Supply chain performance measurement systems: a qualitative review and proposed conceptual framework

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Abstract: Management of supply chain (SC) is becoming more challenging with every passing day due to high competition, globalisation, and digitalisation because of the recent adoption of internet of things (IoT) technologies in order to increase supply chain visibility. Due to this fact, importance of supply chain performance measurement systems (SCPMS) has been increased significantly. To cope with these challenges and remain competitive, organisations are keen to evaluate SC performance more precisely. Therefore, this paper adopts a qualitative review methodology to find out if existing SCPMS are in line with the current emerging technology trends of managing SC and measuring SC performance and if not, what will be the characteristics of future SCPMS. Results show particularly that existing SCPMSs are not adequate to cope with the complexity and the technology advancement observed in supply chain management as a smart way for measuring modern SC performance is needed. Finally, this study proposes a conceptual supply chain performance measurement (SCPM) framework to fill the identified research gaps.

Keywords: supply chain management; SCM; supply chain performance measurement systems; SCPMS; knowledge base system; integrated framework; qualitative review.

Reference to this paper should be made as follows: Khan, S.A., Chaabane, A. and Dweiri, F. (2020) 'Supply chain performance measurement systems: a qualitative review and proposed conceptual framework', *Int. J. Industrial and Systems Engineering*, Vol. 34, No. 1, pp.43–64.

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1 Introduction

Supply chain (SC) managers need a responsive and effective way to manage and evaluate their SC performance. Every decision is important and essential for SC performance and has an impact (directly and indirectly) on overall SC performance. Moreover, experts' opinion and decision makers' knowledge are essential in measuring overall SC performance. Managers and decision makers need to know how well their SC is performing (Sillanpää, 2015). Dweiri et al. (2015) mentioned that emerging trends in the use of IT created an opportunity for organisations to improve organisation performance. Nowadays, organisations are competing with each other by their SC performance. Shorter product life cycle, advancement in technology, and globalisation forced organisations to deliver products more rapidly than before. Ashrafuzzaman et al. (2016) mentioned that in addition to customer expectation, effective management of SC is one of the most important factors for better performance. It is essential for organisations to serve as the principal motivations that force decision makers at each level of SC to evaluate and improve SC process (Miranzadeh et al., 2015). It is important for organisation to know the overall SC performance (Khan, 2013). Therefore to deal with these challenges, organisations need to evaluate their SC performance more effectively. In order to do that they need adequate and appropriate supply chain performance measurement systems (SCPMS) that evaluates SC performance precisely after considering all SC performance criteria. SC performance evaluation is as important as supply chain management (SCM) (Gunasekaran et al., 2001). In addition, developing appropriate SCPMS is fairly difficult due to the complexity of SC network. In performance measurement (PM) of SC, we need to get information about how well each SC functions decision criteria is performing. At the same time, we need to identify which decision criteria at which decision-making level (strategic, tactical, and operational) needs extra attention. SCPMS main purpose is to improve SC efficiency and effectiveness. Moreover, another purpose of SCPMS is to provide management with a guideline for better decision-making and support in analysing and improving organisation overall performance (Tangen, 2005). Almeida et al. (2016) indicated that an organisation needs to improve the quality of their PM system. As per Charan et al. (2008) "a useful, integrated and balanced SCPMS can employ the organisation's PM system as a medium for organisational change and facilitate inter-understanding and integration among the SC members". One of the main challenges the organisations are facing nowadays is to know how to measure and control the performance of SC networks (Mishra and Sharma, 2017).

In recent years, many literature reviews and papers related to SCPMS have been published by researchers, and they classified articles in terms of different perspectives such as balance scorecard perspective, SC link, decision-making level (Gunasekaran and Kobu, 2007); PMSs and its increasing importance (Chan et al., 2006); methodology and content of PMS (Akyuz and Erkan, 2010); performance dimensions and measurement process of PMS (Cuthbertson and Piotrowicz, 2011); PM life cycle (Gopal and Thakkar, 2012); performance dimensions and their qualitative and quantitative nature of PMS (Shepherd and Gunter, 2006); review and classification of PMS (Agami et al., 2012); general SCPMS (Balfaqih et al., 2016); general characteristics, clear definition of SCPMS and content of PMS (Maestrini et al., 2017); purpose and scope of the model, supply chain strategy, choice of metrics, modelling uncertainty, type of model, techniques, learning capacity, type of application, data sources (Lima-Junior and Carpinetti, 2017); and two-dimensional framework to classify and review SCPMS (Manikandan and Chidambaranathan, 2017).

The proposed study is different from the systematic literature review in SCPMS conducted by Maestrini et al. (2017) by several means. Firstly, they adopted a systematic literature review methodology by collecting published articles (from 1998 to 2015) in SCPMS for providing up-to-date SCPMS definition. However, the proposed paper is conducting a qualitative review in the field of SCPMS. Secondly, Maestrini et al. (2017) recommended the future of SCPMS from the articles (92 in total) considered in the study. However, the present study describes the future of SCPMS based on limitations highlighted in existing SCPMS and emerging trends of technology adoption to improve supply chain visibility. Lastly, this study proposes to develop a conceptual framework to evaluate SC performance by integrating different functions and technology adoption awareness in SC.

The paper is relevant to the researchers and decision makers in the area of SCM, SCPMS, and PMS as it will demonstrate "How to measure overall SC performance by integrating short-term and long-term decisions and decision criteria". Specifically, the main objective is to review existing SCPMS and identify their limitation in line with emerging trend of managing SC. In addition, the study provides guidelines for the new proposed SCPM system that overcomes the limitations of existing SCPMS. To achieve this objective, we need to answer the two following research questions: RQ1) are the existing SCPMS in line with the current emerging trend of managing and measuring SC performance?, and RQ2) what are the characteristics of future SCPMS and ways of measuring SC performance under intensive supply chain digitisation?

Our contribution to SCM literature in general and SCPM system literature in particular and novelty of this paper is as follows:

1. Identify the gap between existing SCPM systems and emerging trend of managing SCM.
2. Propose a conceptual framework that increases the alignment with the emerging trend of managing SCM by considering most of the characteristics that are required to find a new way to measure SC performance.

In an attempt to answer these two questions and objectives, we have adopted a qualitative research methodology, which consists of the following sections. Section 2 will provide the background and overview of SCPMS. Section 3 will review existing SCPMS. Section 4 discusses the emerging trends of SCM and Section 5 proposes a conceptual SCPM framework for the future. The last section concludes and discusses the unique contribution and future research directions.

2 Background and overview of SCPMS

To improve any system, you need to measure current performance of a system. If you are not able to quantify your performance, it is difficult to improve your system. Performance can be defined as 'production of valid results'. This shows that you have to measure your performance by calculating results. Once you can measure performance, you need an appropriate way to manage your performance. Neely (1995) defined PM as: "A process, a metric or a set of metrics that used to quantify both the efficiency and effectiveness of actions". It means that we need a systematic way to measure performance. This requires effective and efficient performance management systems (PMSs). PMS can be defined as: "Provides data that will be collected and analysed to use in decision-making". PM plays a vital role in aligning customer satisfaction with decision-making and company's objectives. Moreover, it helps decision makers in identifying which area needs improvement. Neely et al. (2005) mentioned that if we can measure the SC performance and express it in terms of number, the company will be able to improve it. Similarly, Gunasekaran et al. (2001) highlighted the importance of SC performance systems and said effective performance is as necessary as SCM.

Wong et al. (2007) pointed out that literature on PM had not seen SC as a separate entity, therefore, "making it difficult to evaluate performance with several inputs and outputs to the system". Lambert and Pohlen (2001) affirmed that SC metrics are in reality about "internal logistics performance measures that have an inner focus and do not show how the firms make value or profitability in the SC". It is suggested that SC performance indicators should be measured in the form of input-output ratios, despite their qualitative or quantitative characteristic (Asadi, 2012). The use of basic performance measures are inadequate and might be conflicting with the strategic objectives of an organisation.

As defined by Neely et al. (2005), "PMS is a balanced and dynamic system that facilitates support of decision-making processes by gathering, elaborating and analysing information". Taticchi et al. (2010) further explained this definition by commenting on the concept of 'balance' and 'dynamicity'. 'Balance' refers to the "need of using different measures and perspectives which, when tied together, give a holistic view of the organisation". 'Dynamicity' refers to the "need of creating a system that constantly monitors the internal and external context and review objectives and priorities". SCPMS was defined by Bititci et al. (1997) as a "reporting process that gives feedback to employees on the outcome of actions". Tangen (2005) suggested that performance could be defined as the 'efficiency and effectiveness of action'.

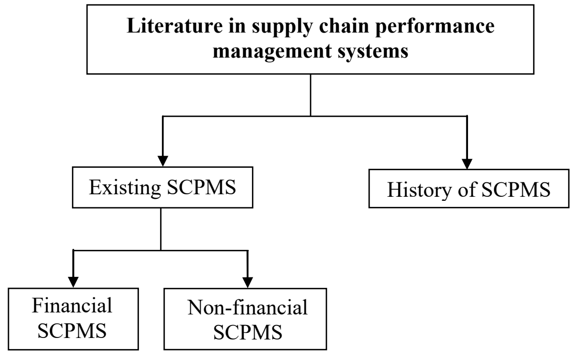
Maestrini et al. (2017) discussed in detail about how SCPMS evolved in the literature and divided SCPMS in terms of different components, which mainly divided into two different broad components such as internal and external SCPMS. After that, he further divided external SCPMS into different sub-components which are suppliers PMS and customers PMS. Supplier PMS were further divided into sub-components and considered first tier and multiple tier suppliers PMS. Similarly, customer PMS was further divided into first tier customers PMS and multiple tier customers PMS.

In recent years, many authors applied different techniques, developed methods and proposed frameworks for SC performance evaluation. Tavana et al. (2016) developed a two-stage method based on data envelopment analysis to evaluate the performance of a supply chain including suppliers, manufacturers and distributors. The proposed method has been implemented in cement industry. Similarly, Maestrini et al. (2018) propose a conceptual framework for SCPMS by considering lifecycle by highlighting key activities of the SCM design, its implementation, and use and review phases. This study also investigated how the different criteria and functions are involved. Due to Industrial Revolution and internet of things (IoT), it is easier for an organisation to improve the efficiency and the accuracy of SCPMS that they are using. In line with this concept, Dweekat et al. (2017) proposed a practical approach and developed a SCPMS able to select strategic SC attributes and choose the required performance metrics based on the data point of view.

3 Review of existing SCPMS

Many authors developed SCPM frameworks specifically for their needs or for specific organisation types. This section will explain existing SCPMS and highlights their limitations in the context of today's competitive, dynamic and demanding SC cycle. Figure 1 shows the classification of literature in SCPMS.

Figure 1 Classification of SCPMS literature



3.1 History of SCPMS

The concept of PM was first introduced in 15th century when book keeping concept I accounting was discovered. The use of book keeping measurement systems was in place until early 1990s Morgan (2004). After that in 1990s, different researchers and practitioners developed SCPMS that was mainly based on ‘time’ and ‘inventories in hand’. After that many researchers came up with different PMS which was based on different performance criteria such as, ‘inventory turns’, ‘line item fill rate’, ‘order item fill rate’, ‘total order cycle time’, ‘total response time to an order’, ‘average backorder levels’ and ‘average variability in delivery’ (Lee and Billington, 1992); ‘inventory levels’, ‘inventory investment’, ‘order fill rate’, ‘line item fill rate’ and an ‘average number of days’ late measures’ (Davis, 1993); ‘average finished goods inventory’ and ‘demand fulfillment’ (Levy, 1995).

Additionally, other researchers introduced further approaches which are adopted by many organisations such as the BSC (Kaplan and Norton, 1992), the PM matrix (Keegan et al., 1989), PM questionnaires (Dixon et al., 1990), and criteria for measurement system design (Globerson, 1985). Neely et al. (1995) have been cited by many researchers of SCM measurement (Beamon and Chen, 2001; Beamon, 1999; Gunasekaran et al., 2004, 2001).

Morgan (2004) divided traditional performance measures into four parts: ‘financial’, ‘operations’, ‘marketing’ and ‘quality’. The problem of using financial metrics is that they are not relevant in ‘day-to-day’ operations because these metrics are available after the execution of SC operations. Essentially financial metrics are most in use at top level management where the strategic decisions are made. Operations measures include operations lead-time, labour utility, set-up time, machine utility, process, etc. Metrics are helpful for low-level management which deals with day-to-day business (Morgan, 2004). Christopher (2005) also presented some SC performance measures such as ‘order cycle time’, ‘order completeness’ and ‘delivery reliability’. It also included ‘delivery performance’, ‘lead time’, ‘level of defects’ and ‘responsiveness’. As suggested by Ramaa et al. (2009), “the performance indicators first came out in the form of a combination of the financial and non-financial criterion”. The performance indicators in the 19th century were in the following forms: ‘the cost per yard’ and ‘the cost per metric ton”. At the start of the 20th century, expansion and authorisation have brought on the reformation of PM.

SCM PM was presented using different approaches in the 2000s. Shepherd and Gunter (2006) classify SC PM Research into 'operational design' and 'strategic research' (Shepherd and Gunter, 2006). Operational research creates mathematical models for increasing SC performance (Smith et al., 2005; Lin et al., 2006). Design research can be classified according to the type of research model: deterministic analytical models (Chen et al., 2006), stochastic simulation models (Hwarng et al., 2005), and strategic research assesses how to match the SC with a firm's strategic objectives (Balasubramanian and Tewary, 2005). Dweiri and Khan (2012) developed SC performance measurement index (SCPMI) to measure overall SC performance.

3.2 Financial performance measurement systems (FPMS)

It is apparent from the literature that many firms measure SC performance in the perspective of financial measure only. Agami et al. (2012) suggested that financial measure primarily focus on indicators that rely on financial parameters and so constantly question for not being suitable because they do not take into account critical strategic non-financial measures which were discussed before. Several authors sort out financial PMS into various categories. Nevertheless, literature showed two very famous financial measurement systems which are as follows:

3.2.1 Activity-based costing

Activity-based costing (ABC) approach was mainly an effort to combine operational performance with financial performance. Kaplan and Bruns (1987) created this approach and developed the breakdown structure and separated activities into single tasks in order to estimate resources in terms of cost. This was the initial attempt at improving the evaluation of the productivity and cost of SC process. Even though it measures the productivity of the whole SC, this approach has a drawback as the total approach relies on financial measures and metrics. Marwah et al. (2014) similarly explained that ABC is an accounting approach that links cost to each activity instead of products or services (Agami et al., 2012).

3.2.2 Economic value added

Stern et al. (1995) built an approach called economic value added (EVA) so that to estimate the return on capital in terms of value added. Agami et al. (2012) stated that this approach utilises operating profits that are added to the invested capital (debt and equity) in an attempt to contend the value created by a firm. Despite the fact that EVA is helpful for determining a high-level executive contribution and long-term value for shareholders, it has its limitation for indicating operational SC performance as it observes only financial indicators (Agami et al., 2012).

3.3 Non-financial performance measurement systems

It is established that several non-financial SCPMs have been developed till now due to the extensive literature review. Numerous authors addressed these non-financial performance measurement systems (NFPMS). Cuthbertson and Piotrowicz (2011), Akyuz and Erkan (2010), Kurien and Qureshi (2011), Ramaa et al. (2009), Lauras et al. (2011), and Estampe et al. (2013) categorised available non-financial SCPMS into nine groups according to their criterion of measurement. Following is the explanation of the nine non-financial PMSs (Agami et al., 2012).

3.3.1 Supply chain balance scorecard

Kaplan and Norton (1992) made a balanced scorecard as a PM tool. Over the year, after its development, it became a leading tool for PM for researchers and practitioners. It offers a framework for firms to execute corporate strategies. As a way to measure success, balanced scorecard separated the performance into four main perspectives which are 'financial perspective', 'internal business process', 'learning and growth perspective' and 'customer perspective'. Mathiyalagan et al. (2014) stated that in balanced scorecard, indicators are chosen according to the firm's strategic objectives. Goals are set that need to be accomplished in a particular period. Goals are very precise, practical, and measurable and time-bound. They are set in a way to take the organisation to its strategic objective. The balanced scorecard can, therefore, give an accurate picture of reality. The balanced scorecard can also facilitate the company to improve itself in all areas both internally and externally. Yet, balanced scorecard is not delivering coordination along the SC network, poor performance cause and effect are not evident, and decision makers decisions are lacking in synchronisation in the SC network (Agami et al., 2012).

3.3.2 SCOR model

SC council created the first version of supply chain operations reference (SCOR) model in 1996. The reason was to help organisations boost the effectiveness of their SC. SCOR model is competent to communicate with the SC partners as the decision procedure in terms of plan, source, make and deliver. SCOR model is excellent for benchmarking and best practice with other organisations, as it explains measures that develop on one another and procedures to be measured. This model illustrates some essential operations that every firm has and presents a detailed description, analysis and assessment of SC. SCOR model stresses heavily on the information flow. Still, it does not contain all processes, overall PM is rather complex, and has no flexibility if you alter measures (Agami et al., 2012).

3.3.3 Dimension-based measurement systems

Ramaa et al. (2009) introduced a new idea in the field of SCPM and stated that every SC performance could be measured in terms of dimensions. The foundation of the dimension-based measurement system (DBMS) is this. This system is typically simple, adaptable to the environment, i.e., easy to execute and flexible. Nevertheless, the key limitation of this system is that it is not able to reflect the performance of sub-criteria of any main criteria in the entire SC network because DBMS mainly focuses on the major criteria (Agami et al., 2012).

3.3.4 Interface-based measurement systems

Lambert and Pohlen (2001) launched an interface-based measurement system (IBMS) and proposed a framework in which they connected performance of each player of the SC network. According to Agami et al. (2012) "the proposed model that starts with the relationship at the main company and moves outward one link at a time". This bounded perspective gives way for bringing into line the performance from the point of the source to the point of use with the general purpose of increasing the shareholder value for the complete SC along with each company. Nonetheless, Ramaa et al. (2009) argued that "this approach, in theory, seems well but in a real business situation, it requires openness and total distribution of information at all stages which is eventually difficult to implement".

3.3.5 Perspective-based measurement system

Otto and Kotzab (2003) created perspective-based measurement system in which they identified six major perspectives so that SC performance in terms of perspectives could be measured. These are 'system dynamics', 'operations research', 'logistics', 'marketing', 'organisation', and 'strategy'. In order to measure the performance of a SC, this system needs a separate metric for every perspective. Perspective-based measurement system gives diverse visions to evaluate SC performance. However, the decision maker has to choose between one perspective and the other perspective (Agami et al., 2012).

3.3.6 Hierarchical-based measurement systems

In 2004, Gunasekaran et al. (2004) developed a hierarchal-based management system (HBMS) to assess performance measure at different decision-making levels; strategic, tactical and operational. The thinking behind this measurement system is to give management a framework to make fast and fitting decisions. Agami et al. (2012) suggested that the metrics are divided as financial or non-financial. This system maps the performance measures with the purpose of the organisation. There were no clear guidelines to decrease different levels of conflicts in the complete SC network.

3.3.7 Function-based measurement systems

Christopher (2005) made a function-based measurement system (FBMS) to assess a comprehensive performance measure so that different measures of different SC process can be combined. Regardless of the fact that this system is simple to execute, it is not competent of measuring the performance of top-level players in the SC. Function-based performance measure only focuses functions separately and in isolation and so the effect of function among each other is not attended in this system (Agami et al., 2012).

3.3.8 Efficiency-based measurement systems

Several authors have developed frameworks and measured SC performance regarding efficiency. Ramaa et al. (2009), Charan et al. (2008), Wong et al. (2007) and Sharma and Bhagwat (2007) offered a framework and proposed approaches in this perspective. The majority of approaches are based on data envelopment analysis, measuring internal SC performance relating to efficiency. All the proposed approaches linked to efficiency-based measurement system measure efficiency relative to each other, despite being a valuable measurement system. These systems are capable of measuring the different units SC efficiency which is related to each other but not beside the target value or benchmarking. Therefore uncertainty is created for decision-making (Agami et al., 2012).

3.3.9 Generic performance measurement systems

Since the 1980s, many models and frameworks that measure SC performance, in general, have been developed. These frameworks are not particularly for SC performance, but many authors used this generic performance measures framework in the perspective of SC. Kurien and Qureshi (2011) reviewed the most mentioned and used performance measure in SC which is as follows.

1 Performance prism

   The performance prism gives a better widespread view of various stakeholders as compared to other frameworks. It is a framework that offers different perspectives to calculate performance. The perspectives contain; stakeholder satisfaction, strategies, processes, capabilities and stakeholder contributions (Neely, 2005). According to Kurien and Qureshi (2011), performance prism can consider new stakeholders such as suppliers, joint ventures and employees.

2 Performance pyramid

   It is a top-down approach, and the aim of the performance pyramid is to offer a link between firm's goals with objectives. It calculates the performance from the bottom up and provides customer's perspective with importance. The main focus of performance pyramid is to join strategic and operational decisions (Agami et al., 2012).

4 Emerging trends in SCM

In this section, we will discuss the emerging trends of managing SC and how the advancement of technology will affect the business environment and increase the complexity of SC. Once Industry 4.0 has been adopted by the organisations and after successful implementation of smart factory concept, smart solutions, and smart innovations, current SC will become 'smart SC'.

Smart SC is highly integrated and automated and depends on digital technologies and cyber-physical systems. This will allow the manufacturer to focus on their core competence and offer a customised product to the customer. Connected SCs will be formed with vertical supply network and allowing integration and automation of physical processes and gives companies high amount of transparency. Therefore, smart SC should be integrated and visible to all key players from raw material order till the point of delivery to the customer. Smart SC increases the visibility of inbound and outbound SC activities. Outbound order tracking will be vital because of managing multiple production and distribution locations, alignment of the assembly process, meeting customer deadlines and minimising overproduction. For the SCM there is high potential using information technology for increasing transparency and quality of information in the SC.

4.1 Characteristics of SCM after Industry 4.0

After successful implementation and adoption of Industry 4.0, the following will be the characteristics of SC.

- *Digitalisation*: as per Geisberger and Broy (2012) "the companies' internal processes, product components, communication channels and all other key aspects of the SC are undergoing an accelerated digitalisation process".
- *Automatisation*: according to Angelov (2012) "Industry 4.0 technologies and concepts are enabling machines and algorithms of future companies to make decisions and perform learning activities autonomously".
- *Transparency*: it was mentioned by Wang et al. (2007) that "global SCs are characterised by highly complex structures, the available Industry 4.0 technologies are increasing the transparency of the whole value creation process". Because of the 'increase in transparency', decision-making in the company will be more 'collaborative and efficient'. This will not only cover the SC processes, but also the behaviour of all stakeholders in SC which also includes customers.
- *Mobility*: according to Schweiger (2011) "the dissemination of mobile devices makes communication, data sharing and generations of values possible from all over the world". This will change the ways of doing business and allow customers to interact with the companies from where are buying products or service and have real-time information about their product or service.
- *Modularisation*: as per Koren et al. (1999) and Putnik et al. (2013) "technologies are enabling the modularisation of products and the whole value creation process, e.g., manufacturing facilities". Modular production facilities will lead in increasing the flexibility of the production processes.
- *Network-collaboration*: Bauer (2014) gives different perspective of network collaboration and mentioned that "just as human beings in our society are interacting in social networks, the companies' processes will be defined, and activities will be decided through the interaction of machines and human beings within specific networks in and out of the company's organisational borders".
- *Socialising*: socialising is very common among the persons. However, Oswald (2014) defined it in the perspective of machines and production process and said: "the collaboration in networks is enabling machines (not only smartphones) to start communicating and interacting with other machines and/ or humans in a socialised manner".

  At this stage, researchers and practitioners believe that the impact of Industry 4.0 on any SC will start from strategic/tactical level and affect the decision at that level. In order to remain competitive after Industry 4.0, decision makers should identify and evaluate which specific characteristic features of Industry 4.0 are essential for their SC activities. Following are the key parts of SC that will be affected because of Industry 4.0.

- *Sourcing*: role of suppliers will change after Industry 4.0. We have to increase the involvement of suppliers' right from the design phase. Risk sharing and information sharing will become an integral part of sourcing decision. Decisions and decision criteria (attributes) at each level of supplier selection decisions must be defined and the integrated system must be developed to evaluate supplier performance.
- *Manufacturing*: after Industry 4.0, organisations need to adopt digital technologies in their manufacturing and production facilities. Machine to machine communications and on time process updates will be essential. Information updating with the distributor and customers will be essential, and use of RFID technology will be a mandatory part of doing business.
- *Warehousing*: it is expected that the biggest impact of Industry 4.0 on any SC function will be on warehousing and distribution centres. The whole warehousing system will be digitalised, and real-time information will be required for customers and manufacturers. Movement of goods will be recorded by automatic tags and performance evaluation of warehouses will be calculated based on different performance criteria (attributes) at each level of decision-making.
- *Logistics*: traditional logistics systems will become 'smart logistics system'. Logistics activities undergo a 'digitalisation process'. For example, 'smart factories' will include 'intra-logistic processes' which support the manufacturing systems with sophisticated applications, such as 'cyber-physical systems' and automated guided vehicles (AGV) transporting systems execute 'intra-logistics processes' within the manufacturing factory of companies. Similarly, the delivery information of transported products can monitor in real time and whenever it is required. As a result, the delivery process for a product that has been already started might be changed if any new information is available that have an impact on the final execution of this process.

After discussing the impact of Industry 4.0 on SC, it is evident that organisations need to develop and/or adopt smart SCPMS which should be in line with the smart SC. Also, smart SCPMS must integrate long-term and short-term decisions and decision criteria (attributes) and evaluates overall SC performance. It means that organisations need new ways of measuring SC performance and should be smart in measuring SC performance.

4.2 Limitations and future of SCPMS

After reviewing the literature of above mentioned SCPMS frameworks and approaches, Figure 2 summarises the SCPMS characteristics.

We can summarise the following limitation of existing SCPMS concerning emerging trends and technology advancement as follows.

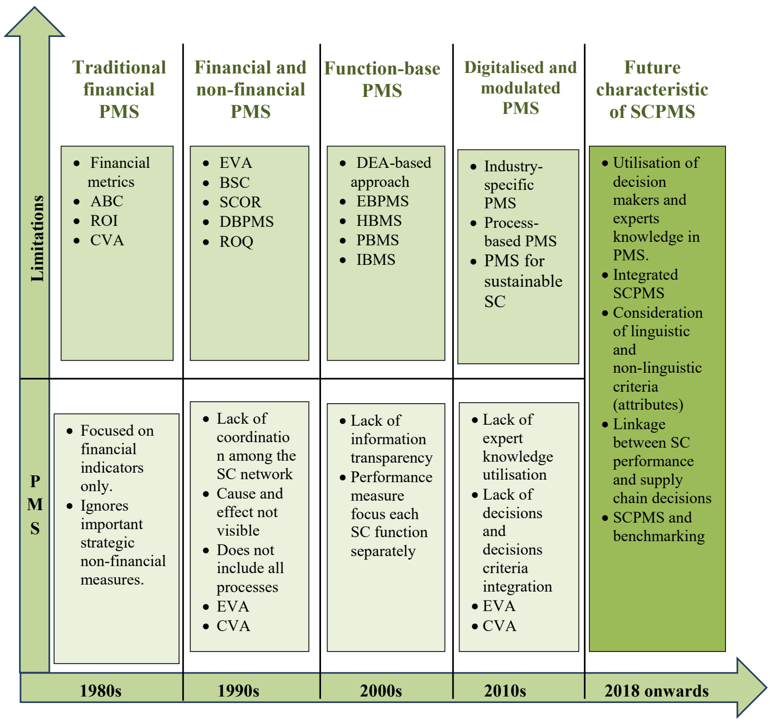
1. There is an inadequate balance between financial and non-financial measurement in current SCPMS.
2. Vague (linguistic) information/data is used in measuring overall SC performance.
3. Existing SCPMS are insufficient to establish a connection between short-term and long-term decisions and decision criteria.

4 Experts' and decision-makers' knowledge and experience were not utilised in measuring SC performance.

5 Lacking in measuring overall SC performance.

6 Deficiency in highlighting underperforming functions of SC network.

Figure 2 Limitations and future of SCPMS (see online version for colours)



Now it is evident from the above-mentioned limitations of existing SCPMS that in order to cope with new emerging trends and fulfil customer demands effectively and efficiently, existing SCPMS are not in line with emerging trends of managing SC.

5 A conceptual framework for future SCPMS

Due to advancement in technology, shorter product life cycle and innovations increase the complexity of supply chain environment. Organisations should adopt 'smart' way of managing their SC. Traditional SCPMS are not adequate and capable enough to cope with these complex SC and meet the desired level of satisfaction to managers and decision makers. We need fast decisions to manage our SC effectively and efficiently. To do that we need 'smart' SCPMS that provides indications of underperforming SC functions and allow decision makers to take fast decisions. However existing SCPMS are lacking in providing such information. In this section, we will discuss the proposed conceptual framework characteristics that are necessary to tackle new trends of SCPMS. Following are the anticipated trends in need of efficient SCPM:

1 SCPMS and decision makers' and experts' knowledge

Smart SCPMS need knowledge and experience of experts and decision makers. After digitalisation and advancement of technology, it becomes very easy to incorporate knowledge and experience of experts and decision makers in any system development. Many tools, computer software, decision support systems are available to do that such as fuzzy inference system (FIS), stochastic multi-criteria acceptability analysis (SMAA). These knowledge based systems can be updated after several years of implementation to incorporate new challenges and criteria in SCPMS.

2 Integrated SCPMS

Integration between SC functions has now become essential for efficient SC. Integrated SC minimises bullwhip effect and improves overall SC performance. Each function and their associated measuring criteria (attributes) have an impact on overall SC performance. In order to know the performance of SC, it is essential that SCPMS must integrate SC decision criteria (attribute) at each level of decision-making. Integration is also essential to provide a link between long-term (strategic and tactical) and short-term (operational) decisions and decision criteria. This will help in making appropriate decisions and know the impact of the decision on overall SC performance. Therefore we need an integrated SCPM system that integrates all functions of SC, provide a link between decisions and decision criteria and measure overall SC performance.

3 Consideration of linguistic and non-linguistic criteria (attributes)

Smart SCPMS must include criteria (attributes) of all SC functions regardless of their nature which is linguistic or non-linguistic and quantitative or qualitative. In managing and evaluating SC performance, we have to consider multiple criteria which are usually conflicting in nature. Criteria such as risk, reputation, service level are qualitative while transportation cost, rejection rate, monetary value, order fulfilment rate, etc. are quantitative criteria. In order to develop integrated SCPMS, we need to find a way to combine both qualitative and quantitative criteria in measuring overall SC performance.

4 Linkage between SC performance and supply chain design

A well-designed SC has a potential to perform well and deliver the product with a focus on 3R's which are 'right product' to the 'right customer' at 'right time'. SC design is a long-term (strategic and tactical) decision and has a long-term impact on SC performance. At present, SC design criteria are not linked to operational criteria which results in inadequate overall SC performance. This happens because the performance evaluating criteria at the operational level is not linked with SC design strategic criteria. For example, if the strategy of the company is to minimise transportation cost. This will lead to the bad performance of SC logistics function. No matter what we do, overall SC performance will not improve until and unless we will not consider transportation criteria at SC design phase at the strategic level. This shows that in order to evaluate SC performance effectively and efficiently, we need to develop an integrated system that provides links between strategic decisions with operational decisions.

5 SCPMS and benchmarking

Nowadays organisations are competing with each other by their SC performance. Managers and decision-makers need to compare their SC performance with competitors. Smart SCPMSs should not only be able to evaluate SC performance but also serve as benchmarking tool. Smart SCPMS must identify the underperforming function of SC and/or long-term and short-term decision criteria (attributes). SC design models will provide expected (optimum) value of SC performance criteria and allow decision makers to compare current performance with the expected (optimum) SC performance. This way organisations and decision makers can easily find the direction of improvement and take fast decisions in the right direction at the right time.

5.1 Proposed conceptual SCPM framework

From the above analysis of existing SCPMSs and detailed analysis of need and characteristics of future SCPMS, it is evident that we need an integrated SCPMS which integrates short-term and long-term decisions and decision criteria, uses experts' and decision makers' knowledge and evaluates overall SC performance. Figure 3 shows that it is possible to integrate short-term decisions and decision criteria and their associated importance weights with long-term decisions and decision criteria and their associated importance weights through a knowledge system based on expert knowledge and experience. Integrated knowledge based system can be developed using integrated multi-criteria decision-making (MCDM) technique.

Bottom of Figure 3 shows the most commonly used SC functions where the execution of operations is going on. This execution will allow organisations and decision makers to collect and store data through different data management systems. Due to the advancement of technology, data collection and its storage become easy. These collected and stored data at the operational level will be easy to store and further utilised to evaluate overall SC performance through integrated knowledge base system.

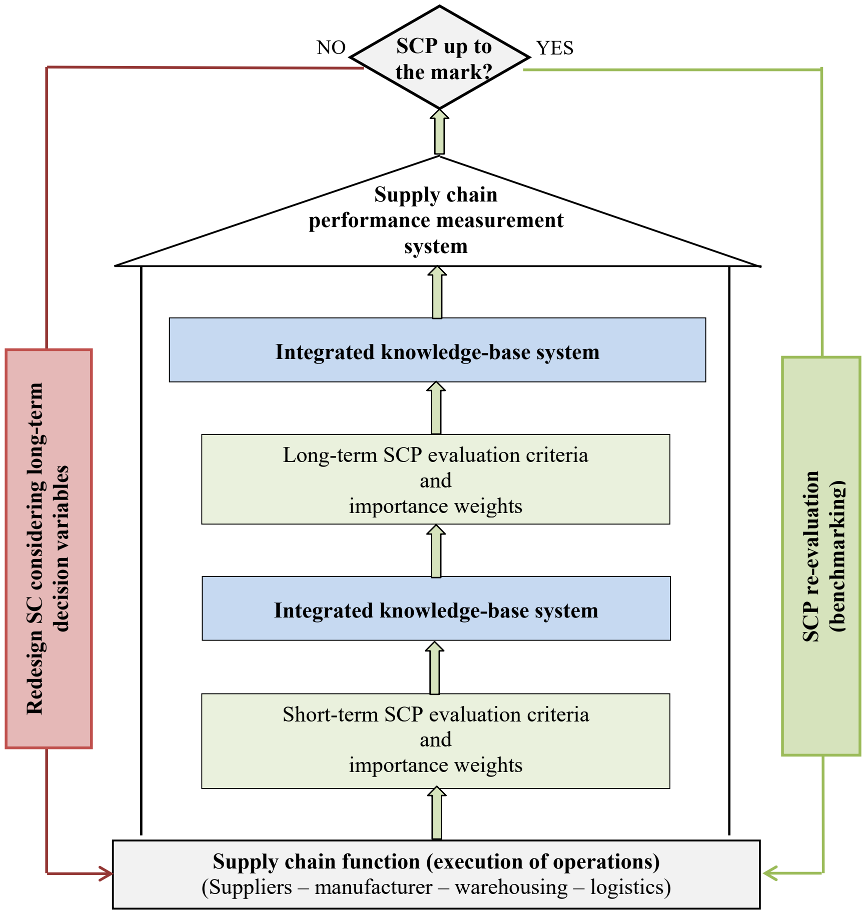
The right side of Figure 3 shows that proposed conceptual SCPM framework can be used for benchmarking as well. For instance, if the performance is up to the mark and acceptable for the organisation, they can keep re-evaluating the SC performance and compare their SC performance with the competitors. It is also recommended that for benchmarking purposes, managers and decision-makers could develop a SC performance dashboard to keep track of SC performance over a period.

The left side of Figure 3 shows the link between overall SC performance and SC design. If overall SC performance is not up to the mark, we can redesign SC by taking decisions related to underperformed SC decision criteria. This can be easily calculated by developing SC design model considering long-term decision variables.

Proposed conceptual SCPM framework is comprehensive and includes all essential aspects of measuring overall SC performance. It can include all required short-term and long-term decisions and decision criteria (attributes) and integrates it with long-term decisions and decision criteria (attributes) by considering decision makers and experts' knowledge and experience. Similarly, proposed SCPM framework provides the link between SC performance and SC design that is missing in the literature. Therefore we believe that proposed SCPM framework is general as criteria (attributes) can be changed and varies from business to business and can be easily implemented in any organisations.

Moreover proposed SCPM framework is in line with emerging trend of measuring SC performance and fills the gap that is created because of the industrial revolution and the introduction of IoT.

Figure 3 Conceptual SCPM framework (see online version for colours)



6 Concluding remarks

In our present paper, we have attempted to find out the applicability of existing SCPMS in today's business environment. Our present paper was guided by the two research questions:

RQ1 Are the existing SCPMS in line with the current emerging trend of managing and measuring SC performance?

In response to RQ1, we have reviewed the existing SCPMS and identified that existing SCPMS are not in line with emerging trend of SC management. Identified limitations in Section 3.4 and Figure 2 affirmed this. Moreover, Section 4 of the present paper also leads to the conclusion that after Industry 4.0, existing way of evaluating overall SC performance will change. Unfortunately, existing SCPMS are not able to cope up with this challenging Industrial Revolution and digitalisation. This paper is an attempt to highlight the limitations of existing SCPMS. This section highlights the changes that will happen because of Industry 4.0 on each function of SC. This leads to the conclusion that organisation and decision makers need to find smart ways to evaluate their SC performance and need smart SCPMS. This paper is an attempt to propose new ways of measuring SC performance.

RQ2 What are the characteristics of future SCPMS and ways of measuring SC performance?

In response to RQ2, the present paper discussed in detail about the characteristics of future SCPMS in Section 5. This section identified that the smart SCPMS must consider decision makers knowledge integrates decisions and decision criteria (attributes) each level of decision-making, provide a link between SC design and operational performance criteria, and consider linguistic and non-linguistic criteria in evaluating overall SC performance. Moreover, smart SCPMS must be used as a benchmarking and provide directions for improvement to decision-makers and organisations. At last, the present paper proposed a conceptual SCPM framework as mentioned in Figure 3.

6.1 Theoretical contribution

Any theoretical paper which is based on qualitative analysis must answer some fundamental questions, which are WHY this paper is important and HOW qualitative analysis of present paper will answer the research questions. In this paper, we identified the need of changing of SCPM because of digitalisation, technology advancement, and shorter product life cycle. After careful and thorough analysis of existing SCPMS, we have concluded that existing ways of evaluating SC performance needs modification. Our qualitative analysis in this paper also discussed the characteristics of smart SCPMS and proposed a conceptual framework to evaluate overall SC performance. Despite the limitations, our paper has made significant attempt to extend the literature of SCPMS in particular and SCM in general. Moreover, this paper also changes the way of measuring overall SC performance and proposed a conceptual framework that is our principal contribution.

6.2 Managerial implications

Our paper is an attempt to propose a conceptual framework to evaluate overall SC performance. However, there are several attempts from many researchers that have been made in the same direction. Our attempt is based on the identified limitations of existing SCPMSs that highlights that there is a need of smart SCPMS that must be aligned with new technology, digitalisation, and Industry 4.0 revolutions. To fill this gap, our proposed conceptual framework focused on the concept of integration among SC function, the linkage between SC design and operational SC evaluation criteria (attributes), and utilisation of decision makers and expert knowledge. It provides a clear differentiation from existing SCPMSs. In addition to this, our proposed conceptual framework will be easily adaptable in any organisation regardless of their business nature. It also allows decision makers and SC managers to calibrate their decisions based on current SC performance and in the right direction.

6.3 Future research directions

We believe that our present paper will lead to multiple future research directions. In this section, we will highlight few of them as follows.

- The present paper proposed a conceptual framework that integrates SC functions and different decisions and decision criteria (attributes). These multiple criteria (attributes) are conflicting in nature. In future, we need to conduct extensive literature survey to identify that which MCDM methods will facilitate in developing integrated overall SCPMS.
- The proposed conceptual framework highlights the importance of utilising experts' and decision makers' knowledge and experience. In future, we need to propose an integrated knowledge base system that utilises decision makers' and experts' knowledge in measuring overall SC performance.
- The present paper recommends considering both qualitative and quantitative criteria (attributes) in measuring overall SC performance. For the future, we need to identify each SC function performance measuring criteria (attributes) through an extensive literature survey.
- SC design models can be developed using many-objective (Ishibuchi et al., 2008) optimisation to find out expected (optimum) SC functions decisions and decision criteria value for benchmarking.

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