Paper title: Key characteristics for designing a supply chain performance measurement system

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Key characteristics for designing a supply chain performance measurement system

Abstract:

Purpose: The paper aims to conduct a review of the literature that gives insight into design elements for constructing a supply chain performance measurement (SCPM) system.

Design/methodology/approach: A systematic review of published research on SCPM systems and frameworks over the last two decades was conducted with the purpose of categorising key functions of SCPM systems by providing an insight into the design, functionality, implementation and practical implications of SCPM systems.

Findings: The review revealed a set of functions governing the SCPM system that have not been fully explored in previous research: the process focus, prioritisation, integration and causality functions of a SCPM system. A relationship between two or more functions can be created to include more functionality based on the needs of the company to create a comprehensive performance measurement system.

Research limitations/implications: The paper concludes with a conceptual framework to guide future research in the area of designing a SCPM system and define the main aspects that should be considered when developing a SCPM system.

Practical implications: The paper brings a new dimension to the SCPM research by identifying the main functions of SCPM systems that could benefit practitioners to set up a SCPM system relevant to its intended function. The paper presents multiple potential stages of merging different functions in one SCPM system. Based on the company's needs and context, the functionality of the SCPM system can be designed at four levels creating ten possible scenarios when designing a company's SCPM system.

Originality/value: The paper integrated the literature and findings of 269 research papers of the last two decades, up on which a conceptual framework was developed as a guide for constructing an effective SCPM system.

Key words: Supply chain performance, Supply chain performance measurement system, Systematic review

Article classification: Literature review

1. Introduction

In recent years, performance measurement and management have become essential for organisations to survive in the current business environment (Taticchi et al., 2010; Bititci et al., 2012; Mishra et al., 2018). Appropriate performance measures can ensure that managers adopt a long-term perspective and allocate the company's resources to the most effective improvement activities. Many companies still rely on traditional, cost-related measures such as return on investment, profit margin and cash flow (Zuriekat et al., 2011), that will provide a limited view to the type of changes required.

In today's business environment, it is vital to combine performance measures that can assess supply chain performance from different perspectives in order to provide a balanced and fair assessment of the company's supply chain (SC) (El-Baz, 2011; Agami et al., 2012; Bititci et al., 2012; Piotrowicz and Cuthbertson, 2015). Researchers began to focus on designing systems that combine financial and non-financial measures and incorporate different levels of decision-making (strategic, tactical and operational). This is in order to set performance targets to reflect the company's strategy and objectives (Gimenez et al., 2012). It has been found that companies' SC measures should be matched distinctively to their respective SC strategies in order to increase competitiveness (Birhanu et al., 2018).

Although various SC performance measures and matrices were proposed, there is still a need for further research that gives more awareness to the design functions of a supply chain performance measurement (SCPM) system. A balanced performance measurement framework should reflect a company's strategic objectives along with the impact of SC performance on a company's overall performance. SC processes and roles need to be

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mapped onto a combination of metrics aligned to the overall business strategy and address the performance of various SC functional areas (Tejas and Srikanth, 2007).

This paper aims to conduct a review of the literature with the propose of providing a framework that guides the design phase of a supply chain performance measurement (SCPM) system for an organisation that takes into consideration different dimensions of SC integration and deals with the overall business strategy. A critical review of published research on SCPM systems and frameworks over the last two decades has been conducted. The review has identified and analysed different functions of SCPM systems in addition to extracting elements that could benefit practitioners to design a framework for a SCPM system.

This review brings together previously disparate streams of work in the area of SCPM to better understand the current SCPM systems and evaluate the challenges of setting a SCPM system for an organisation that takes into consideration aspects of the extended SC. The review concludes with a set of guidelines on the design of a SCPM system. These guidelines are introduced through proposing a conceptual framework to guide future research in the area of designing a SCPM and elucidate the main aspects that should be considered to develop a SCPM system. This review, therefore, aims to address the following research questions:

RQ1: What are the different functions of SCPM systems/frameworks and/or models identified over the past two decades (from 1995 to 2015)?

RQ2: What are the main elements that guide the design phase of a SCPM system?

The methodology employed to conduct the literature review is presented in section two. Section three takes a critical stand in reviewing the literature with the purpose of grouping SCPM systems according to their systems' functions. This section aims to give an answer

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to the first research question. Section four proposes a framework, based on the different systems' functions and the main elements extracted from the review, thus setting a direction towards designing a SCPM system. This section provides the answer to the second research question. Finally, the conclusion and directions for future work are discussed in sections five and six respectively.

2. Methodology

A structured literature review has been conducted following the three stages proposed by Webster and Watson (2002): identifying the relevant literature, structuring the review and developing a model to guide future research. The authors developed this approach from an information systems' angle, over the years their approach is still evident in research in the supply chain area (see for example Jede and Teuteberg, 2016). As SCPM systems are a part of the information systems within an organisation, it was considered relevant to follow the guidelines proposed by Webster and Watson (2002).

2.1 Identifying the Relevant Literature

To identify the relevant literature, the authors have designed a systematic process for selecting articles using 3 online databases (Scopus, ScienceDirect and Emerald). The search was only applied to publications that consider systems and/or frameworks or models of SCPM research published between 1995 and 2015. As the search has been restricted to the understanding of SCPM systems, the authors intended to reveal the lessons learned for over a period of two decades. The search was limited to refereed journal papers within the area of business management, accounting and decision sciences. The keywords used were supply chain management, performance measurement, performance measurement system,

supply chains, performance measurements, benchmarking, supply chain performance and key performance indicators. This selection was considered within the title, abstract and the keywords of an article.

The first search yielded a total of 269 articles (162 in Scopus, 72 in Emerald and 35 in Science Direct) that were saved in the reference management software "EndNote" in order to facilitate the screening process. After removing duplication in EndNote, the list resulted in 251 papers which were then scanned over two stages.

Stage 1: within the 251 identified articles we conducted a full search in the articles' title, abstract and the keywords to identify their suitability. The main elements considered at this stage, where the area of application is supply chain, were the reference to a developed framework or a model of a performance measurement system. Articles referring to improvements in operations and/or services that could potentially lead to improved supply chain performances, although not directed to research on the development of SCPM systems have been disregarded at this stage. This stage concluded with a total of 136 articles.

Stage 2: at this stage of the selection process, all 136 articles were fully evaluated for their suitability to be considered based on their content (details given on the development or design of a supply chain performance measurement system), methodology used, model development and their practical implications. The second stage of the review concluded with a total of 56 articles to be included in the main analysis. The remaining articles from the second stage were used in the general discussion part of the paper if they had not demonstrated the design phase of a SCPM system.

2.2 Structuring the Review

A concept matrix was developed following Webster and Watson, (2002) in order to structure the articles selected for the main analysis of 56 articles). Before identifying the concepts, the following grouping has been considered: research domain, model/framework, performance measures identified and related practical implications. As the concept matrix evolved, it was considered appropriate to split the research domain into three units of analysis: research scope, tools used and the area of study/management theory. These were in addition to basic fields extracted from EndNote (year, author and journal). The structure of the final matrix considered: (1) author, year; (2) journal; (3) research scope; (4) tools used; (5) area of study/theory; (6) model/framework identified; (7) performance measures used and (8) practical implications.

2.3 Developing a conceptual model

The selected 56 articles were structured according to the criteria identified above using a data extraction table, upon which the initial conceptual matrix was developed based on 41 articles. The rest of articles have been used to capture observations that helped to draw the review conclusion. Following the review, four main functions were identified in the reviewed models: process focus, prioritisation, integration and causality. These functions helped us to develop a conceptual framework for designing a SCPMS. The developed framework guides future research and places importance on practical implications as well as helping us to provide an answer to the second research question.

3. Analysis

The review revealed that SCPM systems captured in the concept matrix can be classified around four main functions identified by the authors as process focus, prioritisation, integration and causality. Table 1 presents the main frameworks proposed under each function based on the main scope, tools used, measures and practical implications provided. As illustrated in table 1 based on the literature review findings, the role of process-focused SCPM systems is to evaluate performance, identify processes that require improvement, and then link corresponding measures to goals. A prioritisation SCPM system can be used to evaluate performance, identify measures that need improvement, and prioritise measures with respect to goals. A causality system is used to evaluate the impact of enablers on the performance, predict performance and link measures to goal. An integration function can be embedded in a SCPM system to evaluate and predict the performance, characterise measures and link measures to strategy. Some papers developed models/frameworks that could feature under more than one function. This section will discuss the four alternative functions to design a SCPM system and will then show how they can be combined to result in more potential tracks to design a SCPM system.

Table 1: Classification of SCPMSs with respect to functions

Process focus	Role: identify, evaluate, link the measures with the goal, identify processes that require improvement:
Scope	- measure supply chain performance in order to manage and improve (Agami et al., 2012; Chan and Qi, 2003b; Bhagwat and Sharma, 2007; Bigliardi and Bottani, 2010; Wong and Wong, 2007) - evaluate performance (for example of logistics processes (Bullingery et al., 2002); during disaster response and reconstruction projects (Santarelli et al., 2015)) - measure the holistic performance of a complex supply chain system (Chan and Qi, 2003a) - analyse SCP (Piotrowicz and Cuthbertson, 2011) - link measures to goal (Elgazzar et al., 2012; Presutti and Mawhinney, 2007; Theeranuphattana and Tang, 2008)
Tools	- SCOR (Bai et al., 2012) - BSC (Bhagwat and Sharma, 2007; Bigliardi and Bottani, 2010) - SCOR and BSC (Bullingery et al., 2002) - BSC, SCOR and TOC (Agami et al., 2012) - SCOR and POA (Theeranuphattana and Tang, 2008) - POA (Chan and Qi, 2003b) - SCOR and EVA (Presutti and Mawhinney, 2007) - Fuzzy, SCOR and DS/AHP (Elgazzar et al., 2012) - content, context, process (CCP) framework (Piotrowicz and Cuthbertson, 2011) - DEA (Wong and Wong, 2007)
Analytical tools	- Simulation: Bass diffusion model (Chan et al., 2014); Simulation (Ramanathan, 2014) - Fuzzy logic: Fuzzy set theory (Chan and Qi, 2003b; Olugu and Wong, 2012); Fuzzy-AHP (Elgazzar et al., 2012) - DEA: (Wong and Wong, 2007, Agrell and Hatami-Marbini, 2013) - Mathematical programming: Optimisation and TOC (Agami et al., 2012) - Statistical process control charts: SPC (Morgan and Dewhurst, 2007)
Performance measures	- SCOR metrics and measures (Bai et al., 2012; Elgazzar et al., 2012; Presutti and Mawhinney, 2007; Theeranuphattana and Tang, 2008) and balanced scorecards (Agami et al., 2012; Bullingery et al., 2002; Bhagwat and Sharma, 2007; Bigliardi and Bottani, 2010) - ambition, reality and facility (Lauras et al., 2011) - cost, time, capacity, capability, productivity, utilisation and outcome (Chan and Qi, 2003b) - response time, reliability/flexibility, cooperation/standardisation, beneficiaries' and donors' satisfaction; and cost-performance (Santarelli et al., 2015) - technical efficiency and cost efficiency (Wong and Wong, 2007)
Practical implications	- influence external performance outcomes, specifically process customer satisfaction (Bai et al., 2012) - design performance measurement over the whole SC (Bullingery et al., 2002)

	• enables managing and analysing SC processes through structuring and mapping SC processes (Bhagwat and Sharma, 2007; Chan and Qi, 2003b; Wong and Wong, 2007) • formulating strategies for improved SCM through linking such strategies to the focus area of enhancing the financial performance (Elgazzar et al., 2012) • supports decision making and process control at a SC network level in order to tackle problems of heterogeneity between SC partners (Lauras et al., 2011) • links corporate performance and supply chain performance in a way to help customers and shareholders (Presutti and Mawhinney, 2007) • monitoring the progress of the SC and systematically aligning the metrics with strategies (Theeranuphattana and Tang, 2008) • define a set of best practice approaches to improve the effectiveness and efficiency of humanitarian supply chains (Santarelli et al., 2015)
Prioritisation	**Role: identify, evaluate and prioritise measures**
Scope	• identify and prioritise measures that are evaluating the entire function of the SC (Chan et al., 2003; Sahu et al., 2015); from evaluating the value adding activities in the entire SC (Askariazad and Wanous, 2009) to identifying the most significant practices (Govindan et al., 2015) as well as benchmarking (Sahu et al., 2015) • develop internal focus models (Tyagi et al., 2015; Sharma and Bhagwat, 2007; Kocaoˇglu et al., 2013; Khalili-Damghani et al., 2012; El-Baz, 2011) • models developed to evaluate the environmental performance (Perera et al., 2013); and environmental and economic performances (Govindan et al., 2015); and sustainable performance (Tajbakhsh and Hassini, 2015)
Tools	• AHP (Perera et al., 2013; Kocaoˇglu et al., 2013; Askariazad and Wanous, 2009) • Fuzzy AHP (El-Baz, 2011; Cho et al., 2012; Chan, F. T. S. et al., 2003) • BSC-AHP (Sharma and Bhagwat, 2007) • DEMATEL (Govindan et al., 2015; Tyagi et al., 2015) • DEA (Khalili-Damghani et al., 2012; Tajbakhsh and Hassini, 2015) • TOPSIS and SCOR (Kocaoˇglu et al., 2013) • SCOR, pairwise analysis, eigenstructure analysis (Cai et al., 2009) • Fuzzy logic and grey relational analysis (GRA) (Sahu et al., 2015)
Analytical tools	• Simulation: System dynamics (Cai et al., 2009) • Fuzzy logic: Fuzzy DEMATEL (Govindan et al., 2015; Tyagi et al., 2015); Fuzzy Delphi Method (Tseng et al., 2015); Fuzzy-AHP (Chan et al., 2003; El-Baz, 2011; Cho et al., 2012); Fuzzy TOPSIS, fuzzy VIKOR (Chithambaranathan et al., 2015) • DEA: Fuzzy two-stage data envelopment analysis (FTSDEA) (Khalili-Damghani et al., 2012); Data Envelopment Analysis (DEA) model using Epsilon-Based Measures (EBMs) (Tavana et al., 2013)
Performance measures	Different measures have been used with respect to the systems' needs and goals • demand management, CRM, SRM, capacity and resource management, service performance, information technology management and service supply chain finance (Cho et al., 2012) • engineering, planning, production and customer service (El-Baz, 2011)

	•	reverse logistics, green design, green purchasing, carbon management, supplier & customer environmental collaboration, ISO certification, internal management support, economic performance (Govindan et al., 2015)
	•	product and process design, packaging, transportation and collection, recycling and disposal (Perera et al., 2013)
	•	green design, corporate sustainability, strategic planning for environmental management, supplier cost-saving initiatives and market share (Tseng et al., 2015)
	•	customer satisfaction, degree of integration across the SC, alignment of systems throughout the SC, adoption of a market orientation (Tyagi et al., 2015).
	•	direct and intermediate sustainability measures for economic returns, environment impacts, and meet social expectations (Tajbakhsh and Hassini, 2015)
	•	strategic, tactical and operational performance measures (Sahu et al., 2015)
Practical implications	•	theoretical examples (Chan et al., 2003; El-Baz, 2011)
	•	practical examples applied to service sector (hotel SC) (Cho et al., 2012)
	•	speeding up performance improvements in dynamic SC decision-making environments (Cai et al., 2009)
	•	achieving the strategic goals through connecting SC goals to a series of measures and enablers (Askariazad and Wanous, 2009; Khalili-Damghani et al., 2012; Kocaoˇglu et al., 2013; Tyagi et al., 2015)
	•	managing environmental performance (Govindan et al., 2015; Perera et al., 2013)
	•	puts emphasis on the stakeholder requirements (Tseng et al., 2015)
	•	evaluate the sustainability of a chain of business partners based on a supervisory model applied to two case studies; one in the manufacturing sector and the other in the banking sector (Tajbakhsh and Hassini, 2015).
	•	empirical example to exhibit application potential of a decision support system (DSS) to facilitate SC performance appraisement, benchmarking and related decision making (Sahu et al., 2015).
Integration	**Role: evaluate, characterise, and predict the performance, link measures to strategy**	
Scope	•	evaluate SC performance in balanced way considering different perspectives (Beamon, 1999; Bhagwat and Sharma, 2007; Bigliardi and Bottani, 2010)
	•	characterises the performance of the collaboration in SC (Gruat et al., 2007)
	•	predict the performance of a SC based on the elasticity between supply and demand (Hull, 2005)
	•	linking performance to strategy (Morgan, 2004)
	•	evaluate the effectiveness of SCM (Otto and Kotzab, 2003); evaluate the efficiency and effectiveness and flexibility within the SC (Sabri and Beamon, 2000).
Tools	•	volume flexibility measure (Beamon, 1999)
	•	BSC (Bhagwat and Sharma, 2007; Bigliardi and Bottani, 2010)
	•	the collaboration characterisation model and the collaboration orientated model (Gruat et al., 2007)
	•	elasticity formulas (Hull, 2005)
	•	mathematical programming (Sabri and Beamon, 2000)

Analytical tools	• mathematical programming: multi-objective decision analysis (Sabri and Beamon, 2000) • regression modelling: multiple regression equation for extended supply chain performance (Dubey and Ali, 2015 and Dubey et al., 2015b)
Performance measures	Different measures have been used with respect to the aspects and perspectives of integration • resources, output and flexibility (Beamon, 1999) • finance, customer, internal business process, and learning and growth (Bhagwat and Sharma, 2007; Bigliardi and Bottani, 2010) • customers perspective and company perspective (Gruat et al., 2007) • SC responsiveness due to market shifts, capacity utilization, allocation problems, quantity impact of price discounts or cost increase (Hull, 2005) • performance measures link strategy, the supply chain, the value adding process, the distribution chain and the customer (Morgan, 2004) • system dynamics, operations research, logistics, marketing, organisation and strategy (Otto and Kotzab, 2003) • cost, customer service levels and flexibility (Sabri and Beamon, 2000)
Practical implications	• enables the flexibility application to SCs in the manufacturing sector , in terms of how well the system reacts to uncertainty (Beamon, 1999) • provides a useful guidance for the managers in mapping , evaluation and measuring of SC in a balanced way (Bhagwat and Sharma, 2007) • provides an integrated SCM framework for the food supply chain, however the framework needs further validation (Bigliardi and Bottani, 2010) • predicts the supply chain's ability to respond to supply interruptions, cost increases, and demand shifts and quantify the degree to which it is prone to the bullwhip effect (Hull, 2005) • provides an integrated performance control system to enable proactive management and continuous changes (Morgan, 2004) • proposes metrics and solutions for different SCM perspectives. However, empirical validation in two directions (perspectives and corresponding metrics) is required to gain the holistic view of SCM (Otto and Kotzab, 2003) • aids in evaluation of competing SC networks and facilitates coordinated decision-maker interaction; however, empirical validation is required (Sabri and Beamon, 2000)
Causal frameworks	**Role: Identify and link measures to goal, predict performance, evaluate the impact of enablers on the performance**
Scope	• evaluate the impact of quality assurance systems (QAS) on the performance of the SC (Aramyan et al., 2009) • evaluate the impact of a set of lean, agile, resilient and green (LARG)SCM practices on SC performance (Azevedo et al., 2011) • identify the key SCPMS implementation variables that impact the effectiveness and efficiency of the SC (Charan et al., 2008) • link SC measures to organization performance through utilising the interrelationships between SCM dimensions, SCM performance and organisation performance (Deshpande, 2012) • predict the performance of the SC processes based on causal relationships between metrics of SCOR model (Ganga and Carpinetti, 2011) • link SC performance to the financial performance (Wisner, 2011)
Tools	• self-explicated method, survey (Aramyan et al., 2009) • interpretive structural modelling-based approach (Charan et al., 2008)

	• AHP (Deshpande, 2012) • fuzzy, SCOR (Ganga and Carpinetti, 2011) • financial statements (Wisner, 2011)
Analytical tools	• simulation: system dynamics (Ip et al., 2011; Jaipuria and Mahapatra, 2015) • interpretive structural modelling-based approach (Charan et al., 2008)
Performance measures	• efficiency, flexibility, responsiveness and quality (Aramyan et al., 2009) • operational measures (inventory levels, quality, customer satisfaction and time)/ Economic measures (cost, environmental cost and cash to cash cycle)/ Environmental measures (business wastage) (Azevedo et al., 2011) • "enablers" and "results" variables. The enablers help the SCPMS implementation. The results are the outcome of the SCPMS implementation (Charan et al., 2008) • SC delivery flexibility, inventory cost and customer response time (Deshpande, 2012) • SCOR metrics (Ganga and Carpinetti, 2011) • financial statements' components (Wisner, 2011)
Practical implications	• helps to decide trade-offs between QAS requirements throughout the chain (Aramyan et al., 2009) • offers a checklist to identify possible LARG practices to achieve the operational, economic and environmental SC performance objective (Azevedo et al., 2011) • enables the senior management to determine the key SCPMS implementation variables on which they should focus in order to improve the effectiveness and efficiency of the SC (Charan et al., 2008) • enables managers to meet desired goals through managing long-term relationships between elements of SCM, however the framework needs support with empirical study (Deshpande, 2012) • helps managers in predicting and managing SC performance through establishing causal relations among the performance metrics. The system presented by numerical example (Ganga and Carpinetti, 2011) • enables managers to ensure the compatibility of supply chain actions and decisions with the company's financial goals (Wisner, 2011)

3.1 The process-focused systems

These SCPM systems focus on the key SC processes with the use of mapping for the purpose of identifying those that are not reaching the desired performance. Prior to the late 1990s, SCPM systems were functionally focused. In the late 1990s, there was a shift from function-focused to process-focused measurement systems (Christopher, 1992). This phase witnessed attention towards the process orientation within organisations rather than function- and product-oriented structure through viewing the organisation as a linked chain of activities cutting across departments. During this phase several authors suggested implementing business processes in the context of the SCM (Cooper et al., 1997; Bowersox et al., 1999; Mentzer, 2001). Various applications have been adapted within organisations to establish process orientation; however process mapping was considered the most concrete application for process orientation (Hellström and Eriksson, 2008).

The review revealed that the general scope for the majority of papers under this function is to evaluate SC process performance in order to identify processes that are working well and those that need improvement. Some frameworks, however, were developed to link performance to goal (Theeranuphattana and Tang, 2008; Elgazzar et al., 2012).

The papers reviewed and grouped under this function rely mainly on the SCOR model metrics. The SCOR model is considered the widest business process model implemented and utilised by the researchers to measure SC performance (Huang et al., 2004; Hwang et al., 2008; Theeranuphattana and Tang, 2008; Camerinelli, 2009; Kremers, 2010; Bai and Sarkis, 2012; Kocaoˇglu et al., 2013), while other papers merged the SCOR model with other process-based frameworks such as the balanced scorecard (BSC) (Agami et al., 2012;

Bullingery et al., 2002) and highlighted the BSC approach and the SCOR model as the most commonly used metrics (Piotrowicz and Cuthbertson, 2015).

Other frameworks have been highlighted in Estampe et al. (2013) including SCOR, GSCF, BSC, Activity-Based Costing (ABC) and Efficient Customer Response (ECR).

The developed systems that have a process focus can enable practitioners to control the SC performance through structuring and mapping the key SC processes, making the analysis of the performance and the identification of areas of improvement more traceable. Additionally, process-focused frameworks can help managers to formulate strategies for improved SCM through linking them to the focus area of enhancing performance. The review, however, showed that most of the frameworks were demonstrated from a theoretical perspective with limited practical implementation.

3.2 Prioritisation frameworks

Prioritisation was found to be one of the main functions studied by researchers in the area of SCPM systems. The prioritisation function refers to the identification of the most relevant measures for the purpose of the performance measurement system and the assignment of relative importance weighting for the identified measures with respect to the system needs and goals.

The prioritisation of SC measures allows managers to align their SC performance measurement systems with the organisational goals through identifying the relevant SC performance measures and assigning their relative importance weights with respect to the strategic objectives (Elgazzar et al., 2012). Various approaches have been proposed to deal with the hierarchical nature of SC performance measures and to handle the complexities of the multi-criteria decision-making problems inherent in SC performance measurement

related decisions. The review revealed that the general scope for the majority of papers under the prioritisation function is to identify and prioritise performance measures; however some systems in this domain were developed to evaluate the performance.

The research in this domain relied mainly on three approaches: data envelopment analysis (DEA), analytical hierarchical process (AHP) and fuzzy logic. Some papers merged fuzzy theory with AHP or DEA (Chan and Qi, 2003b; El-Baz, 2011; Cho et al., 2012), while other papers merged fuzzy theory with process-based models (mainly BSC and SCOR) (Sharma and Bhagwat, 2007; Cai et al., 2009). The process-based models were used to determine the measures, then prioritisation approaches to rank the measures and aggregate them in a single indicator.

No specific measures were identified in this domain, the only concern was to consider both qualitative and quantitative measures taking different dimensions, functions and SC processes into consideration.

The developed frameworks can enable practitioners to choose the appropriate SC performance measures and assign their relative importance weights with respect to the companies' strategic priorities. Though the aggregation of SC performance measures provides a holistic view of analysing SC performances, companies should be able to drill down to different measures and different levels of detail in order to trace the contribution of each SC performance measure to the overall performance, and consequently recommend improvement strategies for those critical measures that need improvement. As the review revealed, most of the papers in this domain were presented in numerical examples or with limited application which gives reasons to further examine their validity and generisability.

3.3 Integration frameworks

Although most researchers and practitioners realise the importance of an integrated SCPM system, they do not always represent it in a balanced framework (Gunasekaran et al., 2004). Amongst the most widely highlighted criticisms of current integrated SCPM systems are (Chan, 2003; Chan and Qi, 2003a; Gunasekaran et al., 2004; Gunasekaran and Kobu; 2007; Ramaa et al., 2009; Akyüz and Erkan, 2010; Agami et al., 2012):

- Lack of the connection with the strategy

- Failure to integrate financial and non-financial measures

- Too many metrics and an incompleteness and inconsistency in performance measurement

- Lack of systems thinking

Since previous studies reported a significant impact on SC integration practices on a company's performance, understanding this relationship represents a key driver of a company's performance. The review highlighted several studies focused on the integration concept while developing a SCPM system. Integrated frameworks collate different goals, linkages or dimensions to manage and evaluate the performance of the SC. Definitions and measures of SC integration and performance are diverse in literature to the extent that until now literature has not provided a clear definition of SC integration, and thus, the relation between SC integration and performance remains vague (Fabbe-Costes and Jahre, 2008; Power, 2005; Kahn and Mentzer, 1996). Different approaches and models were proposed to address SC integration and its impact on the performance from different perspectives such as:

- incorporating different types of measures (financial and non-financial, quantitative and qualitative, or operational, economic and environmental)

- covering different business aspects (different processes, different functions or different dimensions)

- incorporating different levels of decision-making (operational, tactical and strategic)

- considering a set of objectives (sustainability, quality assurance, profitability, efficiency, managing cash flow or improving communication channels)

- addressing different directions (towards customers and/or towards suppliers)

- covering different domains (within the organisation and across the SC)

However, these perspectives are not mutually exclusive; an integrated SCPM system may address more than one of these perspectives. Aggregated performance measurement systems aim to present the "bigger picture" - i.e. the overall performance - which can be easier to interpret and communicate between different players within the SC (Tipi et al. 2008).

The review revealed that the general scope for the majority of papers under the function of integration is to evaluate the performance and link measures to strategy, however, some systems were developed to characterise and predict the performance. The measures used were both quantitative and qualitative and can be quantified using mathematical and economics formulas. No specific measures were identified in this domain; different ones have been used with respect to the aspects and perspectives of integration.

As the review revealed, the practical implication under this function was provided in different sectors. The integration between SC activities and operations is clearly reflected

in the value-added functions of the current developed integrated systems. However, what is not yet captured is the "evaluation of this integration over time" and the way in which developed systems can provide information on how to adjust SC activities and operations now, to have a positive effect on the future performance (Maestrini et al., 2018).

3.4 Causal frameworks

The review also revealed the causal relationship as one of the main functions targeted by many of the proposed SCPM systems. Causal frameworks relate the use of a set of practices or variables to the resulting performance. The review revealed that the general scope of the papers under the causality function is to evaluate the impact of enablers on the performance (Aramyan et al., 2009; Azevedo et al., 2011), however, some frameworks were developed to identify and link measures to goal and predict performance (Charan et al., 2008; Ganga and Carpinetti, 2011; Wisner, 2011; Deshpande, 2012).

The developed frameworks can enable managers to meet desired goals through managing long-term relationships between elements of SCM, establishing causal relations among the performance metrics and ensuring the compatibility between performance enablers and goals. However, the review showed that most of the frameworks were demonstrated from a theoretical perspective and further support from empirical studies is needed.

As shown in the previous discussion, various performance measurement systems have been proposed to evaluate SC performance; however, there is still a lack of an integrated SCPM system linking SC operational strategy to the strategic financial priorities (Gardner, 2004; Toyli et al., 2008; Elgazzar et al., 2012). Effective SCM requires a performance measurement system that can appropriately reflect actual SC performance from different perspectives (Azevedo et al., 2011). Developing a balanced performance measurement

system considers the environmental, social, economic as well as financial aspects as being critical to achieving successful implementation of SCM practices (Cagnazzo et al., 2010). In addition, the literature revealed that current performance measurement systems in SCM cannot fully address the conflict between the top down strategy decomposition and the bottom-up implementation process (Kocaoˇglu et al., 2013). Understanding the link between SCM practices and financial performance improvement could help companies to better manage SC processes through linking SC performance to the company's targeted financial objectives (Elgazzar et al., 2011).

Different types of SC systems require different performance measurement characteristics. Various SC performance measurement frameworks for different types of systems have been developed in order to facilitate the analysis and the evaluation of SC performance. Selecting the appropriate SCPM framework in order to identify, map and evaluate the processes in the entire SC is essential for providing a structure to assess the whole SC system.

Gunasekaran et al. (2001) indicated that several studies have provided insights into the design and implementation of performance measures in a SC context; however, the process of choosing an appropriate SCPM system is complex. To develop an effective SCPM system, the selected framework should be reliable, provide a scope of measurement and reveal the viability of strategies. Today's competitive SC environment requires an SC performance measurement framework which can: truly capture the essence of organisational performance; be based on a company's strategy and objectives; allow for setting targets; reflect a balance between financial and non-financial measures; relate to the different levels of decision-making and control; be determined through discussion with all

the parties involved; enable fast feedback and continuous improvement; adopt a proactive approach; clearly define the purpose and related methodology; be valid and reliable; be comparable to other performance measures used by similar organisations; enable aggregation and prioritisation; facilitate integration; be simple and easy to use; avoid overlaps; and be in the form of ratios rather than absolute numbers (Akyüz and Erkan, 2010). According to Tangen (2005), there is no single optimal measurement tool that can be applied to SC performance and different performance measures can be selected for different purposes. Firstly, the fundamental purpose of performance measurement should be defined, then the appropriate measure can be chosen according to the intended purpose. The level, type, direction and degree of integration are objects for the purpose of assessment and the context within which the SCPM system is developed.

Figure 1 demonstrates the four main design tracks that can be established with respect to the function of the SCPM system (the process focus, prioritisation, integration and causality). However, these four tracks are not mutually exclusive. When designing a SCPM system, more than one function can be considered based on the scope of the system. As illustrated in figure 1, the role of any SCPM system - regardless its function - is based on two main pillars: evaluating the performance and linking measures to goals. For each design track, the system starts with evaluating the performance to determine the source of poor performance. Consequently, the relevant system's functions are determined to link measures to the company's goal. This can be achieved through different functions according to the company's context. A relationship between two or more functions can be created to include more functionality based on the needs of the company to create a

complex system. Figure 1 illustrates how the relationship can be established between two or more functions to design a SCPM system.

The functionality of the SCPM system can be designed at four levels creating ten possible scenarios when designing a company's SCPM system. The minimum level will consider only one function when designing a SCPM system based on one of the four scenarios illustrated earlier (the process focus, prioritization, integration, or causality). At the second level of system complexity two functions can be merged - as illustrated with dotted arrows in figure 1- following one of three possible scenarios (the process focus and prioritization; prioritisation and integration; integration and causality). The third level considers three functions in designing a SCPM system following one of two possible scenarios (the process focus, prioritization and integration) or (prioritisation, integration and causality). At the fourth level, the four functions can be embedded in one SCPM system to design a closed loop complex system as illustrated in figure 1.

In the next section, a conceptual framework will be formulated based on the analysis of the conceptual matrix to set guidelines on how to design a SCPM system that suits the need of the performance measurement process.
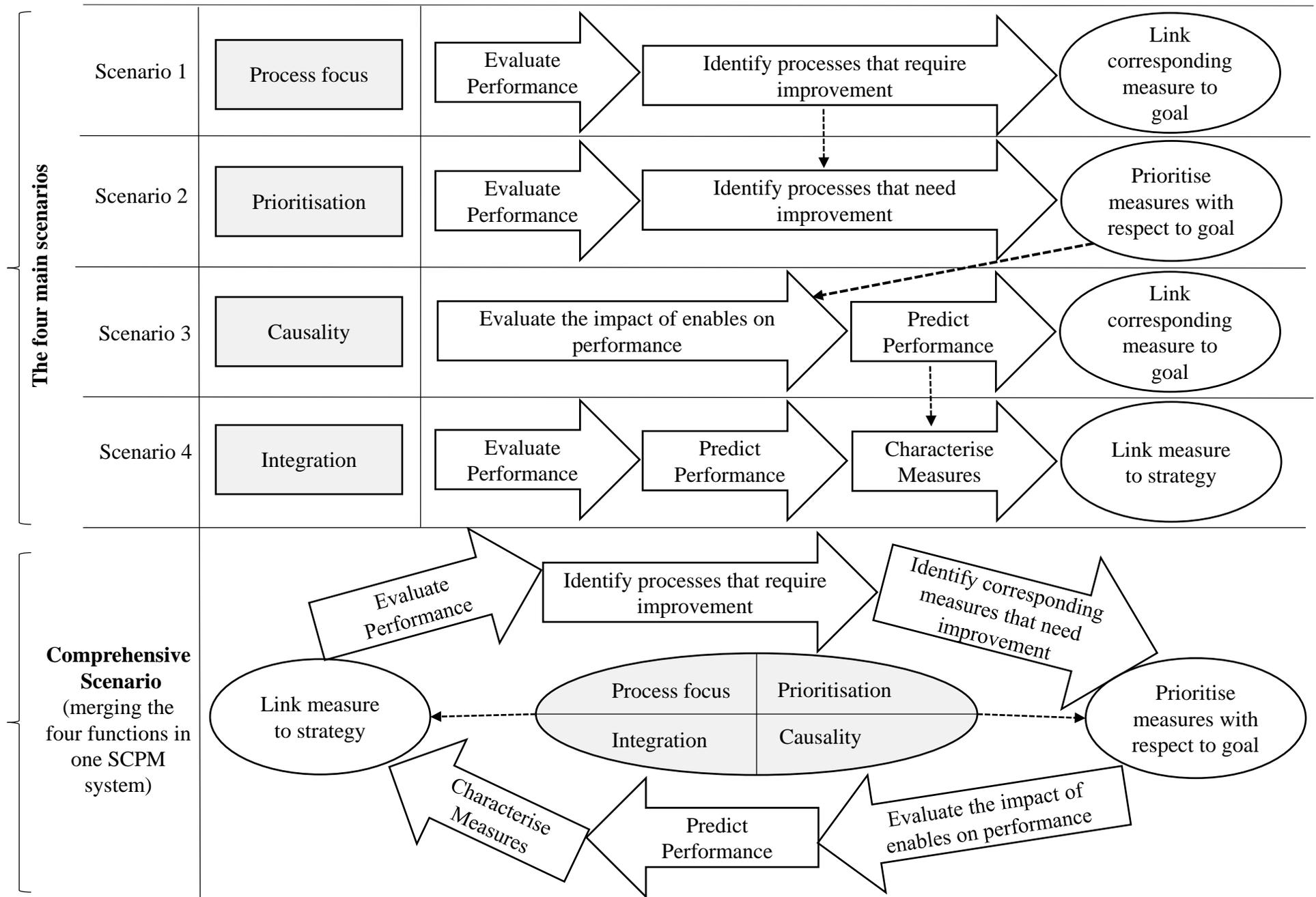
Figure 1: The functions of SCPM systems and their corresponding scenarios

4. Discussion

The effectiveness of the SCPM system in terms of performance improvement is influenced by the SC context. Since SC performance is not a one-dimensional concept, the distinct effect of different dimensions (practices, patterns and attitudes) on different SC performance measures should be considered (Gimenez et al., 2012). Figure 2 illustrates a framework consisting of the pre-design and the design phase, however the authors recognise the relevance of extending this to the implementation phase.

Analysing the characteristics, trends and relationships within an organisation's internal and external environment is considered one of the most important aspects of developing an appropriate SCPM system (Neely et al., 2005; Willis and Anderson, 2010; Olugu and Wong, 2012; Chithambaranathan et al., 2015).

After analysing the external and internal environment, the next step should be analysing the structure of the targeted SC.

The SCPM system can be designed toward measuring the internal performance of each actor in the chain and targeting companies with intra- and inter-organisational maturity levels or it can be designed toward measuring all of the actors in the chain and targeting companies, whose maturity levels have an extended, multi-chain or societal organisation (Estampe et al., 2013).
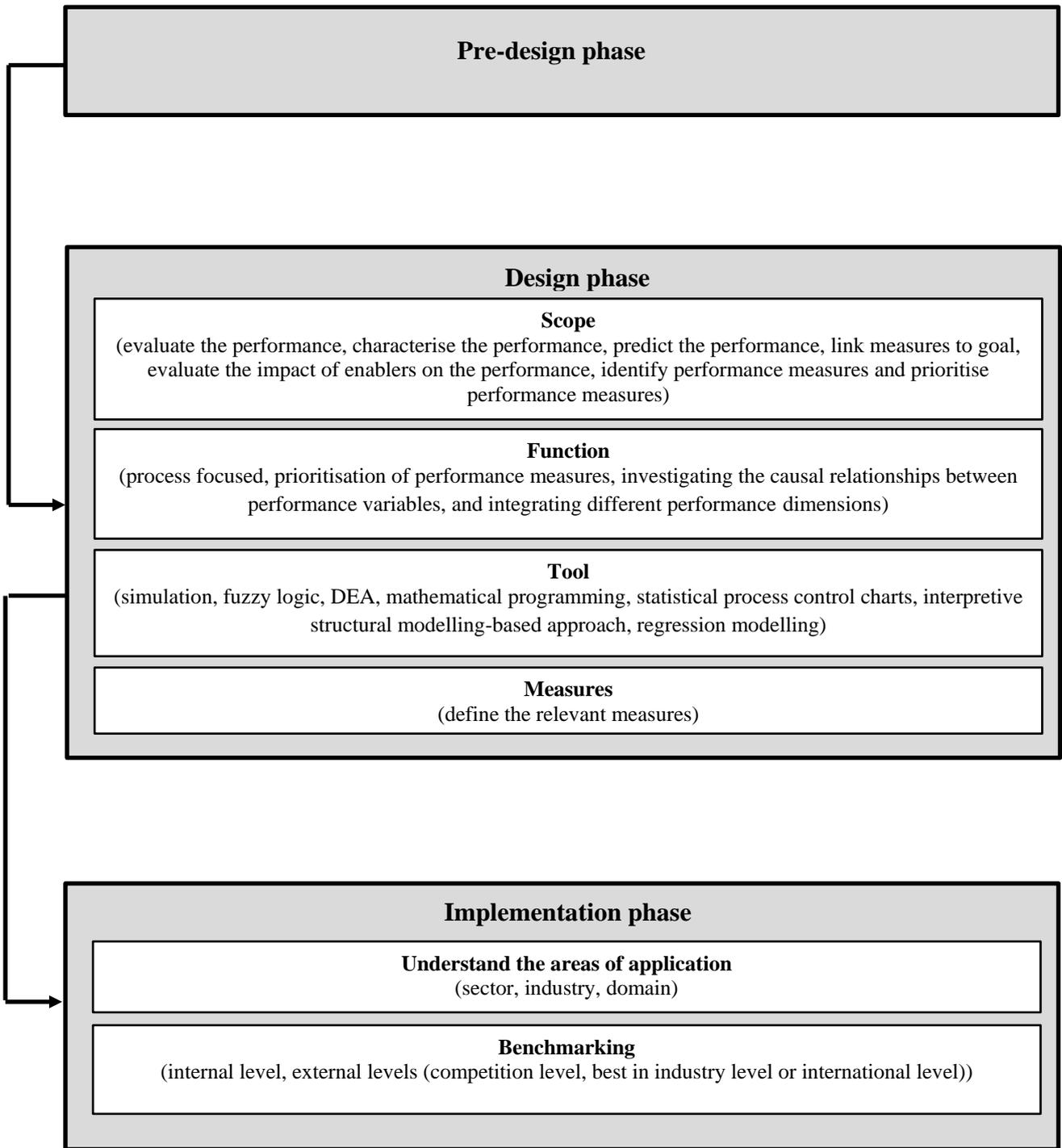
Pre-design phase

Design phase

Scope
(evaluate the performance, characterise the performance, predict the performance, link measures to goal, evaluate the impact of enablers on the performance, identify performance measures and prioritise performance measures)

Function
(process focused, prioritisation of performance measures, investigating the causal relationships between performance variables, and integrating different performance dimensions)

Tool
(simulation, fuzzy logic, DEA, mathematical programming, statistical process control charts, interpretive structural modelling-based approach, regression modelling)

Measures
(define the relevant measures)

Implementation phase

Understand the areas of application
(sector, industry, domain)

Benchmarking
(internal level, external levels (competition level, best in industry level or international level))

Figure 2: A conceptual framework for the design and implementation of a SCPM system

4.1 Design phase

4.2.1 Identify the scope and function of the SCPM system

Once the pre-design stage is carried out, the main scope of the SCPM system should be identified. The review revealed several scopes of the SCPM system: evaluate the performance, characterise the performance, predict the performance, link measures to goals, evaluate the impact of enablers on the performance, identify performance measures and prioritise performance measures (see Table 1).

As illustrated in section three, a SCPM system can be under one or more of the following functions: focuses on SC process, prioritises performance measures, investigates the causal relationships between performance variables, and integrates different performance dimensions. Accordingly, the design of the SCPM framework could consider more than one function.

4.2.2 Select SCPM system tools and measures

Over the years, researchers have employed different analytical tools to construct performance measurement systems. Some of these have been captured in the papers evaluated in this research and they comprise simulation, fuzzy logic, DEA, AHP, mathematical programming, statistical process control and structural modelling approach (see table 1). The purpose of this research is not directed at all the material that uses analytical tools, as it is focused more on reviewing and assessing the performance measurement systems that are present in the literature and designed for SCs. Therefore the deduction in this case is primarily based on the papers selected for this investigation.

Simulation and system dynamics have been used to analyse the interdependent relationship between different key performance indicators (Cai et al., 2009). Other models have

employed system dynamics and ARIMA (Ip et al., 2011) to analyse and predict the stability for long-term management. The predictive aspects have also been indicated in Jaipuria and Mahapatra (2015) to evaluate the effect of the propagation of uncertainties in the SC from lower to upstream. Chan et al. (2014) use simulation to measure the level of innovation of a firm, while Ramanathan (2014) also used simulation to identify the conduciveness of collaboration required for performance improvement and the achievement of business objectives.

Fuzzy logic has been identified as a distinctive category that appears in connection with other tools. Fuzzy set theory has been used by Chan and Qi (2003b) to set importance weights when measuring the performances of a complex SC system. Olugu and Wong (2012) used fuzzy rule-based evaluation methodology for closed loop performance measurement systems. Fuzzy logic applications also appear in combination with other tools such as fuzzy AHP which aims to analyse performance measures at different levels of aggregation, or fuzzy TOPSIS, fuzzy VIKOR (Chithambaranathan et al., 2015) which are based on an MCDM approach to analyse the performance of SC members.

The DEA analytical tool, well known for its benchmarking ability (Agrell and Hatami-Marbini, 2013), is also present in this review with the efficiency model (Tavana et al., 2013; and Khalili-Damghani et al., 2012), as well as the technical efficiency and the cost efficiency model from Wong and Wong (2007).

Other analytical tools identified are the statistical process control charts (Morgan and Dewhurst, 2007) and the interpretive structural modelling-based approach (Charan et al., 2008). Mathematical programming has also been identified for multi-objective decision analysis and optimisation (Sabri and Beamon, 2000; Agami et al., 2012). Multiple

regression equations and factor analysis have also been used as tools in developing and evaluating different aspects of supply chain performance measures (Dubey and Ali, 2015). Several metrics and measures have been proposed for SCP (see table 1). Akyüz and Erkan (2010) highlighted the importance of the balanced scorecard approach and the SCOR model as the foundation of research in the SC performance measurement field. However, the process of development of metrics and measures should consider different structures of the SC through understanding the level of synchronisation of its activity with the level of complexity in the management of measures for each SC structure (Gopal and Thakkar, 2012). Moreover, to select the relevant measures when designing a SCPM system, the external focus of the SC structure should be studied in terms of customers and competitors, clear visibility of customers demand and understanding of collaborative relationships (Tyagi et al., 2017).

4.2 Implementation phase

4.2.1 Define the area of application

The area of application in terms of sector (service or manufacturing), and industry as well as the domain of application should be defined. SCPM systems can be applied in both service and manufacturing sectors, however the review revealed that the majority of research focused on the manufacturing sector. Work in the area of performance measurement systems has been applied to different industries such as the food industry (Bigliardi and Bottani, 2010), retail (Morgan and Dewhurst, 2007), hotels (Cho et al., 2012), the automotive industry (Govindan et al., 2015; Dörnhöfer and Günthner, 2017) and beverages (Elgazzar et al., 2012; Moreira and Tjahjono, 2016).

Different domains of application have been tackled: simulation, humanitarian logistics, green logistics/sustainability, purchasing, information system and manufacturing. The two main areas of application highlighted by the review are information systems (Sambasivan et al., 2009a; Sambasivan et al., 2009b; Dobson et al., 2007; Morgan and Dewhurst, 2007; Barut et al., 2002) and the green SC (Thanki and Thakkar, 2018; Dubey and Ali, 2015; Chithambaranathan et al., 2015; Govindan et al., 2015; Perera et al., 2013; Olugu and Wong, 2012; Azevedo et al., 2011; Hervani et al., 2005). The review revealed that the general scope of the papers in the information systems area is to evaluate the performance. The papers in this area focus on information sharing along the SC. The domain is still immature and few papers are published in this area with limited practical implication. No specific measures were identified, however the measures focused mainly on assessing the information sharing in terms of time, accuracy and intensity in addition to assessing documentation and the financial cycle.

The main scope of SCPM systems applied in the area of green SCs was to propose a set of green practices and to analyse their impact on the SC performance. Several practical implications were indicated in this area for the purpose of enabling managers to identify the most significant green SCM practices in improving environmental, operational and economic performances. Several analytical tools were used, particularly fuzzy logic.

Other frameworks in the area of purchasing, such as Transaction Cost Economics and the Resource Based View have been identified in Spina et al. (2015), who conducted a systematic literature review from 2002-2010 on purchasing and supply management area.

4.2.2 Benchmarking

The last step is to decide how the SC performance benchmarking process will be designed and implemented. According to Beamon (1999), benchmarking is an important step in developing an appropriate SCPM system as it can serve as a method of identifying SC performance improvement opportunities. The main idea behind benchmarking is to identify best practices, study these practices, make plans for improving the performance, implement them and finally, monitor and evaluate the results. In short: benchmarking is to identify and implement best practice (Helgason, 1997). Benchmarking in SCs commenced in the mid-1990s. The initial approach to model SC benchmarking focused on addressing performance measures and later moved into applying benchmarking in an integrated perspective. Compared to other fields, benchmarking in the SC context involves complex relationships and unknown trade-offs between multiple inputs and outputs. The most critical issue in the SC benchmarking process is to define the appropriate performance measures and the integration between them in order to establish the correct metrics to measure a company's performance (Wong and Wong, 2008). In addition, designing and implementing a benchmarking process requires consideration of the level at which benchmarking can take place. Benchmarking can be applied at an internal level or at external levels (competition level, best in industry level or international level). The selected benchmarking level should be relevant to the focus and the purpose of the benchmarking process (Estampe et al., 2013).

5. Conclusion

The novelty of this work lies in providing a comprehensive review summarising the development in the field of SCPM system over a time span of 20 years (1995 – 2015) in order to answer the two research questions.

The first research question is concerned with the main SCPM system characteristics identified over the past two decades. The review conducted here brings a new dimension to the supply chain performance measurement research by identifying a set of characteristics focused on the main functions (process focus, prioritisation, integration and causality) of SCPM systems. Putting the emphasis on these functions brings a new understanding that will allow practitioners to set up a SCPM system relevant to its intended purpose.

Many reviews referred to classifications of SC measures according to particular developments of measures, while this review is focused on previous research that captures the models, frameworks or systems established as an accumulation of measures that are considered to be working together. The review revealed the SCOR model is the most applied of the SCPM frameworks; and confirmed the importance of the BSC.

The review indicates that SCPM systems can be used as a strategic tool that enables companies to evaluate, manage and continuously control the entire set of SC operations in order to achieve their objectives and goals.

This work illustrates the main elements that should be considered when designing and implementing a SCPM system. First, the characteristics, the structure and the strategy of the targeted SC should be analysed. Then, the SC framework is to be designed with a focus

on system, tools used and measures. Finally, the area of application is analysed and the benchmarking process is designed and implemented.

6. Future agenda

A research agenda with a number of research directions that can facilitate the development in the SCPM field is identified and discussed in this section.

The framework proposed here synthesises important elements to be considered for the design and adoption of an effective SCPM system according to particular needs, which can aid researchers and practitioners in applying the appropriate approaches, techniques and measures effectively. Further research can consider elements required to guarantee the effectiveness of the implementation phase of a SCPM system. Maestrini et al. (2018) bring in the idea of a lifecycle framework looking at the effectiveness of a developed supply chain performance measurement beyond the design phase to fully understand if the system is effective.

Capturing the link between strategic objectives and SC processes still requires further attention in the literature as there are aspects that should be explored further in terms of how to model SC processes and how to analyse their performance.

The need to implement a cross-functional business process performance management system has now been recognised. More focus on the SCOR model can help in integrating aspects from different domains (for example, financial, human resource, information, communication & technology, product & portfolio management and sales). With this, an integrated SCPM system can be developed to maintain and monitor information, relationships, resources, assets, business rules, compliance and contracts required to operate the SC.

The SCOR model also proposes a set of strategic environmental metrics that can be added to the model to be used as an effective tool for environmental assessment. Further studies are suggested on the "green metrics" of the SCOR model to be applied to and investigated for environmental performance aspects and green practices.

This sheds light on the importance of performance measurement of sustainable SCs as a competitive requisite in the new business environment. The need for applied sustainable SCPM systems can be the next phase of research in this area in order to face the challenge of fulfilling multiple and conflicting objectives in the new competitive business environment where the environmental and social criteria became an essential element for success. Despite the increasing attention of academia in the area of sustainable SC performance measurement, few studies addressed this topic (Linton et al., 2007; Carter and Rogers, 2008; Bai et al., 2012; Hassini et al., 2012; Dubey et al. 2015a; Dubey et al. 2015b; Acquaye et al. 2018). In addition, most of these studies can be considered as first generation studies focusing on the knowledge related to SC, performance measurement and sustainability, while there is a lack of relevant performance frameworks for industry and practitioners (Taticchi et al., 2013).

The review also revealed that large firms have an advantage over small and medium-sized enterprises (SMEs) when adopting sustainable practices. Thus, more research on the adoption of sustainable practices in SMEs is required (Hassini et al., 2012).

Moreover, the collaborative performance that has become essential for the new business environment requires competition between SCs rather than companies. In essence, further research is required to develop a predictive SCPM system that can be more proactive and

deal with uncertainty in order to enable the SC to respond at the right time, while minimising costs and satisfying service-level requirements.

Although the SC financial performance link is considered one of the recent topics of SC performance research studies, SCM is not yet at the forefront of determining a company's financial performance. A limited number of studies have been conducted to reveal links between SCM practices and financial performance improvements, which means that the concept and application of this idea is in need of further research (Gunasekaran et al., 2004; Woei, 2008; Camerinelli, 2009; Kremers, 2010; Wisner, 2011; Wagner et al., 2012).

There is also great scope for further research in the domain of SC measures and metrics, specifically the issues related to characteristics of measures and metrics, benchmarking of measures, use of management practices, integration and partnership and socio-environmental relevance (Gopal and Thakkar, 2012). Future work to model SC benchmarking is required. Although several approaches to modelling SC benchmarking have been proposed by researchers, some gaps concerning SC benchmarking research still exist. There is a need to develop an adequate methodology to determine the relative importance of performance measures, which vary among companies, and then to aggregate them into a single index of overall performance from which a company can compare its SC performance with other industry members (Simatupang and Sridharan, 2004a, b; Wong and Wong, 2008).

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