metrics for the learning and growth perspective are shown in Table 4.

Table 4 – The learning and growth perspective measures

The learning and growth perspective	Strategic	Tactical	Operational	Financial	N Financial	References
Quality						(BAI; SARKIS, 2012; BEAMON, 1999; BHAGWAT; SHARMA, 2007, 2009; CHARKHA; JAJU, 2015; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006; TAJBAKHSH; HASSINI, 2015)
Level of customer perceived value of product	x				x	
Supplier assistance in solving technical problems		x			x	
Buyer–supplier partnership level	x			x	x	
Order entry methods		x	x		x	
Accuracy of forecasting techniques		x				
Level of information sharing	x				x	
Flexibility						
Flexibility of service systems to meet particular customer needs	x				x	
Supplier ability to respond to quality problems		x			x	
Innovation						
Product development time						
Cost						
Supplier cost saving initiatives		x		x		
Capacity utilization			x		x	

Source: the author, 2017.

To refine and evaluate the proposed model, a Delphi study will be conducted with a group of experts. The Delphi study conduction and the results will be presented in the next session.

5. Delphi study

This section presents the Delphi study procedures adopted and results achieved.

5.1. Planning, design and implementation phases

In the case of this research, the Delphi study was developed and conducted over a period of months from June 2017 to August 2017.

Respondents from various backgrounds were invited to participate, academics, consultants, and industry professionals, with experience in supply chains and performance measurement. Respondents were selected according to the researchers' network of contacts. Initially, 61 experts were selected to participate.

All communication with experts (panelists) was via electronic mail, which proved to be convenient and quite immediate. The geographical base for the study was Brazil and United States. The international composition was important, as the supply chain performance measurement system is a global trend. The use of electronic mail enables such an international study to happen.

Having selected the panelists, the next step was to develop the Delphi survey. This survey was developed by drawing on the model proposed starting from findings of the literature review. The questionnaire contained a total of 11 questions, with a mixture of Likert scale, multiple choice, and open-ended questions. The experts were questioned about the relevant performance dimensions to the supply chain performance measurement and their agreement level with the measures found in the model.

The initial questionnaire was subjected to through the pilot-test, in which 10 experts were invited to participate, but only six panelists responded the complete survey. The pilot test took three weeks.

Based on feedback received from the pilot-test group, the initial Delphi questionnaire was revised. Once revised, it was started the first round that took three weeks. The questionnaires were sent with the language option in Portuguese or English. Of the 61 experts invited to participate in the study, 30 individuals agreed to participate, but only 22 panelists participated in the first round.

The Delphi questionnaire was reformulated based on feedback received from the first-round panelists. The new questionnaire contained a total of 8 questions. The experts were questioned to indicate whether the presented measure is context-dependent to the supply chain which it belongs, or it is nondependent, that is, applicable to any supply chain (generalist). Once again, the questionnaires were sent with the language option in Portuguese or English. Once revised, it was started the second round that took two weeks. A total of 11 panelists participated in the second round.

5.2. Use of data phase

In this section will be present the results obtained and the changes made in each round of the Delphi study. The three sections of pilot test questionnaire were covered with questions about panelist classification, the relevant performance dimensions to the supply chain performance measurement and the agreement level by the panelists with the measures found in the model. This structure was also applied in the 1st round.

In the panelist classification, they were questioned about interviewee specialty, the area of activity and the interviewee's acting time (years). Among the panelists who participated in the pilot test, 50% are supply chain specialists and the other 50% are specialists in both supply chains and management and performance measurement. Table 5 presents a comparison between the panelist's specialties of the pilot test and of the other rounds. Among the panelists who participated in the first round, 41% are supply chain specialists, 32% are specialists in both supply chains and management and performance measurement, 18% are management and performance measurement specialists and 9% of the panelists are specialists in another area, one in Six Sigma and the other one in Operations Strategy. In the second round, 18% are supply chain specialists, 27% are management and performance measurement specialists, 45% are specialists in both supply chains and management and performance measurement, and 9% of the panelists are specialists in Operations Strategy.

Table 5 – Interviewees' specialty

Specialty	Pilot Test	1st Round	2nd Round
Supply chain Management	3	9	2
Performance Management and Measurement	0	4	3
SC Management and Management and measurement performance	3	7	5
Others	0	2	1
Total	6	22	11

Source: the author, 2017

When questioned about the acting area, the respondents could mark more than one option among those listed. Table 6 presents the context of acting of the panelists of the pilot test and of the following two rounds. Among the panelists who participated in the first round, 48% of respondents acting in the industrial area, 34% are academic and only 17% acting in consulting. It is possible to notice that 7 panelists operate in more than one area. As shown in Table 9, 33% of respondents from the second round acting in the industrial area, 40% are academic and 27% acting in consulting. It is possible to notice that 4 panelists operate in more than one area.

Table 6 - Interviewees' acting area

Area	Pilot test	1st Round	2nd Round
Industry	4	14	5
Consulting	2	5	4
Academy	2	10	6
Total	8	29	15

Source: the author, 2017

The last question of this section concerns the interviewees' acting time in the informed specialty. Table 7 shows the interviewees' acting time. It is possible to realize that all the panelists of the pilot test have more than 5 years of experience and that 50% of them have more than 15 years of experience. Among the panelists who participated in the first round, it is possible to conclude that 90% the panelists have more than 5 years of experience and 40% of them have more than 15 years of experience. In relation to the interviewees' acting time from de panelists from de second round, it is possible to conclude that 91% have between 10 and 30 years of experience.

Table 7 - Interviewee's acting time (years)

Interviewee's acting time (years)	Pilot Test	1st Round	2nd Round
From 0 to 5 years	0	2	0
From 6 to 10 years	1	4	1
From 11 to 15 years	2	6	6
From 16 to 20 years	1	3	2
From 21 to 25 years	1	2	0
From 26 to 30 years	1	2	2
From 31 to 35 years	0	0	0
From 36 to 40 years	0	1	0
Total	**6**	**20**	**11**

Source: the author, 2017

In the second stage of the questionnaire, the specialists were asked to select the performance dimensions that they thought were important for the management and measurement of a supply chain. The dimensions found in the literature review were presented to the specialists, among them those used in the

model. The dimensions presented were: quality, innovation, trust, flexibility, responsiveness, costs, asset management, resource utilization, reliability, visibility, security, resilience.

The only dimension that was not considered by any of the panelists was 'asset management'. In order to confirm its relevance, the dimension will be exposed again in the first round of Delphi. In addition to the dimensions presented, the need for other dimensions such as sustainability and polyvalence was identified. In the questionnaire review for the first round of the Delphi, it was added the polyvalence dimension. The sustainability dimension was not added because one of the initial definitions for this research it was not to address issues related to sustainability.

In the last section of the questionnaire, the interviewees were presented with the measures used in the model construction, according to the dimensions to which they belong (one question per dimension). Using a Likert 5-point scale, panelists should express their agreement degree of on the measures relevance for the management and measurement of performance in supply chains. In addition to measures evaluating, the panelists suggested the inclusion of new measures in each dimension, as follows:

- Quality: Number of retained customers;
- Flexibility: Delivery flexibility; Responsiveness to product changes; Responsiveness to changing processes; Materials variety (number of materials available); Adaptability of the upstream and downstream chain;
- Cost: Emergency transportation cost; Machine downtime;
- Reliability: Demand forecast accuracy;
- Innovation: Chain involvement in the development of the new project; New processes implemented per year; Sales ratio of existing products X new products; Investment in R&D; Revenue from new projects.

Once revised, it was started the first round. When asked which performance dimensions are important for supply chain performance measurement (SCPM), the six dimensions proposed in the model are among those most selected by the experts, as can be seen in Figure 1. The cost dimension was considered by 95% of the respondents, followed by the quality dimension with 91%. The innovation dimension, among the dimensions proposed in the model it was the least considered by the interviewees, only 50% of respondents considered this dimension.

Figure 1 – Performance dimensions related to SCPM – 1st Round

Dimensions	*%*
Cost	95%
Quality	91%
Reliability	86%
Responsiveness	77%
Flexibility	73%
Innovation	50%

Source: the author, 2017

In the last section of the first round, using a 5-point Likert scale, the panelists were asked to express their degree of agreement on the relevance of measures refined in the pilot test for the supply chains performance measurement and management.

According to the interviewees' opinion, all the economic and financial measures were considered relevant. It is worth noting that despite the majority of panelists had considered relevant, 'market share' was considered as indifferent to the supply chains management by 29% of the respondents. All quality measures were considered relevant by panelists. The measures 'Quality of delivery goods', 'Delivery performance' and 'Delivery reliability' were considered relevant by all the interviewees.

The 'Flexibility to meet particular customer needs' measure was considered relevant by all the panelists and the other flexibility measures were considered relevant for almost all of the group. The 12 measures associated with the cost dimension were considered relevant for interviewees. The 'Supplier cost-saving initiatives' and 'Total Transportation cost' were considered relevant by all respondents. Except for the 'Demand forecast accuracy' (94%) measure, all reliability measures were considered relevant by 100% of respondents.

All responsiveness measures were considered relevant and the 'Delivery lead time' measure was considered relevant by all the interviewees. The 'Product development cycle time' measure, related to Responsiveness, was the least considered by the interviewees, only 53% of respondents considered this measure, but when related to the innovation dimension, it was considered relevant for 65% of respondents.

According to the interviewees' opinion, all innovation measures were considered relevant. Despite the majority of panelists had considered relevant the measure 'Number of new products launched' was not considered by 42% of respondents, 36% of the interviewees did not agree or became indifferent to the measure 'Product/ Project development cycle time', the measure 'Sales ratio of existing products X new products' was not considered by 24%of the interviewees and the measure 'Revenue from new projects' was considered to be indifferent or not relevant 36% of respondents.

In general, respondents consider all measures to be important for measuring the supply chains performance. However, in specific terms, its importance depends on the sector in which the chain is embedded. The results of the first round confirm the proposed model based on the literature review.

Based on the experts' suggestions, the questionnaire was redefined for the second round. In this phase, the experts were questioned to indicate whether the presented measure is context-dependent to the supply chain which it belongs, or it is nondependent, that is, applicable to any supply chain (generalist). Table 8 shows the measures considered non-dependent to the supply chain by more than 50% of respondents.

Table 8 – Contex-nondependent measures

Economic and financial		**Responsiveness**	
Market share	55%	Product development cycle time	73%
Rate of return on investment	70%	Planning process cycle time	55%
Quality		**Cost**	
Delivery reliability	55%	Manufacturing cost	55%
Accuracy of forecasting techniques	64%	Cost per operation hour	64%
Effectiveness of distribution planning schedule	64%	Inventory cost	64%
Order entry methods	64%	Information carrying cost	64%

Quality of delivery documentation	55%	Machine downtime	64%
Effectiveness on delivery invoice methods	70%	Capacity utilization	55%
Number of retained customers	55%		
Flexibility		**Reliability**	
Responsiveness to changing processes	50%	Inventory accuracy	55%
Materials variety (number of materials available)	55%	On-time delivery	55%
Range of products and services	55%	Demand forecast accuracy	64%
Supplier ability to respond to quality problems	55%		

Source: the author, 2017

6. Refined model

The Delphi study conduction allowed the refinement and validation of the model proposed based on the systematic literature review. The performance dimensions and the initially proposed measures were all considered as relevant and besides these, measures suggested by the experts between the rounds were added. The refined model will be presented in the next tables.

The Table 9 to Table 12 present performance measures related to the four perspectives. The performance measures with (*) are considered non-dependent by the experts, that is, their relevance does not depend on the context in which the supply chain is inserted.

Table 9 – The financial perspective measures - refined

The financial perspective	Strategic	Tactical	Operational	Financial	N Financial
Economic/financial					
Market share*	x			x	
Net profit vs productivity ratio	x			x	
Rate of return on investment*	x			x	
Total cash flow time	x			x	x
Cost					
Manufacturing cost*			x	x	
Inventory carrying cost			x	x	
Information carrying cost*			x	x	x
Variations against budget	x			x	
Supplier cost saving initiatives		x		x	
Cost per operation hour*			x	x	
Quality					
Buyer–supplier partnership level	x			x	x
Delivery reliability*		x		x	x
Supplier rejection rate			x	x	x
Delivery performance		x			x
Responsiveness					
Customer query time	x			x	x
Innovation					
Sales ratio of existing products X new products	x			x	
Investment in R&D	x			x	
Revenue from new projects	x			x	

Source: the author, 2017

Table 10 – The customer perspective measures - refined

The customer perspective	Strategic	Tactical	Operational	Financial	N Financial
Quality					
Customer satisfaction	x				x
Product quality			x		x
Delivery performance		x			x
Delivery reliability*		x		x	x
Level of customer perceived value of product	x				x
Effectiveness on delivery invoice methods*		x			x
Effectiveness of distribution planning schedule*		x			x
Quality of delivery documentation*			x		x
Quality of delivery goods			x		x
Number of retained customers*	x				x
Flexibility					
Responsiveness to urgent deliveries		x			x
Flexibility of service systems to meet particular customer needs	x				x
Flexibility to meet particular customer needs	x				x
Range of products and services*	x				x
Delivery flexibility		x			x
Cost					
Information carrying cost*			x	x	x
Responsiveness					
Order fulfillment cycle time			x		x
Delivery lead time	x				x
Customer query time	x			x	x
Order lead time	x				x
Reliability					
On-time delivery*			x		x
Perfect order fulfillment		x			x

Source: the author, 2017

Table 11 – The internal process perspective measures - refined

The internal process perspective	Strategic	Tactical	Operational	Financial	N Financial
Quality					
Level of supplier's defect free deliveries	x				x
Trust with partners	x				x
Accuracy of forecasting techniques*		x			x
Flexibility					
Flexibility of service systems to meet particular customer needs	x				x
Adaptability of the upstream and downstream chain	x				x
Responsiveness to product changes		x			x
Responsiveness to changing processes*		x			x
Materials variety (number of materials available) *			x		x
Responsiveness					
Product development cycle time*		x			x
Efficiency of purchase order cycle time		x	x		
Supplier lead time against industry norms	x				x
Total supply chain cycle time	x				x
Planning process cycle time*		x			x
Reliability					
On-time delivery*			x		x
Inventory accuracy *			x		x
Demand forecast accuracy*			x		x

Cost					
Capacity utilization			x		x
Total Transportation cost		x		x	
Effectiveness of master production schedule		x			x
Inventory cost*			x	x	
Capacity utilization*			x	x	
Emergency transportation cost			x	x	
Machine downtime*			x	x	x
Innovation					
Number of new products launched		x			x
Use of new technology		x			x
Chain involvement in the development of the new project			x	x	x
New processes implemented per year			x		x

Source: the author, 2017

Table 12 – The learning and growth perspective measures - refined

The learning and growth perspective	Strategic	Tactical	Operational	Financial	N Financial
Quality					
Level of customer perceived value of product	x				x
Supplier assistance in solving technical problems		x			x
Buyer–supplier partnership level	x			x	x
Order entry methods*		x	x		x
Accuracy of forecasting techniques*		x			
Level of information sharing	x				x
Flexibility					
Flexibility of service systems to meet particular customer needs	x				x
Supplier ability to respond to quality problems*		x			x
Innovation					
Product development time					
Cost					
Supplier cost saving initiatives		x		x	
Capacity utilization*			x		x

Source: the author, 2017

The proposed model responds to some of the main problems cited by the researchers in the studies on performance evaluation of supply chains: (i) Lack of a balanced approach. For a balanced approach, companies should bear in mind that, while financial performance measurements are important for strategic decisions and external reporting, day-to-day control of manufacturing and distribution operations is better handled with non-financial measures. (BEAMON, 1999; CHAN et al., 2003; CHAN; QI, 2003; GUNASEKARAN; PATEL; MCGAUGHEY, 2004; MASKELL, 1991; NAJMI; MAKUI, 2012; SHAFIEE; LOTFI; SALEH, 2014; SHEPHERD; GÜNTER, 2006); (ii) Focus on the cost to the detriment of non-cost indicators (BEAMON, 1999; DE TONI; TONCHIA, 2001) and (iii) Lack of a clear distinction between metrics at strategic, tactical, and operational levels. Using a classification based on these three levels, each metric can be assigned to a level where it would be most appropriate (GUNASEKARAN; PATEL; MCGAUGHEY, 2004; GUNASEKARAN; PATEL; TIRTIROGLU, 2001; NAJMI; MAKUI, 2012).

It's worth pointing out that this model is based largely on metrics discussed in the literature and should be regarded as a starting point for an assessment of the need for supply chain performance

measurement. It is hoped that this framework will assist practitioners in their efforts to assess supply chain performance.

7. Conclusion

This work aims at developing a model for supply chain performance measurement. First, a systematic literature review is conducted so as to identify research trends in the supply chain performance field and select the dataset of research papers from which to derive and organize, through content analysis procedures, a set of recommendations for supply chain performance measurement systems and propose the supply chain performance measurement model.

A Delphi study was conducted to refine and validate the proposed model. Two rounds were performed and the performance dimensions and measures proposed in the model were completely validated and new measures were added according to the indications of the respondents.

The relevance of this research is grounded on two main aspects. First, the identification of factors that influence the performance of supply chains, along with the identification of models for measuring performance in supply chains. This is achieved through literature review. Second, the use of systematic literature review to summarize the findings of the supply chain performance measurement area. The contribution to the theoretical field is in terms of mapping and reviewing the field of supply chain performance measurement, as well as in terms of creating conditions for academics to identify future research opportunities. For practitioners, the model is intended to support supply chain performance measurement initiatives.

Amongst the main limitations of the research approach, stand out the fact that the study is limited to the selected scientific databases, document type (i.e. articles), language (i.e. English and Portuguese) and search strings. Thus, it is possible that some important papers have not been selected for the study. However, although these non-selected articles may be pertinent to the field, it can be argued that it is not likely that such articles would significantly change the results of the study, because of the robustness provided by the systematic literature review and the content analysis approaches. This research delineated itself in not addressing the sustainable supply chain management issue. The respondent's selection and the number of participants in the Delphi study are also limiting.

For future works, it is suggested to include the sustainability dimension and other relevant dimensions, for example, corporate governance, as suggested by the panelists. The continuity of the Delphi study is also suggested to evaluate the relationships between the BSC's perspectives and the performance dimensions/measures and the characteristics of measures (i. e. financial/ non-financial; operational/ tactical/ strategic). Also, further research should be carried out so as to validate the model with a supply chain real data.

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