Developing a two dimensional framework to review the Supply Chain Performance Measurement literature

M. Manikandan*[1] and S. Chidambaranathan[2]

1. Research Scholar, Department of Manufacturing Engineering, Annamalai University, Annamalai Nagar, 608002, tamilnadu, india
2. Assistant Professor, Department of Manufacturing Engineering, Annamalai University, Annamalai Nagar, 608002 tamilnadu, india

Abstract — *Nowadays the supply chain management creates the value for companies, customers and stake holders interacting throughout a supply chain, the researchers recognize the need for measuring and monitoring the performance. Performance measurements play an important role in setting objectives, evaluating performance, and determining future courses of actions. Performance measurements pertaining to supply chain management have not received adequate attention from researchers and practitioners. In this paper a two dimensional framework has been developed for classifying the supply chain performance measurement (SCPM) literature which covers articles from the major journals related with SCPM literature and detailed investigation on methodologies, approaches, models were analyzed and gaps have been identified for future research.*

KeyWords — *Supply chain performance measurement, models, approaches*

I. INTRODUCTION

Performance measures are important to the effectiveness of the supply chain (SC). Companies can no longer focus on optimizing their own operations to the exclusion of their suppliers and customers. Supply chain performance measures (SCPM) is as an indicator of how well the SC system is functioning. Measuring the supply chain performance can able to facilitate the greater understanding of the supply chain and improve its overall performance Charan, [1].

Various performance metrics are in place for measuring effectiveness of SC. Different perspectives of supply chain performance measures (SCPM) are cost, non cost, strategic, tactical and operational Gunasekaran, [2].

Very little guidance is available in the literature examined for the actual selection and implementation of supply chain performance measurement system (SCPMs). The present research objectives are as follows.

- To develop a two dimensional framework to classify and review the literature in the SCPM areas.
- Identify strength of existing frameworks of SCPMs.
- To identify the gaps and suggest the future research.

II. DESIRABLE CHARACTERISTICS OF SCPMS

Various suggestions have been offered by the researchers on the subject of designing supply chain performance measurement systems. Beamon, [3] presents a number of characteristics that are trend in effective PMS.

- Inclusiveness (measurement of all pertinent aspects).
- Universality (allow for comparison under various operating conditions).
- Measurability (data required are measurable)
- Consistency (measures consistency with organization goals).

III. CLASSIFICATION BASED ON MODELS USED IN SCPM LITERATURE

There are five groups of models used in the literature and which are categorized as process based model, perspective based model, hierarchical model, six sigma model and uncertainty theory model. The details of the models are as follows:

A. Process based model

Some SC models are developed based on their process. Process based refers to those that take SC as a set of processes (such as manufacturing, logistic, inventory management etc.) and sub processes means a set of activities. This fact that supply chain management is a set of management processes has

been recognized by many other researchers, such as La Londe, [4] and Ross, [5]. Dasgupta, [6] and Lin and Li, [7] constructed their models based on SC processes and sub processes and used six-sigma metrics to evaluates the performance across the entire supply chain. Gunasekaran, [8] presented a framework for performance measures and metrics, by using four major supply chain processes (plan, source, make/assemble, and deliver).

B. Perspective based model

The perspective based model was developed by otto and kotzob, [9]. They take all the possible perspectives of a supply chain into account and provide measures to evaluate the each perspective. The perspectives are operation research or information technology, system dynamics, logistics, marketing, organization, and strategy .Each perspective has its very own notion of a supply chain, its standard problems and solutions, and its performance metrics.

Understanding what happens in a SC and why it happens have been difficult for firms with limited information and what is going on in other parts of the supply chain. One way of reducing this problem without changing the underlying causes is to exchange information. An example of a Perspective-based Measurement Systems (PBMS) is the Logistics Scoreboard Lapide, [10] in which recommended performance measures focus only on logistical aspects of the supply chain. They fall into the following four categories: logistics productivity measures (ex: orders shipped per hour), logistics financial performance measures (ex: expenses and return on assets), logistics quality measures (ex: shipment damage) and logistics cycle time measures (ex: order entry time). PBMS helps to evaluate the supply chain performance. However, there might be a trade-off between measures of one perspective with measures of other perspectives. Two main perspective based models are SCOR based and BSC based models.

C. Supply chain operations reference (SCOR) based model

The SCOR model (Supply Chain Council 2006) was introduced in 1996 and includes five basic processes including plan, source, deliver, make, and return. Also, it represents performance metrics characteristics in reliability, responsiveness, flexibility, cost, and asset attributes. These attributes are the characteristics of the supply chain that permits it to analyze and evaluate against other supply chains with competing strategies. The SCOR model is the only supply chain framework that links performance metrics, best practices and software requirements to a detailed business process model Ramaa, [11].

SCOR contains standard descriptions for management processes, a framework of relationships among the standard processes, standard metrics to measure process performance, management practices that produce best-in-class performance, and it enables the company to evaluate and compare their performances with other companies effectively, identify and pursue specific competitive advantages, identify software tools best suited to their specific process requirements.

D. Balanced scorecard based model (BSC)

Kaplan and Norton, [12] have proposed the BSC approach as a tool for performance evaluation through four perspectives of financial, internal business process, customer, and learning and growth.

BSC proposes that a company should use a balanced set of measures which allows the top managers to take a quick but comprehensive view of the business from four important perspectives. These perspectives provide answers to four fundamental questions Tangen, [13] (i). How do we look to our shareholders (financial perspective)? (ii). what must we excel at (internal business perspective)? (iii). How our customers see us (the customer perspective)? (iv). How we can continue to improve and create value (innovation and learning perspective)? By giving information from four perspectives, BSC minimizes the information overload by limiting the number of measures used. And it also forces managers to focus on the various measures that are most critical. Further, the use of several perspectives are guards against sub-optimization by compelling senior managers to consider all measures and evaluate whether improvement in one area may have been achieved at the expense of another.

E. Hybrid model

Bullinger, [14] proposed a framework for a supply chain performance analysis that includes identification of business objectives and processes, measurement of process performance, and definition of improvement opportunities and optimization measures. For setting objectives, tolerance limits, allocating resources, assigning responsibilities, measuring performance for feedback and corrective action, the authors developed a methodology that is a hybrid measurement model integrating SCOR measurement and balanced scorecards. The authors applied the SCOR-model, because the first concept of material and product flow may be defined and controlled by SCOR metrics. For representation of business objectives and requirement a top-down controlling approach to keep the supply chain on

track towards realizing business strategy and achieving improvement goals, they employed balanced scorecards to supply network scorecards.

F. Hierarchical based measurement model

Hierarchical model can be used in three aspects: metrics, criteria and processes. Metrics were classified at strategic, tactical and operational level which clarifies the appropriate level of management authority and responsibility for performance. Some researchers used hierarchical criteria for constructing models. In these models, objectives or overall performance of supply chain are decomposed into some criteria or sub-entity to investigate the performance based on them. Because of easy usage of multi criteria decision making methods, this perspective is attractive for authors. In hierarchical processes for constructing models, Chan and Qi, [15] [16] decomposed supply chain to six core business processes including supplier, inbound logistics, manufacturing, outbound logistics, marketing and sales, and end customers.

G. Six-Sigma based model

Six-sigma approach was developed by Motorola in 1987 and later it was widely adopted by big companies such as GE and Kodak to achieve re-markable benefits. The six-sigma metrics can be used for performance comparison of different processes. The common six-sigma metrics are dpu (defects per unit), z-value or the sigma value, dpo (defects per opportunity), throughput yield, rolled throughput yield, etc.

Six Sigma is the latest in a long line of approaches to quality and performance improvement. Immense financial benefits have been claimed by various authors and organizations from its combination of rigorous process improvement methodology, highly trained operatives and bottom-line focus (e.g. Hendricks and Kelbaugh, [17], Hoerl, [18].

H. Uncertainty theory based model

Chan and Qi, [15] developed a fuzzy set theory model to address the real situation on judgment and evaluation. With disputing efficacy of analytic hier-archy process (AHP), the authors favor fuzzy ratios for selecting measures.

A different approach to SCPM is using fuzzy logic inference rules to build a prediction model that anticipates results of supply chain lagging metrics based on leading metrics and if then scenarios. Unahabhokha, [19] propose a predictive output values from input values. An approach like this can be used to set targets on leading indicators based on prediction of performance of results.

IV. RESEARCH METHODOLOGY

Figure 1 shows the step by step process and details about this review paper from the selection of data up to the identification of gap.

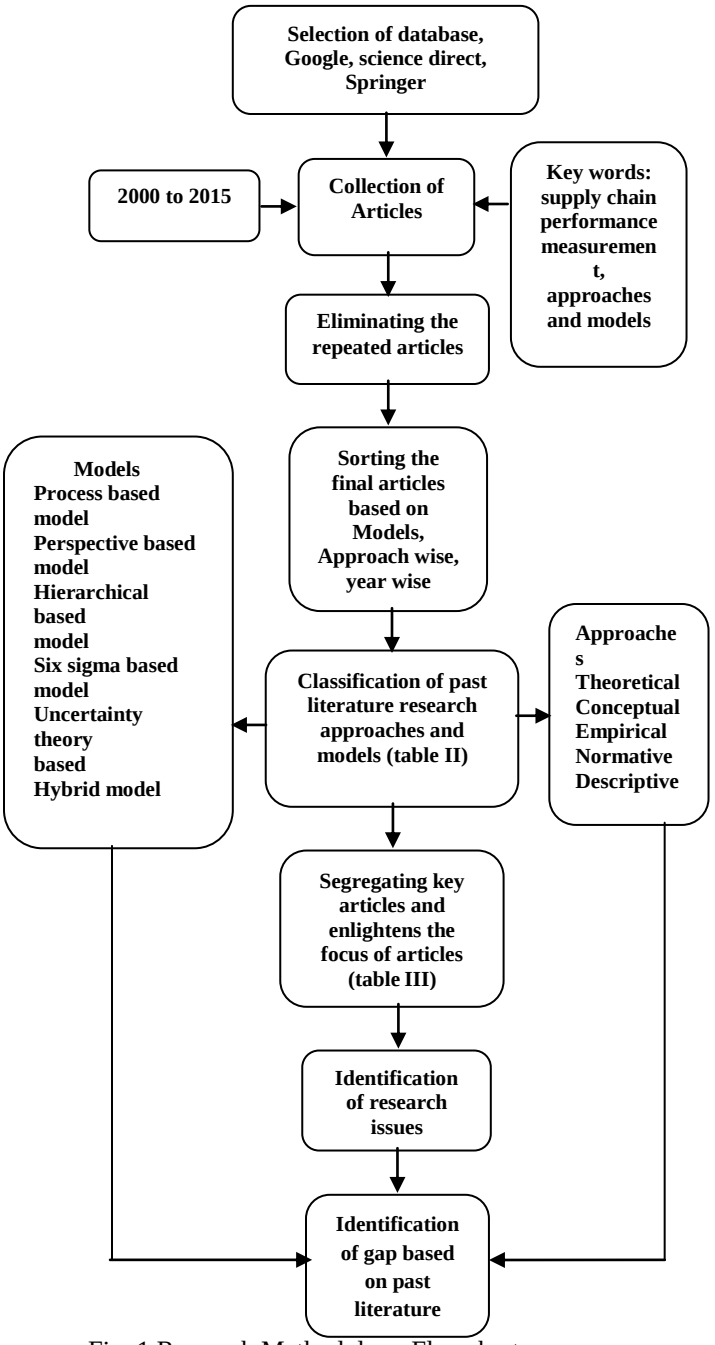

Fig. 1 Research Methodology Flowchart

V. CLASSIFICATION OF APPROACHES

The articles have been classified based upon the research approaches used in the SCPM literature and they are as follows.

The supply chain performance measurement literature can be broadly classified as
1) Theoretical 2) Conceptual 3) Empirical
4) Conceptual and Empirical. 5) Normative and
6) Descriptive

1. Theoretical

Theories are formulated to explain, predict and understand phenomena. And in many cases it helps to challenge and extend existing knowledge within the limits of critical bounding assumptions.

The theoretical frame work is structures which either holds or support a theory of research study. The theoretical frame work introduces and describes the theory that explains why the research problems under study exist.

Advantages

1. An explicit statement for theoretical assumptions permits the reader to evaluate them critically.
2. The theoretical frame work connects the researcher to existing knowledge guided by a relevant theory. It also helps in setting hypotheses and choice of research methods.
3. Having a theory helps to identify the limits of generalizations. (A theoretical frame work specifies which key variables influence a phenomena of interest and highlights the need of examine how those key variables might differ and under what circumstances.).

Limitations

1. All theorists begin from assumptions that may contradict the assumptions made by other theorists.

2. Conceptual

The conceptual categories have their primary focuses on the development of models. It is a generalization from experience or the result of a transformation of an existing idea. Conceptual research focuses on the concept or theory that explains or describes the phenomenon being studied.

Advantages

1. It is generally used by philosophers or thinkers to develop new concepts or to reinterpret existing ones.
2. It is used as a reference point/structure for the discussion of the literature, methodology and results.

Limitations

1. It also have problems in the framework.
   - It is influenced by the experience and knowledge of the individual (initial bias).
   - Ones developed will influence the researchers thinking and may result in some things being given prominence and others being ignored (ongoing bias).
2. Conflict may arise between conceptual framework and accounting standards.
3. May only benefit to interested groups.

3. Empirical

Empirical research mainly relies on the experience or observation alone, often without due regard for system and theory. It is data-based research, coming up with conclusions which are capable of being verified by observation or. The researchers also call it as experimental type of research. The empirically based articles include articles based on surveys, case studies, and interviews and anecdotal.

Advantages

1. It is a data based research coming up with conclusions which are capable of being verified by observation.
2. Empirical evidence (the record of one's direct observations or experience) can be analyzed quantitatively and qualitatively.
3. Possible explanations where provided for the outcomes measured.

Limitations

1. Inadequate explanation of where research lies in the knowledge building process, and therefore inadequate explanation of research purpose.
2. Lack of detail about data sources used.

4. Normative

In a normative or a quantitative framework the accent is on determining specific values for all parameters of the problem and solving for a specific value or a range of values. This model selects the best answer or solution from the available alternatives.

Advantages

1. Testing and validating already constructed theories about how and why phenomena occur.
2. Testing hypothesis that are constructed before the data are collected
3. Can generalize research findings when the data are based on random samples of sufficient size.
4. Useful for obtaining data that allow quantitative prediction to be made.

Limitations

1. The researchers might miss out a phenomena occurring because of the focus on theory or hypothesis testing rather than theory or hypothesis generation (called the conformation bias).
2. Knowledge produced might be too abstract and general for direct application and specific local situations, contexts and individuals.

5. Descriptive

A descriptive or qualitative framework does not attempt to quantity the factors but rather to state them in general terms and idea the problem on that basis. Descriptive models merely describe a present or pest set of conditions or activities and make no attempt to predict or recommend. It also identities possible areas of change; and investigates the consequences of various decision alternatives.

Advantages

1. Useful for studying a limited number of cases in depth
2. Provides individual case information.
3. Provides understanding and description of people's personal experiences about the phenomena (i.e., the epic or insider's viewpoint).
4. Qualitative approaches are especially responsive to local situations, stakeholders' needs, and conditions.

Limitations

1. It is more difficult to test the hypotheses and theories with large participant pools.
2. It generally takes more time to collect data when compared to quantitative research

VI. Two Dimensional Framework To Classifying The Research Articles

The table II shows the two dimensional framework to classifying the research articles. In this the approaches have been considered along one dimension and models along another dimension.

VII. Percentage Of Approaches Used In SCPM Literature

The table I shows the percentage of approaches used in SCPM literature. In this we have total number of 37 papers that have been separated based on the article type.

TABLE I

Percentage Of Approaches Used In SCPM Literature

Approaches	No. of Papers	%
Theoretical	11	28.57
Conceptual	16	45.7
Empirical	10	25.7
Total	37	100

VIII. Percentage Of Articles In Different Approaches

Figure 2 shows that even though various approaches have been used such as theoretical, empirical and conceptual in SCPM. Most of the studies are found to be either theoretical or conceptual in nature. There is a lagging in validation of model developed in the literature through survey or case study. It shows the need of considerations on empirical study.

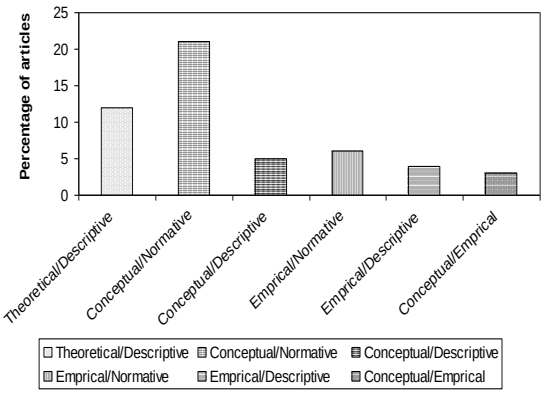

Fig. 2. Percentage of articles in different approaches

IX. Percentage Of Models Considered For Study

Figure 3 shows most of the researchers used the hierarchical model, perspective based model and process based model for their study, and it shows there is a need and much attention on models like six sigma, uncertainty theory model and hybrid model in the area of SCPM.

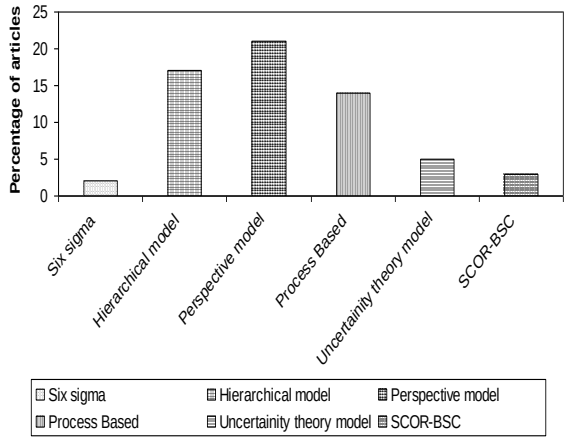

Fig. 3 Percentage of models considered for study

The table 3 shows the summary of SCPM literature and separated the collected papers into year wise and shows the main focus of articles followed by an author and year.

Table II

TWO DIMENSIONAL FRAMEWORK FOR CLASSIFYING THE RESEARCH ARTICLES

Approaches		Models							
		Process Based	**Perspective Based**	**SCOR**	**BSC**	**Hybrid**	**Hierarchical**	**Six Sigma**	**Uncertainty Theory Based**
Theoretical	**Normative**								
	Descriptive	Drizymalski [20], Berrah & Clivilie [21], Persson & Olhanger [22], Chan&qi [16]	Otto and Kotzob [9]	Drzymalski et al [20], Berrah and Clivillie [21]			Drzymalski et al [20], Berrah & Clivillie [21], Chan & Qi[15]		Chan & Qi [15], Chan & Larbani [23]
Conceptual	**Normative**	Dasgupta [6], Gunasekaran et al [2], Gunasekaran etal [8], Theranupatna & Tang [24]	Krishnapriya V1 and Rupashree Baral [25]	Wong [26], Lai et al [27], cai et al [28], Wong et al [29], Theranupatna [24]	Bhagvat et al [30]		Chan [15], Bhagvat et al [30], Gunasekaran et al [8], Theeranupatna & Tang [24], Bhagwat & Sharma [31]	Dasgupta [6]	
	Descriptive	Thakker etal [32], bullinger et al [14], parkan & wang[33]				Thakker et al [32], Bullinger et al [14]	Thakker et al[32], bullinger et al [14]		Parkan & Wang [33], John Storey and Caroline Emberson [34]
Empirical	**Normative**	Lin&li [7], askariazad&wanous [35]			Bhagvat & Sharma [36]		Askariazad & Wanous [35]	Lin&li [7]	
	Descriptive			Danish Irfan, Xu Xiaofei1 and Deng Sheng Chun1 [37]	Yang[38], Bigiliardi & Bottani [39]		Yang [38]		Yang [38]
Empirical & Conceptual	**Normative**	Felix T.S. Chan [40]							Dong Won Cho et al [41]
	Descriptive					Ilias P. Vlachos [42]			Wang et al. [43]

X. SUMMARY OF SCPM LITERATURE

Table III

SUMMARY OF SCPM LITERATURE

Author/year	Article focus
1. Gunasekaran et al. [2]	This paper focuses on designing of measures for supply chain performance
2. Gunasekaran et al. [8]	Focuses on performance measurement, measurement and metrics classification and assessing importance of each performance measures.
3. Berrah L and Cliville [21]	SCP formalization model have been developed according to SCOR model with its five main process(plan, source, make, deliver, and return)
4. Theeranuphattana and tang [24]	The authors employed SCOR model and combined it with chan and qi model
5. Varma et al [50]	Employed BSC perspectives and mapped petroleum supply chain criteria under the four perspectives
6. Cuthbertson R and Piotrewitz [44]	Identification and categorization of measures and benefits from frameworks or theory it focuses on implementing the measures
7.Danish Irfan, Xu Xiaofei , and Deng Sheng Chun [37]	This article presents supply chain management efforts, key challenges and opportunities in pakistan's industrial and organizational sector by deploying the eminent SCOR-model.
8. Bhagwat and Shama [31]	Used BSC approach to analyze their operations from every angle that covers all perspective of business
9. Drzymalski et al [20]	The author utilized SCOR model metrics to measure performance of each level and attributes of reliability, responsiveness, flexibility, cost and profitability
10.Gilberto MillerDevo´ s Ganga [45]	Authors adopted a SCOR model based on fuzzy logic metrics seems to be a feasible approach to predict performance of supply chains
11. Dong Won Cho, Young Hae Lee [41]	Develops a framework of service supply chain performance measurement based on the strategic, tactical and operational level. Processes such as demand management, customer relationship management, supplier relationship management, capacity and resource management, service performance, information technology management and service supply chain finance are applied in the hotel supply chain.
12. Dominique Estampe , SamirLamouri, etal [46]	This paper analyzes various models used to assess supply chains by highlighting their specific characteristics and applicability in different contexts.
13. Elisa Kusrini Subagyo [47]	This paper discusses good criteria for a supply chain performance measurement model and their level of importance. The criteria are divided into two categories, namely efficient and effective. Authors try to examine which criteria can be used to assess a SCPM model, by using a survey.
14. Hamid Kozeem Khanlo Hamid Reza Shadi [48]	Analyze various models used to asses supply chains by highlighting theirs specific characteristics and applicability in different contexts.
15. Wang et al. [43]	Authors developed an empirically validated measurement of supply chain uncertainty and risk in the Australian courier industry
16. C. Mainagi P. Trivellasb [49]	Supply chain partners coordinate their processes through information sharing in order to facilitate supplier customer interactions.

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XI. CONCLUSION

In this paper an attempt has been made to develop a two dimensional framework to classify and review the literature on supply chain performance measurement. Since SCPM has received attention among the researchers and organizations from early 2000 and this study presented a literature review for 37 articles for the period between 2000 and 2015. Further the articles have been classified along two dimensions as a) Theoretical b) Conceptual c) Empirical d) Conceptual and Empirical e) Normative and f) Descriptive along one dimension and models like a) process based b) perspective based c) SCOR model d) BSC model e) hybrid model f) hierarchical based measurement model g) six sigma model and h) uncertainty theory based model along another dimension. The research approaches taken in different functional areas of literature were compared.

From this study, gaps have been identified and guidelines for future research were made which are as follows:

a. No researcher made an attempt to analysis the theoretical and normative type research by using various models. This may be due to that the theoretical framework cannot be combined with normative (or) quantitative framework.
b. Although various models have been utilized in theoretical and descriptive approach, researchers didn't consider the following models namely BSC model, hybrid model and Six Sigma model.
c. In conceptual and normative type approach there is no attempt made by researchers in hybrid and uncertainty theory based model.
d. In conceptual and descriptive approach we found that a researcher doesn't focused on the following models such as perspective based model, SCOR model, BSC model and Six Sigma model.
e. In empirical and normative type research it is noted that no research papers which have employed various models namely perspective based model, SCOR model, hybrid model and uncertainty theory model.
f. In case of empirical and descriptive approach most of the researchers used SCOR model, BSC model, hierarchical model and uncertainty theory model. And there is need of the study on process based model, perspective based model, hybrid model and Six Sigma model.
g. In empirical / conceptual with normative approach no research paper had made an attempt in the following models namely, perspective based, SCOR model, BSC model, hybrid model, hierarchical model and six sigma model.
h. In empirical / conceptual with descriptive approach researcher employed hybrid model and uncertainty model then other models have not been considered.

XII. FUTURE SCOPE

The following suggestions may be considered as future scope:

1) Researchers can develop a measurement index (combinations of system dynamics, operations research, logistics, marketing, organization and strategy perspectives) by using normative type research approaches and the models namely perspective based, hybrid, hierarchical and six sigma models may be considered and it can be validated through a survey or case study for getting optimum supply chain performance.
2) Need of more empirical research on effects of management practices (tactical, operational. etc) with combination of supply chain management practices.
3) Researchers should focus on case study approaches for process based studies where collaboration and information sharing are the key components of business process management.
4) A hybrid benchmarking approach is seldom adopted on SCPM of this approach can be validated through empirical research.
5) In SCPM literature most of the researchers used process based model, hierarchical model and perspective model it shows that there is a need for the consideration of hybrid, six sigma and uncertainty model by using various approaches considered in this study.

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