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Study of performance measurement practices in supply chain management

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Abstract

Considerable research has been carried out and literature available in the field of Supply Chain Performance Management since 1990. Different perspectives of Supply Chain Performance Measures are cost and non-cost perspective; strategic, tactical or operational focus; business process perspective and financial perspective. Successful supply chains use integrated measurement systems as a vehicle to achieve their organizational goals. A comparative analysis of some most widely cited performance measurement systems have been undertaken and it indicates that validity of many of the measurement frameworks needs to be established through further study. The process of choosing appropriate supply chain performance measures is difficult as a result of the complexity of these systems. The objective of this paper is to review the literature in the field of performance measurement for supply chains to understand current practices, identify gaps and suggest future research agenda The paper also presents an overview and evaluation of the performance measures used in supply chain models.

Keywords: Supply Chain, Performance Measurement, Performance Management, Performance Measures.

1. Introduction

Business organizations need to capitalize on Supply Chain (SC) capabilities and resources to bring products and services to the market faster, at the lowest possible cost, with the appropriate product and service features and the best overall value (Gunasekaran et al., 2001). Performance measures are important to the effectiveness of SC. Companies can no longer focus on optimizing their own operations to the exclusion of their suppliers' and customers' operations. Supply Chain Performance Measures (SCPM) serve as an indicator of how well the SC system is functioning. Measuring SC performance can facilitate a greater understanding of the SC and improve its overall performance (Charan et al., 2008).

There is an emerging requirement to focus on the performance measurement of the SC in which company is a partner (Charan et al., 2008). Interest on performance measurement has notably increased in the last 20 years (Taticchi et al., 2010). Companies have understood that for competing in continuously changing environment, it is necessary to monitor and understand firm performances. Measurement has been recognized as a crucial element to improve business performance (Taticchi et al., 2010).

Various performance metrics are in place for measuring effectiveness of SC. Different perspectives of Supply Chain Performance Measures (SCPM) are cost and non-cost perspective; strategic, tactical or operational focus (Gunasekaran *et al.*, 2001); business process perspective and financial perspective (Beamon, 1999). The earlier focus of performance measurement was on financial perspective which is gradually changing to non-financial perspectives. Most of the models have gone through some empirical testing and some have only theoretical developments (Taticchi et al., 2010). 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 review the literature in the SCPMS areas.
- Identify strengths and limitations of existing frameworks of SCPMS.
- Identify SCPM success factors as well as reasons for failures.
- To identify the gaps and suggest the future research.

The paper has been organised as follows: Definition and characteristics of SCPMS are given at Section 1 and 2 respectively; Section 3 gives an overview of evolution of SCPMS; Classification of PMS literature is attempted at Section 5; Structure and

classification of metrics and measures in SCPMS is given at Section 6; Some of the most cited PMS frameworks and models are described at section 7; Success factors, selection and implementation of SCPMS are brought out at Section 8; Future PMS and Research Directions are mentioned at Section 9 and results of this study is discussed at Section 10.

2. Definition and Objectives of SCPMS

Neely et al. (2002) defined Performance Measurement System (PMS) as a balanced and dynamic system that enables support of decision-making processes by gathering, elaborating and analyzing information. Taticchi et al. (2010) further elaborated this definition by commenting on the concept of 'balance' and 'dynamicity'. 'Balance' refers to the need of using different measures and perspectives that tied together give a holistic view of the organization. The concept of 'dynamicity' refers instead to the need of developing a system that continuously monitors the internal and external context and reviews objectives and priorities.

Bititci et al. (1997) defined SCPMS as the reporting process that gives feedback to employees on the outcome of actions. Stefan Tangen (2004) proposed that performance be defined as the efficiency and effectiveness of action, which leads to the following definitions: (i). Performance measurement is defined as the process of quantifying the efficiency and effectiveness of action; (ii). A performance measure is defined as a metric used to quantify the efficiency and/or effectiveness of an action; and (iii). Performance Management System is defined as the set of metrics used to quantify the efficiency and effectiveness of an action.

Effective supply chain management (SCM) has been associated with a variety of advantages including increased customer value, increased profitability, reduced cycle times and average inventory levels and even better product design (William et al., 2007). The objective of SCPM therefore has to facilitate and enhance the efficiency and effectiveness of SCM. The main goal of SCPM models and frameworks is to support management by helping them to measure business performance, analyze and improve business operational efficiency through better decision-making processes (Tangen, 2005). An effective, integrated and balanced SCPMS can engage the organisation's performance measurement system as a vehicle for organisational change. SCPM can facilitate inter-understanding and integration among the SC members. It makes an indispensable contribution to decision making in SCM, particularly in re-designing business goals and strategies, and re-engineering processes (Charan et al., 2008).

3. Desirable Characteristics of SCPMS

A number of suggestions have been offered by various experts on the subject of designing PMS. Beamon (1999) presents a number of characteristics that are found in effective performance measurement systems, which include the following.

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

According to Gunasekaran et al. (2001), for effective management in a SC, measurement goals must consider the overall SC goals and the metrics to be used. These should represent a balanced approach and should be classified at strategic, tactical and operational levels, and be financial and nonfinancial measures, as well.

Below is a list of desirable characteristics of SCPM derived from different sources (Beamon, 1999; Gunasekaran et al., 2001; Gomes et al., 2004; Tangen, 2005; and Thakkar et al., 2009). Some of these apply to all measures and some apply to a limited number of a firm's measures. It is also very difficult to fulfil all requirements suggested in literature when designing a PMS (Tangen, 2005). A firm's performance measures should:

- Be simple and easy to use.
- Have a clear purpose.
- Provide fast feedback.
- Relate to performance improvement, not just monitoring.
- Reinforce the firm's strategy.
- Relate to both long-term and short-term objectives of the organization.
- Match the firm's organization culture.
- Not conflict with one another.
- Be integrated both horizontally and vertically in the corporate structure.
- Be consistent with the firm's existing recognition and reward system.
- Focus on what is important to customers.
- Focus on what the competition is doing.
- Lead to identification and elimination of waste.
- Help accelerate organizational learning.

- Evaluate groups not individuals for performance to schedule.
- Establish specific numeric standards for most goals.
- It must reflect relevant non-financial information based on key success factors of each business.
- It must make a link to reward systems
- The financial and non-financial measures must be aligned and fit within a strategic framework.
- Minimum deviations should exist between the organizational goals and measurement goals;

4. Evolution of SCPMS

Performance measurement has its roots in early accounting systems. According to Gomes et al. (2004), performance measurement evolved through two phases. The first phase was started in the late 1880s, while the second phase in the late 1980s. The first phase was characterized by its cost accounting orientation. This orientation aimed at aiding managers in evaluating the relevant costs of operating their firms. It incorporated financial measures such as profit and return on investment. A study has indicated that by 1941 about half of US companies were using budgetary control in one form or other and by 1958, over 95 % of the companies, budgets were used for overall control of company performance (Bourne et al., 2003). These accounting based performance measures were financially based, internally focused, backward looking and more concerned with local departmental performance than with the overall health or performance of the business (Bourne et al., 2003). These traditional financially-based performance measurement systems failed to measure and integrate all the relevant factors critical to business success. By the 1980s, traditional accounting measures were being criticised as inappropriate for managing businesses of the day. The mid-1980 was a turning point in the performance measurement literature, as it marked the beginning of the second phase. This phase was associated with the growth of global business activities and the changes brought about by such growth. In the late 1980s, some frameworks, which attempted to present a broader view of performance measurement started to appear (Gomes et al., 2004). They underscored the need for the alignment of financial and non-financial measures in order to be in accordance with business strategy. The emphasis was on the development of better integrated performance measurement systems.

The structure of the business organization also evolved during this period. The early 19th century saw the birth of systematic large organizations. During the 1980's the business organizations became global and 1990's were significant with automation of business processes. The 2000's saw the emergence of e-commerce and boarder less business activities. PMS also changed with this evolution of business organization from cost accounting system (before 1980s), mixed financial and non financial systems (1990's) to balanced integrated approach (2000's). **Table 1** summarises the evolution of SCPM in an organizational context.

Table 1. Evolution of PMS in an organizational context (Gomes et al., 2004 and Morgan, 2007)

Period	Characteristics of business organisation	Characteristics of PMS
Before 1980	Systematic large organizations	(i). Cost Accounting orientation. (ii).Retroactive approach and results used to promote organizational efficiency, facilitate budgeting and attract capital from external entities (iii).Performance measurement dominated by transaction costs and profit determination
1980 - 1990	Business organizations became global	(i). Cost Accounting orientation (ii).Retroactive approach and results used to promote organizational efficiency. (iii).Enhanced to include operations and value adding perspectives.
1990 – 2000	Automation of business processes	(i).A mixed financial and non financial orientation. (ii).A mixed retroactive and proactive approach. (iii).Results are used to manage the entire organization. (iv).PMS enhanced to include process, quality & customer focus
2000 - 2010	e-Commerce and borderless business activities	(i).A balanced and integrated orientation. (ii).A more proactive approach. (iii).Results are used to enhance organizational responsiveness. (iv).Performance measurement enhanced to give a balanced view of the organization and included the SC & inter-process activities.

Literature survey indicates development of a number of Performance Measurement Models since 1980s. Most of the models have gone through some empirical testing and some have only theoretical developments. The most widely cited performance measurement systems are the SMART (1988), the performance measurement matrix (1989), the Balanced Scorecard (1992), and the integrated dynamic PMS (1997). In the Indian context, there have been many attempts to measure the performance at the organizational level, but very few attempts have been made to measure the performance at inter-organizational level (Saad and Patel, 2006). Table 2 lists the major Performance Measurement Models based on literature survey.

Table 2. List of Performance Measurement Models (Taticchi et al., 2010 and Morgan, 2007)

Name of the model	Period of introduction
The ROI, ROE, ROCE and derivates	Before 1980s
The economic value added model (EVA) The activity based costing (ABC) – the activity based management (ABM,1988) The strategic measurement analysis and reporting technique (SMART,1988) The supportive performance measures (SPA,1989) The customer value analysis (CVA,1990) The performance measurement questionnaire (PMQ,1990)	1980-1990
The results and determinants framework (RDF,1991) The balanced scorecard (BSC,1992) The service-profit chain (SPC,1994) The return on quality approach (ROQ,1995)	1991-1995
The Cambridge performance measurement framework (CPMF,1996) The consistent performance measurement system (CPMS,1996) The integrated performance measurement system (IPMS,1997) The comparative business scorecard (CBS) The integrated performance measurement framework (IPMF,1998) The business excellence model (BEM,1999) The dynamic performance measurement system (DPMS,2000)	1996-2000
The action-profit linkage model (APL,2001) The manufacturing system design decomposition (MSDD,2001) The performance prism (PP,2001) The performance planning value chain (PPVC,2004) The capability economic value of intangible and tangible assets model (CEVITA,20041)	2001-2004
The performance, development, growth benchmarking system (PDGBS,2006) The unused capacity decomposition framework (UCDF,2007)	2006-2007

5. Classification of Performance Management Literature

The literature related to SCPMS belongs to two major orientations. They are: (i). Conceptual articles and (ii). Empirical articles. The conceptual works tend to focus on measurement constructs and prescriptive methodologies. Topics normally covered in conceptual articles are related to performance definition, theoretical evaluation criteria, models and issues with measures. The empirical works tend to focus more on performance content than on measurement process. Empirical articles include descriptive studies, methods, taxonomies, benchmarking and prescriptive performance improvement activities. (Keebler, 2001)

Performance measurement literature of the past twenty years can be classified into five general phases of evolution. This classification of PMS literature is related to evolution of PMS. Table 3 shows the five phases in Performance Measurement literature.

Table 3. Phases in Performance Measurement Literature (Neely, 2005)

Category	Period	Characteristics
Phase 1	1980 -1990	Dominant theme was a discussion of the problems of performance measurement systems; recognising and discussing the weaknesses of measurement systems and their organisational impact.
Phase 2	1990 -1995	Potential solutions – e.g. measurement frameworks such as the BSC were being proposed; search for "frameworks" that might provide useful ways of addressing the previously identified problems.
Phase 3	1996 - 2000	The search for ways in which the proposed frameworks could be used; processes and methodologies for populating measurement frameworks were being developed and discussed.
Phase 4	2000 - 2005	Robust empirical and theoretical analysis of performance measurement frameworks and methodologies; analysis of impact of PMS on organisations
Phase 5	2005 onwards	Theoretical verification of frameworks; application and impact on supply chains; focus on multi-firm performance.

6. Performance Measures and Metrics in SCPMS

Fundamental processes of performance measurement according to Neely (2004) are the following.

- Measurement system design.
- Implementation.
- Managing through measurement and
- "Refreshing" the measurement system.

In 'Measurement system design', the challenge lies in choosing the right measures; it is identifying what you need to measure so as to concentrate on what is absolutely vital. 'Implementation' involves ensuring access to the right data, and the political and cultural issues, notably people's fear of measurement and the games they consequently play to try to manipulate target-setting to ensure targets are achievable and no blame can be attributed. To combat this, people inside organizations need to be educated to understand the purpose and use of the measurement system. The challenge in managing through measures requires a cultural shift in many organizations. "Refreshing" is to ensure that, as the organization changes the measurement system keeps pace.

Sambasivan (2009) defines measure as a more objective or concrete attribute that is observed and measured and metric as an abstract, higher-level latent attribute that can have many measures. Because SC is a network of firms that includes material suppliers, production facilities, distribution services and customers linked together via the flows of materials, information and funds (Gunasekaran et al., 2001), the measures have been classified as follows: fund flow (cost and profitability), internal process flow (production level flexibility, order fulfilment and quality), material flow (inventory and internal time performance), sales and services flow (delivery performance, customer responsiveness and customer satisfaction), information flow and partner relationship process flow (supplier evaluation and sharing of information with suppliers and customers). Figure 1 shows measures and metrics at four basic links in a SC: plan, source, make/assemble, and deliver. However, according to Bourne et al. (2003), frameworks on their own are not a complete solution. Frameworks provide different perspectives for categorising performance measures, allowing one to consider the balance between the demands on the business.

According to Beamon (1999), a supply chain measurement system must place emphasis on three separate types of performance measures: 1. Resource measures (generally costs); 2. Output measures (generally customer responsiveness); and 3. Flexibility measures (Ability to respond to a changing environment). Each of these three types of performance measures has different goals and purpose. Resource measures include: inventory levels, personnel requirements, equipment utilization, energy usage, and cost. Output measures include: customer responsiveness, quality, and the quantity of final product produced. Flexibility measure a system's ability to accommodate volume and schedule fluctuations from suppliers, manufacturers, and customers (Beamon, 1999).

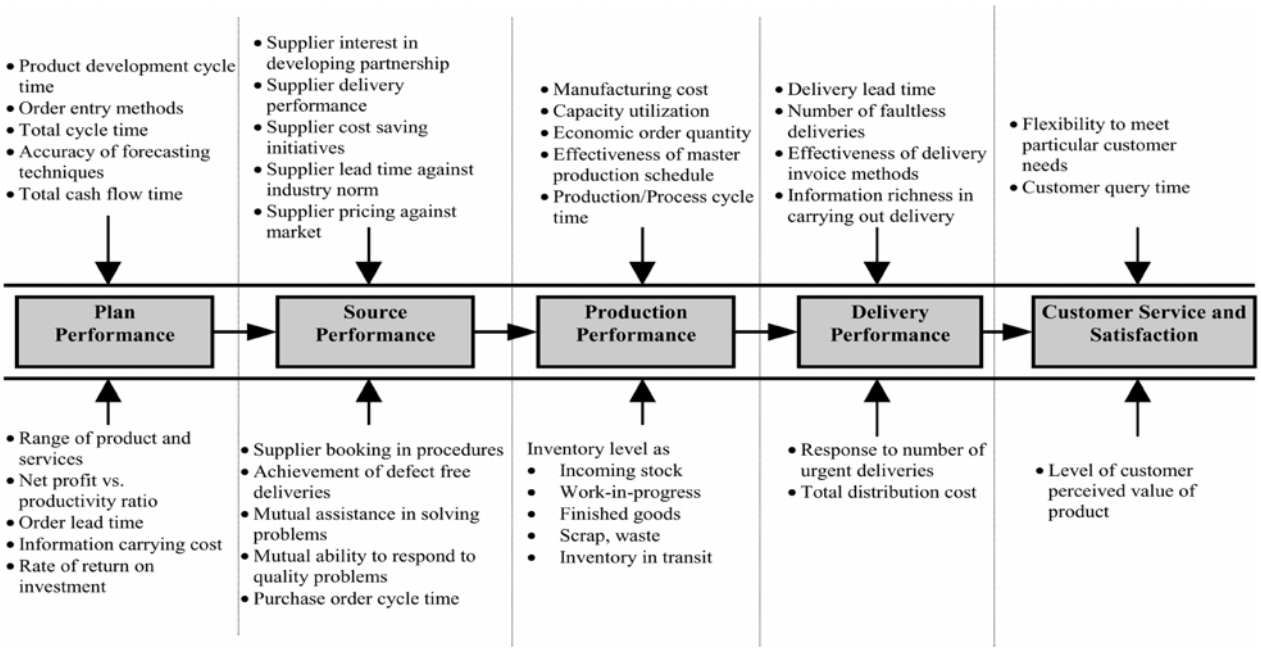

Figure 1. Measures and metrics at four basic links in a SC (Gunasekaran et al., 2001)

Many authors have classified PMS in different ways. A basic classification offered by Cagnazzo et al. (2010) consists of grouping PMS models into: (i). Balanced models; 2. Quality models; 3. Questionnaire-based models; 4. Hierarchical models; and 4. Support models.

6.1 Balanced Model: Balanced models consider the presence of both financial and non-financial indicators. In these models several separate performance measures which correspond to diverse perspectives (financial, customer, etc.) are considered independently. Some of the important existing models are (i). Performance Measurement Matrix; (ii). Balanced Scorecard (BSC); and (iii). Performance Prism.

6.2 Quality Models: These are frameworks in which a great importance is attributed to Quality. An example of quality model is the Business Excellence Model (EFQM-Model) (EFQM, 1999).

6.3 Questionnaire-based Models: These are frameworks based on questionnaire. The Performance Measurement Questionnaire (PMQ) and TOPP System (a research program studying productivity issues in Norwegian manufacturing industry) (Rolstadås, 1998) are examples.

6.4 Hierarchical Models: SCPM models that are strictly hierarchical (or strictly vertical), characterised by cost and non-cost performance on different levels of aggregation are classified as hierarchical models. Frameworks where there is a clear hierarchy of indicators are: (i). Performance Pyramid; (ii). Advanced Manufacturing Business Implementation Tool for Europe (AMBITE); (iii). The European Network for Advanced Performance Study (ENAPS) approach; and (iv). Integrated Dynamic Performance Measurement System (IDPMS).

6.5 Support Models: Frameworks that do not build a performance measurement system but help in the identification of the factors that influence performance indicator are classified as support models. These models are: (i). Quantitative Model for Performance Measurement System (QMPMS); and (ii). Model for Predictive Performance Measurement System (MPPMS) (Cagnazzo et al., 2010).

7. Common Frameworks and Models for Performance Measurement

A number of frameworks and models for performance measurement have been developed, since 1980s (Bititci et al., 2000). These frameworks all have their relative benefits and limitations. Literature review indicates that empirical and theoretical validity of some of the frame works are established whereas information about others is not available. This section is an attempt to study and analyze few widely cited measurement systems.

7.1 Balanced Score Card (BSC): BSC proposes that a company should use a balanced set of measures that allows top managers to take a quick but comprehensive view of the business from four important perspectives (Figure 2). These perspectives provide

answers to four fundamental questions (Tangen, 2004): (i). How do we look to our shareholders (financial perspective)? (ii). What must we excel at (internal business perspective)? (iii). How do our customers see us (the customer perspective)? (iv). How can we continue to improve and create value (innovation and learning perspective)?

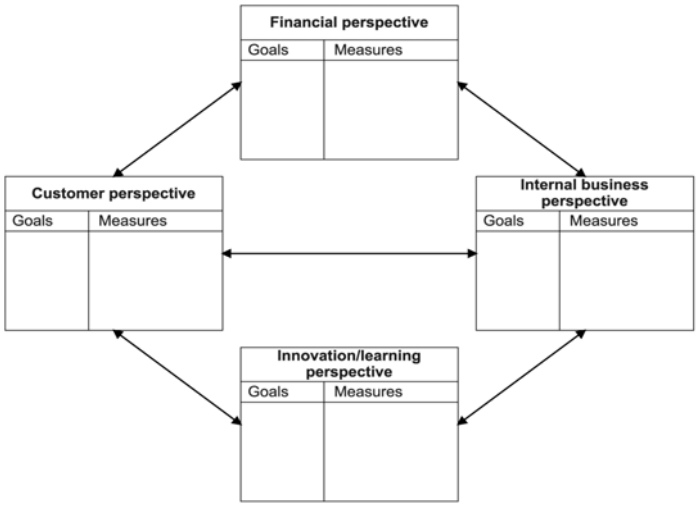

Figure 2. Balanced Score Card (Source: Tangen, 2004)

The BSC includes financial performance measures giving the results of actions already taken. It also complements the financial performance measures with more operational non-financial performance measures, which are considered as drivers of future financial performance. By giving information from four perspectives, the BSC minimizes information overload by limiting the number of measures used. It also forces managers to focus on the handful of measures that are most critical. Further, the use of several perspectives also guards against sub-optimisation by compelling senior managers to consider all measures and evaluate whether improvement in one area may have been achieved at the expense of another.

According to Ghalayini et al. (1996), the main weakness of this approach is that it is primarily designed to provide senior managers with an overall view of performance. Thus, it is not intended for (nor is it applicable to) the factory operations level. Further, they also argue that the BSC is constructed as a monitoring and controlling tool rather than an improvement tool. Furthermore, Neely et al. (2000) argue that although the BSC is a valuable framework suggesting important areas in which performance measures might be useful, it provides little guidance on how the appropriate measures can be identified, introduced and ultimately used to manage business. They further conclude that the BSC does not consider the competitor perspective at all. It does not specify any mathematical logical relationships among the individual's scorecard criteria. It is thus difficult to make comparisons within and across firms using BSC (Soni et al., 2010). BSC is more like a strategic management tool, rather than a true complete PMS (Gomes et al., 2004).

7.2 Performance Prism: The performance prism framework suggests that a PMS should be organised around five distinct but linked perspectives of performance (see Figure 3) (Neely et al., 2001): (i). Stakeholder satisfaction (Who are the stakeholders and what do they want and need?); (ii). Strategies (What are the strategies we require to ensure the wants and needs of our stakeholders?); (iii). Processes (What are the processes we have to put in place in order to allow our strategies to be delivered?); (iv). Capabilities (The combination of people, practices, technology and infrastructure that together enable execution of the organisation's business processes, both now and in the future, and what are the capabilities we require to operate our processes?); (v). Stakeholder contributions (What do we want and need from stakeholders to maintain and develop those capabilities?)

The performance prism has a much more comprehensive view of different stakeholders (e.g. investors, customers, employees, regulators and suppliers) than other frameworks. Neely et al. (2001) argue that the common belief that performance measures should be strictly derived from strategy is incorrect. It is the wants and needs of stakeholders that must be considered first. Then, the strategies can be formulated (Neely et al., 2001). Thus, it is not possible to form a proper strategy before the stakeholders and their needs have been clearly identified. The strength of this conceptual framework is that it first questions the company's existing strategy before the process of selecting measures is started. In this way, the framework ensures that the performance measures have a strong foundation. The performance prism also considers new stakeholders (such as employees, suppliers, alliance partners or intermediaries) who are usually neglected when forming performance measures.

Figure 3: Performance Prism (Tangen, 2004)

Although the performance prism extends beyond "traditional" performance measurement, it offers little about how the performance measures are going to be realised. Another weakness is that little or no consideration is given to the existing PMSs that companies may have in place (Medori et al., 2000).

7.3 The Performance Pyramid: The purpose of the performance pyramid (refer Figure 4) is to link an organisation's strategy with its operations by translating objectives from the top down (based on customer priorities) and measures from the bottom up. This PMS includes four levels of objectives that address the organisation's external effectiveness (left side of the pyramid) and its internal efficiency (right side of the pyramid). The development of a company's performance pyramid starts with defining an overall corporate vision at the first level, which is then translated into individual business unit objectives. The second-level business units are short-term targets of cash flow and profitability and long-term goals of growth and market position (e.g. market, financial). The business operating system bridges the gap between top-level and day-to-day operational measures (e.g. customer satisfaction, flexibility, productivity). Finally, four key performance measures (quality, delivery, and cycle time, waste) are used at departments and work centres on a daily basis. Ghalayini et al. (1996) suggest that the main strength of the performance pyramid is its attempt to integrate corporate objectives with operational performance indicators. However, this approach does not provide any mechanism to identify key performance indicators, nor does it explicitly integrate the concept of continuous improvement.

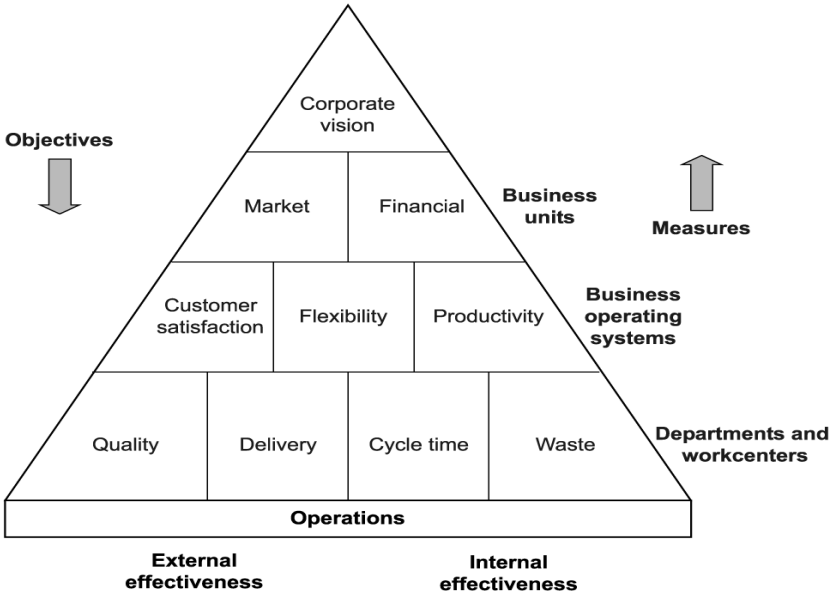

Figure 4. Performance Pyramid (Tangen, 2004)

7.4 Theory of Constraints: Goldratt (1990) developed an approach called the "theory of constraints" (TOC) as a process of ongoing improvement. TOC mainly focused on production planning and scheduling methods, but have also been involved in

performance measurement. Within a system, a constraint is defined as anything that limits the system from achieving higher performance relative to its purpose. TOC offers a systematic and focused process that organisations use to pursue ongoing improvement successfully. Within the TOC three global performance measures are used for assessing a business organisation's ability to obtain the goal (i.e. making money). These global measures are net profit, ROI and cash flow. Studies have shown that the major strength of the TOC approach is that it provides focus in a world of information overload (Tangen, 2004). Another advantage is that the performance measures within TOC are both easy to access and easy to comprehend. However, TOC is far from being a complete SCPM system. One could argue that TOC simplifies the reality a little too far, as TOC assumes that there always is a legible constraint in the system, which is not necessarily true.

7.5 Medori and Steeple's Framework: Medori and Steeple (2000) presented an integrated framework for auditing and enhancing PMSs. This approach consists of six detailed described stages (see Figure 5). Similar to most frameworks, the starting point begins with defining the company's manufacturing strategy and success factors (stage 1). In the next stage, the primary task is to match the company's strategic requirements from the previous stage with six defined competitive priorities (e.g. quality, cost, flexibility, time, delivery and future growth (stage 2). Then, the selection of the most suitable measures takes place by the use of a checklist that contains 105 measures with full descriptions (stage 3). After the selection of measures, the existing PMS is audited to identify which existing measures will be kept (stage 4). An essential activity is the actual implementation of the measures in which each measure is described by eight elements: title, objective, benchmark, equation, frequency, data source, responsibility and improvement (stage 5). The last stage is based around the periodic review of the company's PMS (stage 6).

This framework can be followed by a measurement practitioner in practice. A major advantage is that it can be used both to design a new PMS and to enhance an existing PMS. It also contains a unique description of how performance measures should be realised. Its limitations are mainly located in stage 2, where a performance measurement grid is created in order to give the PMS its basic design. Little guidance is given here, and the grid is only constructed from six competitive priorities (e.g. quality, cost, flexibility, time, delivery and future growth). As described earlier, performance measures can be divided into many other categories.

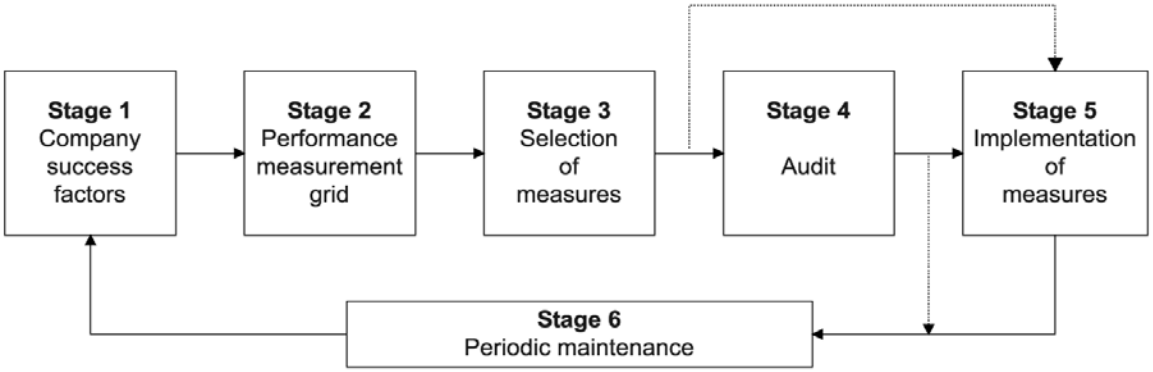

Figure 5. Medori and Steeple's framework (Medori et al., 2000)

7.6 The Supply-Chain Operations Reference (SCOR) Model: The SCOR model was developed by the Supply-Chain Council (SCC) to assist firms in increasing the effectiveness of their SCs, and to provide a process-based approach to SCM. The SCOR model provides a common process oriented language for communicating among supply-chain partners in the following decision areas: PLAN, SOURCE, MAKE, and DELIVER. SCOR model is designed as a tool to describe, measure and evaluate any supply-chain configuration. There are 12 performance matrices as part of the SCOR model to measure process performance (Huan et al., 2004). These 12 performance measures are grouped as (i). Delivery reliability; (ii). Flexibility and responsiveness; (iii). Costs; and (iv). Assets. Huan et al. (2004) is of the view that to derive at a quantifiable SC performance measure, there will be an additional requirement of Overall Supply Chain Efficiency Measure incorporated in the SCOR model.

7.7 Data Envelopment Analysis (DEA): DEA is a multi-factor productivity analysis based on mathematical model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). DEA Analysis is receiving increasing importance as a tool for evaluating and improving the performance of manufacturing and service operations. It has been extensively applied in performance evaluation and benchmarking of schools, hospitals, bank branches, production plants, etc. The primary advantages of this technique are that it considers multiple factors and does not require parametric assumptions of traditional multivariate methods (Talluri, S., 2000). It can evaluate the performance measures quantitatively and qualitatively. It is based on the idea of efficient frontier analysis. It is not based on average value but takes the best value form the set of data. DEA has a limitation on the limit of number of relationships that can be analyzed between the input and output units. DEA also suffers another disadvantage that only likeable units can be compared hence all the decision making units must have same strategic goals and objectives (Soni et al., 2010).

7.8 Time-based Performance Measures: In the literature, four time-based measures appear most frequently, they are: (i). New product development time; (ii). Manufacturing lead time; (iii). Delivery speed; and (iv). Responsiveness to customers. The popularity of these measures suggests that new product development, manufacturing, delivery, and customer service are key integrated strategic processes contributing to supply-chain time-based performance. The arguments supporting the competitive value of supply-chain time-based performance have been shown primarily by means of case studies and anecdotal evidence (Jayaram et al., 2000).

7.9 Other Frameworks of SCPM: There are many frameworks other than the ones mentioned above seen in literature. They are in various stages of development, trials and implementation. Thakkar et al., 2009, proposed a framework combining the features of BSC and SCOR model to deliver a comprehensive performance measurement framework for small and medium scale industries. The framework includes both tangible and intangible measures. The hard measures: cost, time, capacity, productivity, and utilization are tangible and thus relatively easy to collect data while other soft measures: effectiveness, reliability, availability, and flexibility are intangible, and thus cannot be directly measured. These measures need to be transformed to other performance indicators. The developed framework has conceptualized the various SCOR decision areas – plan, source, make, and delivers in a way that they are built on a cyclic view of SC (procurement cycle, manufacturing cycle, etc.) and hence ensuring the linkage between organization specific performance measures and SCM-based metrics. The framework includes metrics for various categories of BSC and users are advised to further classify them into strategic, tactical and operational level. This makes the purpose of a particular measure and associated necessary decisions more explicit for managers.

Internal benchmarking for assessment of SC performance was proposed by Sony et al., 2010. An extensive use of performance value analysis (PVA) and strength, weaknesses, opportunities, and threats (SWOT) analysis provided for diagnosis of SCs. This analysis can be useful in leveraging the SC drivers of various SCs belonging to same focal organization and hence bring performance of all the SCs at the same performance level.

There are newly emerging IT based management tools specifically targeted to performance measurement **(**Bititci et al., 2000). Few of such tools include: (i) Integrated performance measurement software (IPM) by Lucidus Management Technologies, Oxford, UK; (ii). Ithink Analyst by ISEE systems; formerly High Performance Systems; (iii). PerformancePlus by InPhase Company, Gerrards Cross, Buckinghamshire, UK; and (iv). Pb Views by Panorama Business Views inc. ERP vendors such as SAP and Oracle are at advanced stage of developing integrated performance development software as part of their ERP software.

The main benefit of using an IT platform for managing the performance measurement system within an organisation is that maintenance of the information contained within the systems becomes much simpler **(**Bititci et al., 2002). Based on a case study Bititci et al. (2002) concluded that appropriately designed performance systems, if supported through appropriate IT platforms will improve visibility, communications, teamwork, decision making and proactive management style. However, Lockamy et al. (2004) are of the view that information technology solutions are only part of the answer to improved SC performance and its measurement. Integration is an organization and people issue, and that IT should serve as an enabler to organization and process change. Thus, firms who have purchased an information technology solution and expect it to drive improvements in SCM may be disappointed with the final results, due the limitations of IT's impact on SC performance.

8. Success Factors, Selection and Implementation of SCPMS

A PMS should be derived from the company's objectives. Otherwise, the PMS may support actions that have the opposite effect of those implied in the strategy (Tangen, 2004). A PMS ought to consist of various types of performance measures covering all important aspects agreed as representing the success of a company. There must in turn be a balance between the various performance measures in the SCPM. A PMS should be appropriately focused on short- and long-term results, different types of performances (e.g. cost, quality, delivery, flexibility and dependability), various perspectives (e.g. the customer, the shareholder, the competitor, the internal and the innovativeness perspective), and various organisational levels (e.g. global and local performance).

As the performance measures by which employees are evaluated greatly impact their behaviour, an improper set of measurements can lead to dysfunctional or unanticipated behaviour. A PMS must therefore guard against sub-optimisation, possibly by establishing a clear link from the top of the company all the way to the bottom, to ensure that employee behaviour is consistent with corporate goals. (Tangen, 2004). To create appropriate action it is necessary to use a limited number of performance measures.

A PMS's main goal is to give important information, at the right time, to the right person. An important point to remember is that the PMS must be designed in such a way that information is easily retrieved, usefully presented and easily understood by those whose performance is being evaluated. (Tangen, 2004). A performance measure should have a clear purpose and be defined in an unambiguous way along with details of who will use the measure (e.g. collect the data, with what frequency, and how to act on the measure).

The reasons for failure in SCPM are varied and of diverse nature. Morgan (2007) suggests following reasons for failure of SCPM systems: (i). Preoccupation with dyadic relationships and a lack of supply network focus and strategy. Current SC relationships are of network nature and not just dyadic. 'Supply Chains' are usually not supply chains but supply networks. In these networks relationships are difficult to define; (ii). Inability of many organisations to create SC visibility because of technical and system problems; (iii). Poor connections between marketing and supply network activities; (iv). A general lack of managerial awareness of the need to engage the organisation's performance measurement system as a vehicle for organisational change.

Bourne et al., (2003) lists four barriers to implementation of performance measurement systems. These were identified through individual cases. These barriers are: (i) Vision and strategy are not actionable; (ii) Strategy is not linked to department, team and individual goals; (iii) Strategy is not linked to resource allocation; and (iv) Feedback is tactical and not strategic. He also suggests three important factors for the success of a performance measurement system; they are: (i) Developing information architecture with supporting technology; (ii). Aligning incentives with the new measurement system and (iii). The lead given by the CEO. Those companies which already have a sophisticated IT infrastructure and well developed corporate information architecture are likely to find their ability to develop and support SCPM greatly enhanced.

A large number of different types of performance measures have been used to characterize systems, particularly production, distribution, and inventory systems. Such a large number of available performance measures makes performance measure selection difficult (Beamon, 1999). These frameworks all have their relative benefits and limitations, with the most common limitations being that little guidance is given for the actual selection and implementation of selected measures (Medori et al., 2000). Businesses rarely want to design PMS from scratch and usually managers are interested in eliminating any weaknesses in their existing system (Neely, 2004).

A comprehensive framework for selection of a suitable SCPM model for a SC is not found in literature surveyed. According to Tangen (2004), the choice of a suitable measurement technique depends on a number of factors as follows.

- The purpose of the measurement;
- The level of detail required;
- The time available for the measurement;
- The existence of available predetermined data; and
- The cost of measurement.

The literature suggests that successful implementation is not easy (Bourne et al., 2003). Implementation of any of the SCPM framework described above is fraught with complexity of varying levels and therefore implementation issues are critical for its success. According to Thakkar et al., (2009), Strategy, Leadership, Culture, and Capability are four critical factors that have a role in effective implementation of SCPM. Each of these elements is inter connected with each other and simultaneously exercises the influence on implementation of the suggested frameworks. Organisations are governed by strategy formulated by its owner and hence it is necessary to match the expectations of the leader for successful implementation of frameworks. Organisation's strategy implementation fails in absence of needed capabilities (technological or human resource capabilities) and long-term vision. A match between culture and capability is must for organizations which have highly lucid and flexible work culture. The link between culture and leadership is critical in a way that expectations and vision of owner/CEO dictate the practices and kind of value system to be adopted by people and hence influences the development of culture in an organization.

According to Charan et al. (2008), for better results on implementation of SCPM, top management should focus on improving the high-driving power enablers such as awareness of PMS in SC, commitment by the top management, consistency with strategic goals, funding for PMS implementation, and effective information systems. Enablers of SCPMS implementation as suggested by Charan et al. (2008) are: (i). Effective information system; (ii). Employee's commitment; (iii). Dynamic, inter-connectable, cross-functional and usable SCPM; (vi). Partnership with dealers, distributors and retailers; (v). Appropriate performance metrics; (vi). Overcoming mistrust; (vii). Funds for PMS implementation; (viii). Commitment by top management; (ix). Awareness about PMS in SC; and (x). Consistent with strategic goals.

9. Future PMS and Research Directions

A suitably designed and implemented PMS is considered as Critical Success Factor (CSF) in emerging SCs (Cagnazzo, et al., 2010). As organisations evolve the requirements and objective of the PMS also changes. The changes taking place in new SCs are listed below:

- Network relations between organisations; dyadic relations in SC are replaced with networks of interrelated organisations.
- E- Commerce and e-supply chains.
- Green organisations and sustainability in SCs.
- Resilient SCs due to increased uncertainties and risks.
- Agile SCs due to competition and short product life.
- Quality improvement initiatives.

- Multi cultural and global orientation

The focus for measurement is changing as evolution of organisations takes place. In the future SCPMS, there will be a shift from the traditional *transaction focused measurement* to *process focused measurement systems*; from '*process only*' to '*process and process interface'* systems; from *monoculture* to *poly-cultural* measurement systems; and from *measurement proliferation* to *measurement simplification* (Morgan, 2007). Some of the significant characteristics of PMS of the near future which are likely to yield competitive advantage are identified as following:

9.1 Integrated IT Tools: Most of the existing ERP packages have a Performance Measurement module as part of it. Future PMSs will have enterprise wide, integrated IT tools that will extract, collect and elaborate data characterizing their business. Future PMS will be more IT dependant.

9.2 Integration of Operation Research and Fuzzy Logic with PMS: There have been attempts to integrate multi criteria decision making tools like Analytical Hierarchical Process (AHP) and Data Envelopment Analysis (DEA) with existing PMS frameworks (George et al., 2008; El-Baz, 2011). Integration of OR models and heuristics in PMS is likely to enhance effectiveness of future PMS.

9.3 New Themes: There would be new themes which would be part of future SCPMS. They are: (i). Measure and manage risk in extended supply networks; (ii). Aligning performance measures to achieve strategic objectives; (iii). Recognising and incorporating the varying cultural elements in the supply network; and (iv). Response to a volatile demand led environment that may include lean and agile elements.

9.4 Soft Issues: There is a need to develop deeper understanding of the soft issues that make or mar supply network management and development. There will be more focus on the central relationship between culture and performance measurement and how this varies in different countries in a global context.

There has been considerable research carried out and literature available in the field of SCPM since 1990**.** The empirical and theoretical validity of some of the frame works are yet to be established. Neely, 2005, proposed the following questions for future research which are still valid:

- How to design and deploy enterprise performance management rather than measurement systems?
- How to measure performance across SCs and networks rather than within organisations?
- How to measure intangible as well as tangible assets for external disclosure as well as internal management?
- How to develop dynamic rather than static measurement systems? and
- How to enhance the flexibility of measurement systems so they can cope with organisational changes.

Some additional questions identified based on the present study are the following:

- What are the strengths and limitations of the existing frameworks of SCPMS? Can the existing SC Performance Measurement Frameworks be improved? If so, how to improve existing SCPM Frameworks?
- What are SCPM needs and expectations of select Industry? How are these needs met in the existing setup?
- What technology is available for SCPM?
- What are the Operations Research (OR), Heuristic, Modelling and other techniques suitable for incorporation with SCPMS?
- Can OR, Heuristic, Modeling and other techniques be integrated with SCPMS framework? What are the benefits of integrating these techniques with SCPMS?
- How to analyze the effectiveness and suitability of a SCPM framework for a select SC?
- What lessons can be learned on implementation of integrated SCPM framework?

9.5 Implementation Model for SCPM: In a study only three out of the six case companies that were observed undertaking a performance measurement design process, went on to implement the majority of the measures agreed during the process. Others have highlighted difficulties with implementation (Bourne et al., 2003). However, there is little discussion in the literature of the implementation failures. There is a necessity of further research on implementation issues and reasons for failure of SCPM initiatives. Development of an implementation model for SCPM is a necessary area of future research.

9.6 Return on Investment (ROI) Analysis: More measurement demands more analysis time. It is a waste to collect data if they are ignored. It is therefore important to pay attention to limiting the data requirements to both the necessary detail and frequency and

to consider whether the data is needed for a specific useful purpose, and whether the cost of producing it is not higher than its expected benefit. A large number of performance measures also increases the risk of information overload – it becomes difficult to know which performance measures should be prioritised. (Tangen, 2004). Therefore, there is a need of research on ROI on SCPM.

*9.7 Emerging Areas of Interest***:** Literature survey showed a certain stability of the areas related/affected by SCPM, such as Strategy, Operations and Quality. However there is very little study found on emerging themes affected by and related to SCPM (Taticchi et al., 2010). The areas relatively less explored in existing PMSs, but gaining more significance in today's organisations are:

- Measurement of risk.
- Measurement of effects on environment
- Measurement of sustainability
- PMS for Project Management
- PMS specific to E- Commerce and e-supply chains
- PMS specific to Small Scale Industries
- Measurements in a network environment where organisations have network relations instead of dyadic relations.

Getting existing performance measurement systems working well will take many organisations well into the future. In many cases a linear extrapolation of the existing framework will help where existing practices and skills will provide solutions to these problems. However many of the factors mentioned above will require significant re-thinking in, and development of, the performance measurement systems.

9.8 *Models for integration in SCPMS:* Incorporating Mathematical Models and Heuristics in SCPM is expected to be beneficial. Preliminary study indicates suitability of the following OR and Heuristic Models as candidates for incorporation in SCPM :

- Analytical Hierarchical Process (AHP) (Hepler et al., 2007; Islam et al., 2005; Saaty, 2008)
- Data Envelopment Analysis (DEA) (Talluri, 2000; George et al., 2008)
- Queuing Theory
- Theory of Constraints (TOC) (Goldratt, 1984; Tangen, 2004)
- Failure Mode and Effect Analysis (FMEA)
- Use of Fuzzy Logic (El-Baz, 2011).

There are instances available in literature of using DEA, AHP, Fuzzy logic and other mathematical models in Performance Measurement and Management. The preliminary work proves the scope and benefit in incorporating OR and Heuristics in PMS and developing such models. Future research in this direction will therefore be necessary.

9.9 Framework for Evaluation and Validation of the SCPMS Models: There are many SCPMS frameworks presented in literature in the last ten years. These theoretical framework needs to be tested and evaluated in live situations. . Estampe et al. (2011) have suggested a framework for analysing SCPMS models. Many authors have evaluated its effectiveness and utility differently. Further research is necessary in this field to develop criteria and framework for evaluation and validation of the SCPMS models.

10. Results and Discussions

Literature review indicates significant amount of work done in the area of PMS in the past decade. Even though remarkable progress has been made over recent years in the design of performance measurement frameworks and systems, many companies are still primarily relying on traditional financial performance measures (Tangen, 2004). The modern frameworks have addressed the underlying conceptual issues, but have rarely addressed the practicalities of measurement in ways that render them meaningful to practitioners. Studies reveal that some of the best practices proposed as mechanisms for improving overall SCM performance may not have the degree of impact often presented in the literature (Lockamy et al., 2004). It shows that some best practices help to improve SC performance only in specific decision areas. Further research on this topic might indicate that some practices are industry or "configuration" specific and do not provide the same results for every SC. Result of the present study indicates the following:

- SCPMS is critical to effectiveness of SCs.
- Measurements encourage desired behaviors; the goal of encouraging desired organizational behavior across SCs can be achieved through PMS.
- There is requirement to align activities / process with strategy and SC goals. SCPMS can facilitate this alignment.

- Existing measures usually have little to do with SC strategy and objectives and may even conflict resulting in inefficiencies.
- Emerging (new) PMS frameworks are in an evolutionary stage and measure performance of adjacent channels only. Measures spanning entire SC do not exist; there is requirement to go beyond internal matrix and take an SC perspective.
- It is expected that future SCPMS will be incorporating technology, Operations Research techniques and heuristics in measurement frameworks.

Organizations and people in organizations respond to measures. The right measures not only offer a means of tracking whether organization's objectives are being implemented, but also a means of communicating strategy and encouraging its implementation. Right SCPMS is vital for effectiveness and sustenance of SCs. For the SCs to be successful its members must shift their focus from individual-member performance to SC performance and this requires integration. Trust, commitment and communication between the SC members (managers) are critical to achieve integration (Sambasivan et al., 2009). The performance measures and metrics must reflect these initiatives.

Companies need a structured method or framework to audit existing performance measurement systems (Medori et al., 2000). Managing the variance in a SC system may be more important to an organization's financial performance than managing average (William et al., 2007). Many researchers state that there is a need to limit the number of performance measures to avoid information overflow (Tangen, 2004). There is a need for further research in the area of SCPMS. Research to explore how these conceptual frameworks can be translated and tailored to fulfil the unique needs of a specific organisation will result in effective measurement systems for future SCs.

11. Conclusion

Performance measurement is critical to effective SCM practices. Literature review indicates that significant amount of work is done in the area of PMS in the past decade. Though PMS has its roots in accounting practices of 1880s; integrated, balanced, inter-organisational measures applicable to SCs are still in the emergent stage. A comprehensive SCPMS incorporating specific need of organizations and which are implementable are yet to realize. Selection of appropriate PMS suitable to an organisation and its implementation strategy are important. IT tools, OR and heuristic models, soft issues and new themes are likely to have a major stake in the future SCPMS. There is a need for further research in the area of SCPMS. This paper also suggests some research agendas for the future in the area of PMS in SCs.

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