# Critical Review of Performance Measurement Frameworks in Supply Chain Management

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## Abstract

*Performance measurement of supply chain management (SCM) is a rapidly growing multi-dimensional problem owing to the large number of factors affecting the supply chain . There exist a number of well known models and frameworks for operations, logistics and supply chain management The right choice of performance metrics and measures is critical to the success and competitiveness of the firms in the era of globalisation number of frameworks have been developed in the past. This paper aims to take a critical view of all the frameworks developed by researchers till now and understand the basic philosophy behind each to them. Limitations and strength of each framework is discussed in detail in the paper*

## 1. Introduction

As a concept, Supply Chain Management (SCM) originated in the manufacturing industry in early 1980s as a facilitator for manufacturing techniques like Just-in-Time(JIT), Total Quality Management(TQM)(Wong & Fung, 1999). Supply chain can be observed as an extension of the manufacturing innovations that were heralded by the Japanese companies in order to increase efficacy of its facilities. Going further, the focus is not only to increase the internal effectiveness of the organization, its goes well beyond and encapsulates the value addition happening due to implementation of SCM. SCM is also seen to have a major impact on waste reduction. As a concept, SCM has shifted the significance from internal environment to the external structure . Supply Chain Management is visualised as a combination of various processes that come together in order to achieve complete co-ordination right from supplier's supplier to the customers customer. SCM helps in developing greater synergy through collaboration along the whole supply chain.

By definition, The Council of Supply Chain Management Professionals also defines" that supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers and customers. In essence, supply chain management integrates supply and demand management within and across companies".

Sink and Tuttle (1989) claim that “you cannot manage what you cannot measure”. Many manufacturing and service organisations have used performance measures and measurement systems to determine their performance. Browne et al. (1998) develop the ENAPS approach of performance measurement, which consists of a generic set of performance measures and indicators and uses a process-oriented top down approach. It contains a large number of performance measures or factors. Hudson et al. (2001) investigate strategically aligned performance measures, which can help stimulate continuous improvements; this is achieved by linking performance measures to specific improvement efforts and helping to drive performance towards critical strategic objectives, which are designed to be revisited and updated regularly. Rouse and Putterill (2003) argue that a performance measurement framework assists in the process of performance measurement system building, by clarifying performance measurement boundaries, specifying performance measurement dimensions or views and may also provide initial institutions into relationships among the performance measurement dimensions. Folan and Browne (2005)present different performance measurement frameworks specifically designed for the inter-organisational environment. They further develop a performance measurement system looking into the requirements of extended enterprise, via two performance measurement frameworks: the structural extended enterprise balanced scorecard and the procedural framework for the selection and implementation measures.

Development of the literature on performance measurements can be divided into two distinct phases (Dixon et al., 1990). The first phase relates to the period until the 1980s and concentrates on financial measures such as profit, return on investment and productivity. The second phase, which commences in

the late 1980s, corresponds to the emergence of new management concepts such as supply chain management. It attempts to place a greater emphasis upon the inclusion of less tangible and non-financial measures in performance measurements.

There are the range of limitations of existing measurement systems for manufacturing, including: they lack strategic focus (the measurement system is not aligned correctly with strategic goals, organization culture or reward systems) (Banks and Wheelright, 1979) they encourage short termism (Hayes and Garvin, 1982) they encourage local optimisation (Fry and Cox, 1989) they encourage minimisation the variances from standard, rather than seek to improve continually (Lynch and Cross, 1991) and they do not being externally focused (Kaplan and Norton, 1992). In an attempt to overcome these and other criticisms, performance measurement frameworks have been developed and provide a balanced view between levels in the organisation (Cross and Lynch, 1988-1989), between external and internal focus (Keegan et al., 1989), between results and determinants (Fitzgerald et al., 1991), between the four perspectives of the balanced scorecard (Kaplan and Norton, 1992) and the multiple perspective of the stakeholders (Kennerley and Neely, 2002). The excellent overview of performance measurement provided by Neely et al. (1995) has been widely cited in recent research into supply chain performance measurement systems and metrics (e.g. Beamon, 1999; Beamon and Chen, 2001; Gunasekaran et al., 2001, 2004). These, and other studies, have highlighted how the majority of the limitations cited by Neely and his collaborators remain salient in the case of performance measurement systems for supply chains. Moreover, they have stressed the need for new measurement systems and metrics which address these deficiencies. Whilst this represents an important step forward, this research argues that there is a need for reflection on contemporary research that has investigated a number of important issues.

## 2. Performance Measurement Frameworks in Supply Chain Management

A number of researchers have given different set of frameworks for measuring the effectiveness and efficiency of a supply chain. In this section the frameworks are discussed, with the methodology and limitations of each of them .

Performance measurement issues need to be compared with some pre defined standard models , also known as frameworks. In one of the first frameworks presented , Beamon, 1999, has presented a primary overview of the performance measurement process. The paper further evaluates performance metrics used in models in a manufacturing supply chain. The paper analyses a framework based of three key performance metrics: resources, Output and Flexibility. These parameters are deemed as essential for any supply chain performance measurement system. The paper suggests a flexibility measurement approach for supply chain.

A major drawback of this proposal is that it lacks in holistic view of the entire supply chain.

Gunasekaran et.al. (2001) enumerate different performance measures and metrics and provide a picture of the measurables in supply chain management. This paper also deals with how the measureables need to be dealt with. In this framework, the metrics are categorised in three types: Strategic, tactical and Operational. Further to this, the metrics are also classified as financial and non financial ones. This facilitates a suitable costing method , hinging on activity analysis.

The limitation of this framework is that large number of metrics and measures given in the framework, firms find it difficult to use. Not many firms use all metrics and measures in day-to-day business operations. Also, the framework does not provide guidelines to prioritise these metrics. Further, firms require a comprehensive way to analyse their operations from every angle that covers all perspectives of business.

Otto & Kotza, 2003, provide us with six sets of unique supply chain metrics based on six different perspectives: system dynamics, operational research, logistics, marketing, organization and strategy.

Each of these perspective has a different set go goals on which a different types of performance metrics are based. Each perspective in this framework has a different notion of the supply chain management and the issues therein.

All the metrics provided in this paper are not feasible to be measured quantitatively and qualitatively for developing a comprehensive framework

Chang and Qi,(2003) provide another framework for measuring the performance of a supply chain. The framework they propose has a innovative performance measurement technique that contributes t development of supply chain management from five core processes: supplying, inbound logistics, core manufacturing, outbound logistics and marketing & sales. This framework uses fuzzy logic and other soft computing techniques to make a process based systematic perspective. A cross organization holistic performance system is introduced to address the real life situation in judgement and evaluation processes.

The limitation of this system is that it doesn't account for the strategic, operational and tactical levels of decision making ability.

Gunasekaran *et al*. (2004) develop a framework to promote a better understanding of the importance of supply chain management performance measurement and metrics. This framework measures the supply chain processes (plan, make, source and deliver) in respect to strategic, operational and tactical levels. This framework then evaluates apriority wise score for each listed metric by three levels: highly important, moderately important and low importance.

The limitation of this framework is that it lacks identifying critical success factors for the whole supply chain system. Furthermore, for evaluating the score, the organization, suppliers and customers should come together to discuss how they will address the measurement and improvement of supply chain management performance. Industry consortiums, consultants and researchers could be helpful in promoting supply chain management performance measurement generally, and in developing measures and measurement techniques specifically.

Huang *et al.* (2005) have described in detail the Supply Chain Operations Reference (SCOR) Model in detail with the help of some case studies and benefits thereof. In this paper computer-assisted tool to configure supply chain threaded diagram per SCOR specification has been developed. Supply chain configuration is an integral part in SCOR project implementation. Currently, the configuration of 'as-is' or 'to-be' threaded-diagram describing a supply chain is done manually. To automate this process, a computer-assisted configuration tool has been developed and described in this paper.

However, the configuration tool can so far only deal with a single manufacturing facility of a company. It does not take into account the interactions among multiple manufacturing facilities. Thus, this research limits to only single manufacturing facility of a company for studying.

Aramyan et al (2007) have developed a framework for measuring performance in supply chain of a Dutch German company dealing in tomatoes. The case study concludes with the following key indicators of performance in the supply chain under study: efficiency, flexibility, responsiveness and food quality. This study further develops an integrated supply chain performance measurement framework that combines metrics of both financial and non financial nature.

However, due consideration needs to be given to the fact that this framework was limited to the case company and that too in agri supply chain, Generalization of this framework is not advice as different industries might be having different set of measures

Berrah and Cliville(2007) have suggested a framework by linking the overall performance expression to basic performance levels. The overall performance matrix is formed by linking the metrics to a global objectives further aggregating it in a colloary way. Taking the list of performance indicators from Gunasekaran (2004) forward, this paper provides a case study of a bearings company. Relationship between the performance indicators and groups : Plan, Source, Make, Deliver is established. A weighted arithmetic mean (WAM), of the involved elementary performances is calculated . Besides, the multi attractiveness categorical based evaluation technique (MACBETH) methodology has been applied to the performance expression of the four main processes of a supply chain. The positive that comes out from this study is that a structured framework

This framework consists of four management processes: Plan, Source , Make , Deliver. It fails to take the fifth process of return into account.

Bhagwat and Sharma(2007a) have taken Balance Score card (BSC) as the basis of developing a framework. BSC involves evaluating day to day business processes in the following perspectives: finance, customer, internal business process and learning and growth. Three Indian companies in the small and medium sector have been taken in for developing a case study of the BSC based framework. This study gives a very practical and implementable framework that the practicing managers can use for evaluation and measuring of supply chain management in a balanced way.

This approach needs to be further researched so as to know what more measures and perspectives can be added, or is the current level sufficient for measuring the effectiveness of supply chain system

Jammernegg and Reiner (2007) discuss the opportunities and challenges for improving the performance of supply chain processes by coordinated application of inventory management and capacity management. The case study taken by this study is unique in a way that encompasses various geographies, example being given of a telecom and automobile company that due to lower labor costs among other factors might be producing somewhere else and selling in a completely different continent. A relationship between inventory management and capacity management is derived using process simulation.

The paper deals only in costs v/s service level paradigm and hence it lacks to see the SCM process in a holistic manner.

Yeh *et al.* (2007) in their study have done evaluation of the performance of a supply chain by using a fuzzy logic technique named fuzzy linguistic computing. This study uses the DMAIC technique of six sigma methodology to create a framework for checking supply chain performance. Delphi technique is employed in this study for integrating expert opinion on criterion selection, weighting identification and performance appraisal that are expressed in terms of fuzzy linguistic variables. A geometric translator and symbol translation is use to encompass the FLC technique and develop 2-tuple terms involved. The drawback of this paper is that it is silent on decision making issues.

Robb et al. (2008) propose and develop a model that establishes a relationship between supply chain or operations practice and operational or financial performance by using a structural equation model taking a set of China furniture manufacturers as a part of case study. The uniqueness of this industry lies in the fact that while increasing labour productivity has been a challenge as in recent times remains relatively low, exports in this sector have undergone substantial growth. One of the major research highlights of this study is relative importance of supply chain and operations practices and the study shows impact of practice on business performance , mediated by capabilities on operations dimensions One of the unique learning's of this paper is the impact of human resources on supply chain performance. This paper takes a look at training and development of operational manpower as a key area for supply chain performance .The limitation of this research is it studied only operations dimension performance, not taking a holistic view of the supply chain

Zhu et al. (2008) empirically investigate the construct and the parameters for evaluating green supply chain management (GSCM) practices that can be implemented across manufacturers., the measurement scale instrument in the form of a survey questionnaire developed from the various literature sources and interview academics and practitioners among Chinese manufacturers. Confirmatory factor analysis is used to test and compare the measurement frameworks developed in the course of this study. Using a multi- item five-point Likert scale to evaluate the different aspects of green supply chain management practices implemented and evaluate their strengths and weaknesses. However, this study concentrates only environmental performance with operational performance, not for the whole supply chain performance.

Iterative key performance indicators forms the basis of framework proposed by Cai et. al (2009). Interdependent relationships among various KPIs is explored and analysed in this framework. This framework can be extensively used in a dynamic supply chain environment. Extending the Eigen structure analysis methods, a work transformation matrix is derived from design structure matrix from engineering to business performance measurement. The focus area of this study is to develop a KPI accomplishment cost transformation matrix.

The point to be kept in mind while implementing this framework is that this paper should not be adopted as a decision making paradigm but only as a support argument for making the right decision.

Chae (2009) has developed a hand-on practical and implementable approach to the framework issue in supply chain performance context and proposes key performance metrics which can be easily adapted for different businesses. An exhaustive list of essential key performance indicators (KPIs) across industries is presented. Potential KPIs develop for each of the SCOR model's four meta-process (plan, source, make and delivery) and have to be hierarchically grouped such as primary and secondary metrics. The study also reviews industry standards and best practices in supply chain performance measurement suggesting that that 'less is better' as to developing performance metrics. The study is of the opinion that companies should focus on only a limited number of KPIs which are critical for their operations management, customer service, and financial viability. The lack of this development model is the return process not considered in this work.

Balanced scorecard (BSC) approach on the logistics industry for measuring supply chain performance is the basis of the proposed framework by Chia et. al.(2009) . This study , based on empirical considerations evaluate the measurement perception of senior level functionaries in the supply chain domain. A survey designed on the basis of four pillars of the BSC is conducted on senior executives involved in the supply chain functions of organizations across industries, and those executives from the logistics service provider industry. This study suggests that the measurement of performance of supply chain entities could be improved by using a more balanced perspective as provided for by the BSC framework. Further, the results show an apparent lack in the focus on drivers of strategic future performance, as implied in the results of the measurement of internal business processes and learning and growth indicators. These two perspectives contain measures that create future value, and address the development of core competencies but they were not as well measured. The limitation of this work is the sizes of some respondent

clusters are smaller than others. Hence, the results may not be representative of the individual clusters.

Rodriguez et al. (2009) propose the quantitative relationships performance measurement system (QRPMS) a framework that establishes a discrete relationship of a group of strategic objectives and associated key performance indicators (KPIs). This study presents a unique proposal able to objectively identify and quantify relationships between KPIs defined within a performance measurement system base on the balanced scorecard (BSC), that offering additional information to managers to make cross-enterprise decisions. Then, the research projects KPIs upstream in the performance measurement system, establishing meaningful cause and effect relationships at the objectives levels. A case study of a baby cloth manufacturer is part of this research. The framework developed is applied on the industry . As the research studied only one manufacturing company, it may be the disadvantage for this paper.

Thakkar *et al.* (2009) provide a brilliant insight into the hybrid framework arena when they integrate the elements of Balanced Scorecard (BSC) with supply chain operation reference (SCOR). This framework integrates supply chain performance measurement framework for the case of small and medium scale enterprises (SMEs) in India using set of qualitative and quantitative variables that are part of a case study of Indian SME sector as a part of this research. Measures are linked to various processes in supply chain management like source, make and deliver. This framework also has limited usage at the decision making levels.

Bigliardi and Bottani (2010) have studied the food supply chain and developed a balanced scorecard (BSC) model that is designed for performance measurement in the food supply chain. This study takes BSC to be a building block for performance measurement and develops a model that aims to serve as a point of reference for the food industry by implementing the In the study. Then a list of performance metrics is given to a panel of experts, which operate on the principle of Delphi technique, to gather possible suggestions or revisions , if any. In its final form, the resulting BSC model is tested on two companies operating in the food industry, for a final validation. However, the fact that a specific industry field (the food industry) is examined could be seen as a limitation of the work as the results presented are not suitable to be generalized or extended to other contexts.

Flynn et al. (2010) study the relationship between three dimensions of supply chain integration, operational and business performance, from both a contingency and a configuration perspective. This research defines supply chain integration as the degree

Flynn et al. (2010) study the relationship between three major elements of supply chain: integration, operational and business performance, from both a contingency and a configuration perspective. This study offers a definition of supply chain integration as the degree to which a manufacturer strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational processes, in order to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the customer. The technique of hierarchical regression is used to determine the impact of individual supply chain integration dimensions and their interactions on performance. In the configuration approach, cluster analysis is used to develop patterns of supply chain integration, which are analyzed in terms of supply chain integration strength and balance.

This study lacks in decision making capabilities to be integrated i the supply chain

Lin et al. (2010) present a proposed model which is implemented in Taiwanese hi tech manufacturing organizations. The paper focuses on innovation in channel integration of these organizations. Confirmatory facet analysis is used to test the model developed through AMOS 7.0 analysis The study tests the measurement model for overall factors with a confirmatory factor analysis (CFA) through AMOS 7.0 analysis. The results indicate that a significant relationship has been established between market related metrics (customer focus, competitor-oriented and cross-functional coordination) and supply chain performance.

However, this model only concentrates on innovation perspective.

All the reviewed frameworks have been tabulated for easier look. It can be observed that this is not a case of one size fits all, but each framework has had its limited utility

Table 1: Summary of Supply Chain Management Performance Measurement Frameworks

| S.No. | Paper & Author | Technique used | Advantages | Disadvantages |
|---|---|---|---|---|
| 1 | Beamon, 1999 | Framework based on : resources, Output and Flexibility | Emphasis on Flexibility, Essential Parameters | Does not take into account the holistic nature of supply chain |
| 2 | Gunasekaran et.al. (2001) | Operations, Strategy, Tactical Performance metrics | Comprehensive coverage of financial and non financial metrics | High number of variables, usability of all metrics |
| 3 | Otto & Kotza, 2003 | Six set of metrics: system dynamics, operations, logistics, marketing, organization & strategy | Different aspects and notions of SCM come together | Difficulty in quantification |
| 4 | Chang and Qi,(2003) | Supply Chain Process using fuzzy theory | Identify five core processes as holistic supply chain measurement | Overlooks the decision making ability |
| 5 | Gunasekaran et. al (2004) | Decision Making in SCM | Decision making in PM system is integrated in the framework | Extensive collaborative effort from all echelons of supply chain is needed |
| 6 | Huang *et al.* (2005) | Supply chain operations reference (SCOR) model | A computerised tool for SCR model is made | Limited to only one manufacturing organization |
| 7 | Aramyan *et al.* (2007) | Key indicators of performance in the in food supply chain: efficiency, flexibility, responsiveness &food quality | Both financial and non financial measures are taken into account | Only relevant for a food supply chain. Feasibility in other supply chains is an issue |
| 8 | Bhagwat and Sharma (2007) | Balanced score card perspective | Used and validated on three SME companies in India | Need to determine the proposed perspectives and measures |
| 9 | Jammernegg and Reiner (2007) | Comparison of Internal and External measures | Co ordinated evaluation of storage and capacity management | Concentrates only on service levels and costs |
| `10 | Yeh *et al.* (2007) | Six Sigma (DMAIC) processes | 2tuple Fuzzy model for measuring performance | Doesn't link with decision making |
| 11 | Robb *et al.* (2008) | Operations practice and performance | Modelled for operations function | Other elements have been ignored |
| 12 | Zhu *et al.*(2008) | Green supply chain management | green supply chain practices implementation | Works only for environment and operations |
| 13 | Cai *at el.* (2009) | Systems approach using PCTM | Makes an effort to increase the quality of KPI's in SCM | Doesn't provide validation and provides only support for existing documentation |
| 14 | Chae (2009) | SCOR model | practical approach to performance measurement and propose key performance metrics | Does not take into account the return process |

| S.No. | Paper & Author | Technique used | Advantages | Disadvantages |
|---|---|---|---|---|
| 15 | Chia *et al.* (2009) | Balanced score card perspective | Applies on the logistics industry | Size of respondents differs greatly |
| 16 | Rodriguez *et al.* (2009) | Balanced score card perspective | Quantitative relationships | Study only one manufacturing company |
| 17 | Thakkar *et al.* (2009) | Integrated balanced score card and SCOR model | Integrated framework for SMEs | Decision making not considered |
| 18 | Bigliardi and Bottani (2010) | Balanced score card perspective | Developed a framework for Food supply chain | Industry specific |
| 19 | Flynn *et al.* (2010) | Supply chain integration, operational and business performance | Linking Business, Operation and integration | Overlooks the decision making angle |
| 20 | Lin *et al.* (2010) | Supply chain innovation | Channel integration | Talks only of innovation perspective |

Conclusion:

Implementing a performance measurement framework in supply chain systes is a complex task and needs careful thought before rushing into the same. The paper has made an attempt to critically view the available frameworks thouroughy so that an effective, robust, discrete and measurable framework can be developed, keeping in mind the shortcomings of existing frameworks. Creative inputs are essential in order to design new frameworks and tools for assessing the performance of each organization that encompasses the supply chain. All the elements of a supply chain: Suppliers, Organizations and customers should be equally involved in making a robust framework for measuring performance of supply chain effective and quantifiable. The paper dwells into available frameworks and shows how can an existing framework can be taken in as a building block and improvement on the same can provide us with a better option

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