

Supply Chain Performance Measurement Model: A Literature Review

Ferdoush Saleheen ^{#1}, Md. Mamun Habib ^{*2}, Zurina Hanafi ^{*3}

[#]School of Quantitative Science, Universiti Utara Malaysia (UUM)
06010 Sintok, Kedah, MALAYSIA

¹ferdoushsaleheen@gmail.com

²mamunhabib@gmail.com

³h.zurina@uum.edu.my

Abstract - Supply chain management is being envisaged as an extended enterprise connecting business in different places and facilitating allies to propel competitive advantage in the era of globalization. Substantial research has been undertaken along with literatures on supply chain performance management from cost and non-cost standpoint, strategic, functional or emphasis on operational aspects; perspectives from commercial as well as financial arenas. In order to gratify customer orders rapidly and efficiently than competitors, supply chain needs to warrant continuous upgradation of its processes and competitive strategies and to apprehend how supply chain contests? it is indispensable to realize the overall performance of the supply chain. However, still many companies miscarry to acquire effective performance measurement tools and techniques to attain integrated supply chain management (SCM). The rationale of this paper is to evaluate the literature on performance measurement for supply chain to apprehend current practices, recognize gaps and advocate future research itineraries. The paper also offers a synopsis and appraisal of the performance measurement used through different supply chain models.

Keywords - Supply chain performance measurement system (SCPMS), Supply Chain Operations Reference Model (SCOR), Balanced Score Card (BSC), Activity-Based Costing, Hybrid of SCOR and BSC Approaches.

1.0 Introduction

Supply Chain Performance Measurement (SCPM) model studies the effectiveness of an organization. The solicitation of SCPM intensely benefits business managers in the process of decision making with its entrenched capacity of processing multiple information simultaneously [1]. SCPM also channels a holistic approach to assist an organization in knowing its expectation, aspiration and general performance [2]. Hence, an organizational goals and objectives for both long term and short term period becomes comfortable. Moreover, the performance measurement tools have an involvement to all the major departments in an organization to integrate and coordinate the flows both

within and among the organization.

The different aspects of decision making in the Supply Chain Performance Measurement (SCPM) are as follows:
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Strategic: high-level decision-making regarding the marketplace to be directed the size as well as the location of production sites, the partnerships to ascertain with suppliers, etc.

Functional: focus on adopting measures (best practices) that results efficiency in SCM such as demand planning, purchasing strategy, etc.

Operational: controlling the actual flows from one end of the supply chain to the other (taking orders from customers, transmitting the information downstream, controlling the costs, ensure logistics operations, etc.).

2.0 Literature Review

Ref. [3] itemized the characters of an effective performance measurement system. These characters include: unifying the entire units, comparing various operating conditions, measurability of necessary data and maintaining consistency with organizational goals. Ref. [1] noted that performance measurement should be well defined, concise enough for easy understanding, ensure the combination of both financial and non-financial indicators and the use of minimal number of metrics. The findings from the study in Ref. [4] revealed that lack of clarity from the target and outcome is the sole hindering challenge which affects the development of a performance measurement system and accountability. The study also explained some of the challenges which obstructs the development of the performance measurement system. The result presented that developing a performance measure is the first focal point; the research also reported that quality, time, cost and flexibility are the most essential measures to assess manufacturing performance.

2.1 SCPM Approaches

The SCM performance can be divided into financial and non-financial measures. Top management needs financial measures for management level decisions, but junior management and workers need operational measures for

daily business. The frameworks with metrics of SC performance are as follows:

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|---|---|
| Financial Performance Measurement System | Activity Based Costing (ABC) |
| | Traditional Cost Accounting |
| Non-Financial Performance Measurement System | Supply Chain Balanced Score Card System |
| | Supply Chain Operations Reference Model (SCOR) |
| | Dimension and Information Based Measurement System (DBMS, IBMS) |
| | Perspective based Measurement System (PBMS) |
| | Hierarchical based Measurement System (HBMS) |
| | Function based Measurement System (FBMS) |
| | Efficiency based Measurement System (EBMS) |
| | Generic Performance Measurement System (GPMS) Performance prism: Performance pyramid: Medori and Steeple's framework |

Fig 1. SCPM Approaches [32]

| | Type of Measurement System | Criteria of Measurement |
|---|--------------------------------------|--|
| 1 | Function-based Systems (FBMS) | Performance measures of functions within each process of the supply chain |
| 2 | Dimension-based Systems (DBMS) | Performance evaluation of pre-determined key dimensions across the supply chain |
| 3 | Hierarchical-based Systems (HBMS) | Performance measures identified on three levels of management: Strategic, Tactical and Operational |
| 4 | Interface-based Systems (IBMS) | Performance measures defined between supply chain linkages, i.e. stages. |
| 5 | Perspective-based Systems (PBMS) | Performance measures on six perspectives of the supply chain: Operations Research, System Dynamics, Logistics, Marketing, Organization and Strategy. |
| 6 | Efficiency-based Systems (EBMS) | Performance measures to evaluate the supply chain efficiency. |
| 7 | SC Operations Reference Model (SCOR) | Performance measures along the five main supply chain processes: Plan, Source, Make, Deliver and Return. |
| 8 | SC Balanced Scorecard (SCBS) | Performances measures across four supply chain perspectives: Financial, Customer, Internal Business Processes and Innovation and Learning. |
| 9 | Generic Systems (GPMS) | Performance measures are strategy aligned |

Fig 2. Non-Financial Performance Measurement Systems (NFPMS) with their criteria of measurement [31]

2.1.1 Activity-Based Costing

Established in 1987 by Ref. [5], ABC emphasizes in an effort to fasten financial measures to operational performance which contains breaking down activities into distinct jobs or cost drivers while appraising the resources, such as time and costs needed for each one. Costs are then distributed based on these cost drivers rather than conventional cost accounting approaches such as allocating overhead proportionately or based on less appropriate cost drivers. The method was planned in such a way to permit for improved evaluation of the accurate productivity and costs of a supply chain process.

2.1.2 Supply Chain Balanced Scorecard

In 1992, Ref. [6] pronounced that (Balanced Scorecard) BSC as an authoritative performance management tool. Since then, it has been acknowledged as the principal instrument for performance measurement both in research and commerce. It allows administrators to detect a composed understanding on operational and financial measures at a glimpse. The authors recommended four basic perceptions that administrators should monitor and follow: financial, customer feedback, internal business processes and innovation & learning perceptions. BSC is dominant in delivering managers with a comprehensive image of the business performance [7]. Nevertheless, it

undergoes two elementary restraints.

First, it is a top-down tactic. Hence, it is not participative and might miscarry to perceive prevailing collaborations between different procedure metrics. Ref. [8] stated that, BSC is a static method that applies in business situation which does not deliver a prospect to develop, communicate and implement policy. Second, though dominant and broadly used in industry, BSC stipulates a theoretical framework only. That's why it has deficiencies on execution methodology and diverges from the merit of perception itself.

2.1.3 Supply Chain Operations Reference Model

SCOR framework was formed by the Supply Chain Council (SCC) [9]; [10] and the original version was established in 1996. It is an outline to investigative supply chain elaborately through outlining and classifying the procedure that constructs the chain, conveying metrics to such progressions and appraising similar yardsticks. The SCOR model outline can be uncovered in ref [9]. It is an interconnected cross-functional framework that associates performance measures, best practices and software requirements in detailed. The SCOR model states supply chain as five main assimilated processes: Plan, Source, Make, Deliver and Return. Performance procedure is measured from five perceptions: Reliability, Responsiveness,

Flexibility, Cost and Asset. As the model stretches the chain from supplier's supplier to customer's customer and affiliates with operational strategy, material, work and information flows, it is deliberated as a comprehensive method that necessitates a well-articulated set-up, entirely committed managerial resources and continuous business process re-engineering to affiliate the business with best practices.

Dimension-based Measurement Systems

DBMS notion is well-known on the principle that any supply chain can be measured on magnitudes referred in Ref. [11]. Initially separated three methods in supply chain performance measurement systems, i.e.: Flexibility (F), Resources (R) and Output (O) and she envisioned that each of these are critical to imitate the overall performance achievement of a supply chain. Examples of resource performance measures are inventory cost, manufacturing cost, and return on investment (ROI). Output measures include fill rate, total sales, on-time deliveries, whereas flexibility parameters measure volume changes and new product introduction.

2.1.4 Interface-based Measurement Systems

IBMS was predominantly stated in 2001 by Ref. [12], a framework where each stage is connected within the supply chain. The structure commences in association with the principal business and travels outward one link at a time. This style produces a means for associating

performance from point of origin to point of consumption with the objective of improving the stockholder value for the overall supply chain as well as business enterprise. The IBMS approach seems hypothetically perfect but in real business scenery, it needs openness and total visibility of information at every stage which is eventually challenging to execute Ref. [11] noted.

2.1.5 Perspective-based Measurement Systems

PBMS perceives supply chain with all the possible insights and delivers measure to apprise each of them [11]. It was conceptualized in 2003 by Ref. [13] noted that acknowledges six core viewpoints: Operations Research, System Dynamics, Marketing, Logistics, Organization and Strategy. The authors pronounced six exclusive metrics, one for each insight, to assess performance of supply chains. PBMS in its Logistics Scoreboard Ref. [14] recommends only logistics aspects of the supply chain which falls into the following general categories: logistics financial performance measures (E.g. return on assets and expenses), logistics productivity measures (E.g. orders shipped per hour), logistics quality measures (E.g. shipment damage) and logistics cycle time measures (E.g. order entry time). PBMS stipulates different perception to assess the supply chain performance. However, there could be a trade-off amongst measures of one perception with measures of other perceptions.

2.1.6 Hierarchical-based Measurement Systems

HBMS concept developed by Ref. [15] was classified as strategic, tactical or operational. The main principle deals with appropriate management level to facilitate fast and appropriate judgements [11]. The metrics further elaborates as financial and non-financial matters that links together with the hierarchical interpretation of supply chain performance measurement and maps. HBMS precisely measures to enterprise goals as well. However, in such methods a clear direction cannot be stated to put the measures into different levels to reduce the conflict among the different supply chain partners.

2.1.7 Function-based Measurement Systems

FBMS syndicates to cover the different methods of supply chain Ref. [11] noted that was originally intellectualized in 2005, Ref. [16] noted to cover the comprehensive performance measures. It is pertinent at different linkages of the supply chain. Though the process is simple to implement and targets can be dedicated to individual departments but it does not provide top level measures to cover the entire supply chain. FBMS are generally criticized for viewing the separate supply chain functions in isolation with the overall strategy. Hence the result benefits in a limited scale and it may harm to the whole supply chain.

2.1.8 Efficiency-based Measurement Systems

EBMS measures the supply chain performance in terms of efficiency. Ref. [17]; [18]; [19]; [20] & [21] noted that provides framework to study supply chain performance by developing a Data Envelopment Analysis (DEA) model for the internal supply chain performance efficiency using case study applications.

2.1.9 Generic Performance Measurement Systems

Quite a few generic performance measurement models and frameworks have been developed since 1980 that has benefits as well as limitations.

2.1.10 Performance Prism

The performance prism advocates that performance should be assessed throughout five diverse scopes of performance as suggested in Ref. [22] noted that strategies, processes, capabilities, stakeholder satisfaction and stakeholder contributions. This model has broader views to different stakeholders than other frameworks. The core focus of this theoretical structure is that it cross-examines the business strategy before the progression of choosing methods which eventually warrants the root foundation of the performance measures with the organization. The process also reflects new stakeholders (such as workforces, suppliers, associated partners or agents) who are mostly ignored when performance measurement process starts. However, the main disadvantage is that it guides less about how the performance measures would be acknowledged and chosen [23]; [24].

Performance pyramid knots organizational strategy with its operation by transforming the assigned objectives at a top down approach (based on customer urgencies) and quantifies from the bottom up approach [24]; [25]. This structure contains four stages of objectives that adopts an organization's peripheral effectiveness (left side of the pyramid) and its inner efficiency (right side of the pyramid) as validated by Ref. [1] noted. The growth of a company's performance pyramid outlines an inclusive corporate concept at the first level, which is then transformed into separate SBU (strategic business unit) wise objectives. The second-tier focuses on the profitability, cash flow, longstanding growth and concentrates on market position. The operating system links the crack between highest level and operational procedures such as productivity, customer satisfaction and business flexibility. Lastly, four key performance measures: delivery, quality, cycle time and waste are used at the departments and work centers on a daily basis. Ref. [26] noted that this approach does not deliver any instrument to classify key performance indicators, nor does it unambiguously assimilate the impression of continuous improvement.

2.1.11 Medori and Steeple's Framework

Ref. [27] outlined a cohesive structure for auditing and enhancing performance measurement methods. It

comprises six phases that begins with describing manufacturing tactic and achievement factors. In the following phase, the principal job is to balance the company's strategic necessities from the preceding period with competitive urgencies and choose the most appropriate procedures. Once the selection procedure is completed, the prevailing performance measurement system is inspected to diagnose which existing measures would be kept. The last stage is based on the periodic appraisal of the business performance measures. A significant advantage is that it can be used both to design a new structure and to improve a prevailing one. It also includes an exclusive description of how performance measures should be designated.

2.1.12 Balanced Score Card Model

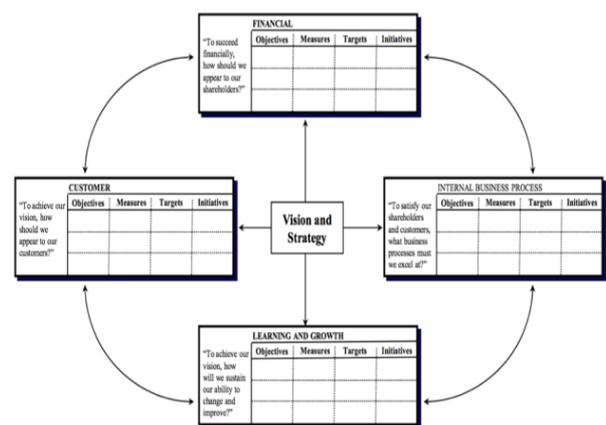


Fig 3. Balanced Score Card Model [1]

The BSC retains financial metrics as a fundamental outcome to measure a company's success, but supplements these with metrics from three additional perspectives – internal process, customer, learning and growth. The Balanced Scorecard, dated back in (1950-1980), of course was not original to support the nonfinancial measures to quantify, motivate and evaluate company performance. General Electric, back in 1950 conducted a project to develop performance measures for GE's dispersed business units. The project team recommended that divisional performance can be measured by one financial and seven nonfinancial metrics.

- Profitability (measured by surplus income)
- Productivity
- Market share
- Public responsibility (legal and ethical behavior, and responsibility to stakeholders including shareholders, vendors, dealers, distributors, and communities)
- Product leadership
- Employee attitudes
- Personnel development
- Balance between short-range and long-range objectives

The origins of the Balanced Scorecard could be apprehended through these eight objectives. Presented by the GE metric based on financial aspects as first aspect,

productivity, market share, public responsibility, product leadership, employee attitude, personal development and the 8th metric captures the essence of the Balance Scorecard between short range and long range objectives etc. have been placed in respective order. Regrettably, the project didn't get imbedded into the management performance appraisal and incentive structure of GE's business units due to priorities for short-term profits and compromise long-term visions as well as corporate obligations. At the same time, Carnegie Institute of Technology (later Carnegie-Mellon University) classified several commitments for accounting information in organizations. Some accounting academics recommended procedures through which business expenditure can produce intangible assets that might be capitalized and positioned as assets in the corporate balance sheet.

The importance of Human accounting exploded by 1970's and subsequently, Baruch Lev and his doctoral students and colleagues propositioned that financial reporting might be significant if corporations capitalize their expenses on intangible assets or discover other approaches by which these assets could be positioned on corporate balance sheet.

However, certain factors steered due to lack of placing beliefs for intangible assets on corporate balance sheets as a complicated linkage made it difficult to place a financial value on an asset such as employee competences or self-esteem, much less to measure deviations from period to period in such a financial value.

Ref. [5] noted that the model is extensively recognized and gives understanding of the process such as:

Financial perspective: Stakeholders aspects.

Customer's perspective: perceived from customer's views.

Internal Perspective: assume internally for self-appraisal.

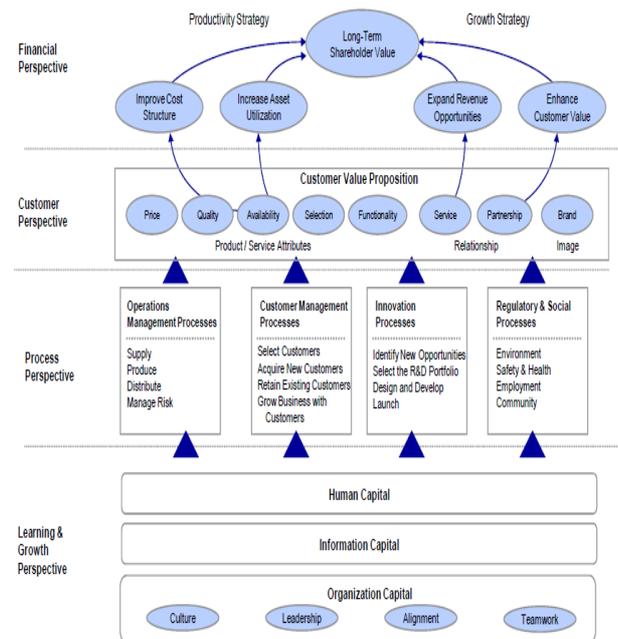


Fig 4. Strategy Map [6]

The strategy map links intangible assets and critical process to the value proposition on customer and financial outcomes

The impression of pivotal linkage among Balanced Scorecard objectives and measures direct to the creation of a strategy map, articulated in Harvard Business Review article and several books [6]. The diagram demonstrates the current configuration for a strategy map. As of now, all BSC assignments build a strategy map for strategic objectives first and only then select metrics for each objective. This is recognizable that the spongiest linkage in a strategy map and Balanced Scorecard is the growth perspective and learning. The learning and growth viewpoint has been considered as "the black hole of the Balanced Scorecard.", however corporations had some generic assessment tools for their employees, such as measuring employee turnover, absenteeism, lateness, employee job satisfactions etc. None had metrics that linked their employee capabilities to the strategy. However, few scholars had examined the association between developments in human resources and better financial performance.

2.1.13 SCOR Model

Originated by SCC to support organizations to increase their effectiveness.



Fig 5: SCOR Model [29]

Business process reference model is indispensable for a company to examine the overall supply chain strategically and to determine its strong as well as its fragile linkage that displays a path for improvement. The objective of the SCOR model designed to regulate a terminology and procedure to benchmark organizations supply chain parameters [29]. These parameters are inter-connected to the bottom-line of the organization performance and it reflects on companies' financial statements.

The mechanism of SCOR model that assimilates as a process to re-engineer and to benchmark cross functional that stretches from supplier's supplier, up to the end consumer and voyage through each stage of the supply chain.

The SCOR model was designed and established by the SCC to stimulate firms in increasing the effectiveness of their SCs, and to deliver a process-based method to SCM. The SCOR model stipulates a common route and uniform vocabulary among the partners in the supply chain community in the following decision areas: PLAN, SOURCE, MAKE, and DELIVER. SCOR model has been designed as an instrument to define, measure and appraise any supply-chain configuration.

There are 12 performance matrices as part of the SCOR model to measure process performance [30].

These 12 performance measures are clustered as (i). Delivery reliability; (ii). Flexibility and responsiveness; (iii). Costs; and (iv). Assets. Ref. [30] noted the opinion to develop a quantifiable SC performance measure, there will be an additional obligation of overall supply chain efficiency measure incorporated in the SCOR model.

2.1.14 Hybrid of SCOR and BSC Approaches

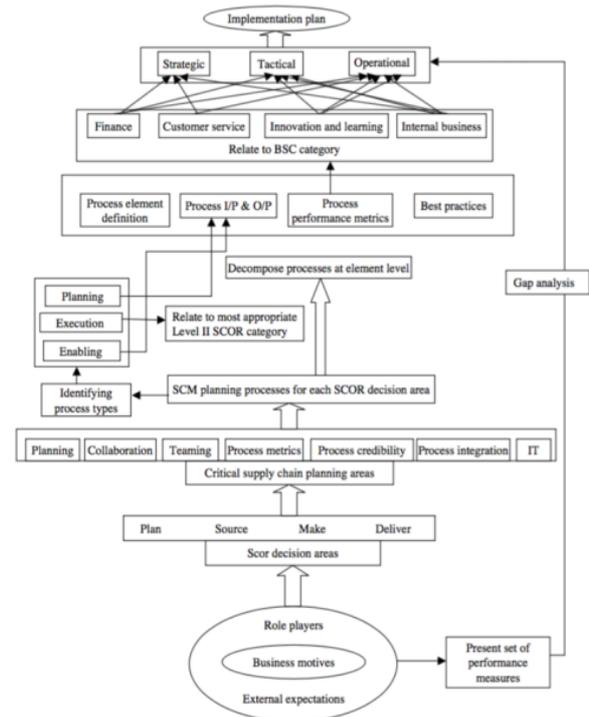


Fig 6. Skeleton of SCOR-BSC framework for SMEs [28]

Ref. [28] endorsed a model that encompasses identification of business objectives and procedures, measurement of process performance, and definition of improvement opportunities and optimization measures for a supply chain analysis.

The authors developed a methodology called hybrid measurement approach for setting objectives, tolerance limits, allocating resources, assigning responsibilities, measuring performance for feedback and corrective action. This measurement approach combines SCOR measurement and adapts balanced scorecards. The first concept of material and product flow may be defined and run by SCOR metrics as a result, the author put it to use in the study. Also, Balanced Scorecard was deployed for the representation of business objectives and the requirements of a top-down controlling approach to keep the supply chain on course towards realizing business strategy and achieving improvement, to supply network scorecards.

The author also used important features of balanced scorecards to provide a comprehensive performance measurement framework for small and medium scale enterprises. The main aim for suggesting an integrated approach of SCOR and balanced scorecard was to ensure a greater effectiveness of performance management system on (1) SCOR adopts a building block approach and gives complete traceability, because BSC does not provide mechanism for maintaining the relevance of defined measures, (2) it gives clear definition on the type of process (planning, execution and enabling) and designs them to suit in a way that suits the supply chain requirements, thereby covering the BSC flaw of integrating top level, strategic scorecard, and operational level measures and (3) BSC does not specify a user-centered development process.

Ref. [6] noted that BSC conveys diverse classes of business performance – financial and nonfinancial, internal and external. The key purpose for suggesting a cohesive approach of SCOR and BSC is to ensure the greater effectiveness of Performance Measurement System (PMS) on the subsequent grounds:

BSC doesn't deliver apparatus for supporting the significance of distinct measures. SCOR approves a building block method and offers comprehensive traceability. BSC miscarries to assimilate top level, strategic scorecard, and operational level procedures potentially making execution of strategy problematic. SCOR undoubtedly outlines the type of procedure (planning, execution and enabling) and arranges them to outfit the supply chain requirements.

BSC miscarries to stipulate a user-centered elaboration procedure. A comprehensive exercise on SCOR generates sufficient information to even acquire tailor-made software system. An outline of the suggested SCOR-BSC framework is shown. The process starts with an initial understanding of business objectives, responsibility players, external prospects and performance measures. These were associated to various decision areas of SCOR model in Level 1. For each SCOR choice zone numerous supply chain planning processes Ref. [29] noted were contemplated. These progressions were then categorized based on their type – planning, execution, or enabling. The procedures relating to execution category should be related to most appropriate level 2 SCOR classification and a suitable plan-source-make-deliver configuration should be decided by an individual organization. The steps are determined at level 2 are then disintegrated to sub-processes at level 3 and process element definition, inputs-outputs, process, and performance metrics are summarized. The performance measures are associated to numerous groups of BSC and further classified into strategic, tactical, and operation level. Finally, a gap analysis is done to recognize difference between the present scope of performance measurement and proposed scope of SCOR-BSC framework to originate a suitable implementation plan (at Level 4).

Level 1 of SCOR investigated the relationship between nine key supply chain management planning practices (includes planning procedures, collaboration, teaming, process measures, process credibility, process integration, information technology (IT) support, process documentation and process ownership) and four decision areas in SCOR model (plan, source, make, deliver).

The planning variables in SCOR model areas have the strongest correlation to supply chain performance. Collaboration variables have an uninterrupted impact on supply chain performance in the deliver decision. Teaming variables have an uninterrupted impact on supply chain performance in plan and source areas. Process metrics variables have uninterrupted impact on supply chain performance in the deliver area and have only indirect impact on other areas of SCOR model.

Process integration, process credibility and IT support variables have a direct impact on supply chain performance in deliver area. Process documentation and process ownership have only indirect impact on supply chain performance in all four SCOR model areas.

3.0 Research methodology

An extensive overview of the practices of Supply Chain Performance Measurement (SCPM) is investigated using published research papers and some major SCM practices were uncovered. Widespread research papers and conference papers have been appraised from International Journals such as PROQUEST, EMERALD, EBSCO, IEEE, ACM, JSTOR etc. These classified practices are then associated to explore the relationships relationship between them for better understanding and application.

4.0 Discussions

4.1 *Balanced Scorecard (BSC)*

- BSC is devised as a monitoring and controlling tool rather than an improvement tool that gives direction for strategic level instead of functional or operational level [1,31]
- It delivers little guidance on how the appropriate measures can be identified, introduced and ultimately used to manage business [1,31,32]
- It does not reflect the market competition perspective [32,33]
- It does not stipulate any mathematical logical relationships among the individual's scorecard criteria [1]
- It is challenging to construct comparisons within and across firms [1,31,32]
- It is not effective for small and medium-sized organizations, because it requires a lot of skill and expertise of the management, time and expenditure of money [32,33]
- It does not take into account the relation of cause and effect over time, provide mechanisms for selecting best measures of performance [32,33,36]
- BSC particularly refer to the internal corporate perspective. External factors like risk issues, government regulations, uncertainty, collaborations, sustainability is not considered [1,31,34,36]
- It does not also consider continuous improvement [38].

4.2 *SCOR model*

- It does not consider global perspectives on market uncertainty, external risk factors [1,31,36]
- Information technology, information visibility does not cover within SCOR [1]
- Business sustainability issues does not cover within SCOR [1,31,36]
- Training and development, capacity building are also excluded in the SCOR scope [1,35,33]
- No clear interaction of inter and intra organizational or functional activities [1,35]

4.3 Future research for Supply Chain Performance Measurement (SCPM)

- Green organizations and sustainability in supply chain [1,31]
- Resilient due to increased uncertainties and risks [1,31, 37]
- Continuous improvement due to technological advancements and competitions [1,31]
- Agility due to competition and short product life [1,31,37]
- E- Commerce and e-supply chains [1,31,37]
- Incorporating Mathematical Models, OR techniques: Analytical Hierarchical Process (AHP) in SCPM is expected to be beneficial [1,31]
- Incorporating Mathematical Models, OR techniques: Analytical Hierarchical Process (AHP) in SCPM is expected to be beneficial.

4.4 Contribution

This study unlocks the frontier, particularly model development for the perspective researches in the area of supply chain performance measurement.

5.0 Conclusion

The literature review demonstrates that the prominence and scope of appraising supply chain management performance measurement is increasing exponentially

where academicians as well as industry practitioners have been progressively converging on how to design and implement performance measurement techniques in the perspective of borderless free trade economy having stiff rivalries. The paper primarily delivers definitions, hereafter converses the significance of performance measurement systems where a paradigm shift is observed that emphasizes both financial data (i.e. ROI, ROA) as well as non-financial data (i.e. quality, flexibility).

An interwoven relationship has been appraised through the study of a hybrid measurement model: SCOR and BSC where complexity factors – strategy, leadership, culture, and capability are critical. The literature recommends that performance is reliant on strategy continuously acknowledging the changes in the external atmosphere. Strategy and culture are indissoluble to boost the competitiveness by incorporating a sharing culture into the overall strategic direction of the firm. The Hybrid model in the literature largely focuses on organizational capabilities or competencies in larger organizations with a dearth of research in smaller firms. It is necessary for the firms to strive for a set of capabilities like involvement of top management, involvement of line managers, flexibility to adapt unanticipated changes, advertise or promote the product or service and make rapid design changes to receive the maximum advantage of proposed framework.

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