

Supply Chain Performance Measurement Models: A Comparative Study

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Abstract— The study investigated supply chain performance measurement models based on the primary and the secondary data and the justification of this paper is to evaluate the literature on performance measurement of the supply chain management to capture current practices, distinguish gaps and advocate future research prospects used through a comparative study of different supply chain performance measurement models. As of today, the measurement of supply chain performance is dependent on the Balanced Scorecard (BSC) and the Supply Chain Operations Reference (SCOR) model which requires the adaptation of a holistic approach such as the application of sustainability, and resilient supply chain considering the constant change of the business dynamics. As a result, many manufacturing companies failed to attain a precise performance measurement evaluation due to a lack of an Integrated Supply Chain Performance Measurement (ISCPM) model and knowledge in the manufacturing industry. This study illustrates the Integrated Supply Chain Performance Measurement (ISCPM) model and makes a comprehensive comparison with the BSC and the SCOR model. ISCPM model has been developed through the supply chain performance attributes and performance measurement index in the outlook of input-process-output considering the BSC and the SCOR model at three decisions levels. The model applies quantitative techniques to bring synergic effect to all stakeholder issues and incorporates ten supply chain performance measurement attributes and 36 performance measurement indexes as supplier relationship management (SRM), internal supply chain management (ISCM), and customer relationship management (CRM).

Keywords - *Integrated Supply Chain Performance Measurement (ISCPM), Supply Chain Operations Reference (SCOR), and Balanced Scorecard (BSC).*

1. Introduction

Supply Chain Management (SCM) has been gaining considerable attention from business practitioners and researchers, where it is now acknowledged as a weapon to bring cutting-edge knowledge and a new paradigm to bring multi-dimensional efficiency. This is an integrated process to perceive an operation from a holistic approach of an organization from raw

material suppliers, product manufacturers, storage, delivery and ultimately reaching to the end customers at the stores [1].

In the era of a free-trade economy with the accessibility of information, organizations continuously thrive to satisfy customers. Simultaneously due to the in-equilibrium situation of demand versus supply, the expectation level of the customers is getting unexpectedly higher [2]. Companies, therefore, need to focus on cost efficiency to retain their profitability.

A substantial study has been conducted on supply chain performance measurement (SCPM), however, manufacturing companies were unsuccessful to have precise performance measurement tools due to lack of an Integrated Supply Chain Performance Measurement (ISCPM) model and knowledge in the manufacturing industry. Supply Chain Performance Measurement (SCPM) framework and model facilitates to measurement and assess the overall efficiency level of the organization [12]. It also helps business managers to take decisions by giving consolidated information by processing all the information with different tools. Supply Chain Performance Measurement (SCPM) helps an organization to understand its overall position through understanding a holistic approach [7]. Therefore, decision-making on setting its goals, objectives for the long term as well as the short term becomes convenient. Organizations nowadays are keen to measure the efficiency level through developing different sets of performance measurement parameters from procurement, manufacturing, warehouse, distribution, customer service as well as the financial impacts of the organization. Top executives are more interested to see the bottom-line impacts [6].

2. Literature Review

There are several parameters and performance measurement tools available, however, the major concern is to validate the tools and their applicability. These parameters in some cases don't reflect a holistic view rather it gives a biased picture focusing on one particular aspect. [5] reviewed performance measurement system designed and focused on three perspectives. The first perspective was the performance measures and the study revealed that the most important measures of manufacturing's performance are related to quality, time, cost, and flexibility. The second outlook is to deal with the performance measurement system as an entity [10], [25].

The study also reviewed the various dimensions of a performance measurement system and categorized the “balanced scorecard” as the best-known performance measurement framework.

The BSC model provides managers with sufficient information to address the financial perspective, internal business perspective, customer perspective, and innovation and learning perspective. Concerning this assumption, the study classified the performance measurement system environment into two dimensions, the internal environment which presents the organization itself, and the external environment to reflect the market within which the organization competes. [2] discussed some of the challenges hindering the development of a performance measurement system to improve performance and accountability. The findings revealed that a successful performance measurement system requires its purposes to be set and its targeted outcome clearly to be identified. A resource-based strategy focuses on measuring costs by assessing how efficiently a process' inputs are utilized to produce a targeted output. The review indicated that the real challenge within the emerging context is to develop an integrated and holistic understanding of performance measurement through understanding performance measurement as a social system, understanding performance measurement as a learning system [4], [35], [36].

3. Supply Chain Performance Measurement

Performance Measurement System (PMS) helps to take decisions by synchronizing, analyzing, and consolidating the information or data through a systematic process. In PMS, the term "Balanced" is used to explain its view as holistic, which is connected throughout the organization both internally as well as externally [9], [28]. Supply Chain Performance Measurement (SCPM) framework and model facilitates to measurement and assess the overall efficiency level of the organization. It also helps business managers to take decisions by giving consolidated information by processing all the information with different tools. Organizations nowadays are keen to measure the efficiency level through developing different sets of performance measurement parameters from procurement, manufacturing, warehouse, distribution, customer service as well as the financial impacts of the organization. Top executives are more interested to see the bottom-line impacts [13].

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The performance measurement requires also have the capacity to measure applying different measuring tools simultaneously and oversee it financial, non-financial and understand its qualitative approach.

Performance measurement parameters are aligned with certain characteristics such as its comprehensiveness (to include all factors), universal acceptability (capable to compare under different circumstances), quantifiability (capable to numerically measure), and steadiness (continuous performance with similar pace aligned with organizational goals). The performance of Supply Chain Management (SCM) is classified into financial and non-financial are as follows:

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

Figure 1. Classification of SCM Performance Measurement [29]

Activity-Based Costing (ABC) emphasizes an effort to fasten financial measures to operational performance which contains breaking down activities into distinct jobs or cost drivers while appraising the resources, such as time and costs needed for each one. Dimension-based Measurement Systems (DBMS) is well-known on the principle that any supply chain can be measured through Flexibility (F), Resources (R), and Output (O). Perspective-based Measurement System (PBMS) perceives supply chain with all the possible insights and delivers measures to appraise each of them. It was conceptualized that acknowledges six-core viewpoints - Operations Research, System Dynamics, Marketing, Logistics, Organization, and Strategy [29].

The Hierarchical-based Measurement System (HBMS) concept was classified as strategic, tactical, or operational. The main principle deals with appropriate management levels to facilitate fast and appropriate judgments. Function-based Measurement System (FBMS) was originally intellectualized in 2005 to cover the comprehensive performance measures. Efficiency-based Measurement System (EBMS) measures the supply chain performance in terms of efficiency that provides a framework to study supply chain performance by developing a Data Envelopment Analysis (DEA) model for the internal supply chain performance efficiency using case study applications [30].

Generic Performance-based Measurement System (GPMS) have been developed since 1980 that have benefits and limitations as well. Performance Prism Model suggests Performance Measurement System under five perspectives

- Stakeholder satisfaction, Strategies, Processes, Capabilities, and Stakeholder contributions. Performance Pyramid Model perceives to evaluate the organization's strategy from top-down perspectives.

It measures external as well as internal effectiveness. It evaluates the company's vision, quality, customers, productivity, cycle time, flexibility, etc. Medori and Steeple's Framework outlined a cohesive structure for auditing and enhancing performance measurement methods. It comprises six phases that begin with describing manufacturing tactics and achievement factors. In the following phase, the principal job is to balance the company's strategic necessities from the preceding period with competitive urgencies and choose the most appropriate procedures [31].

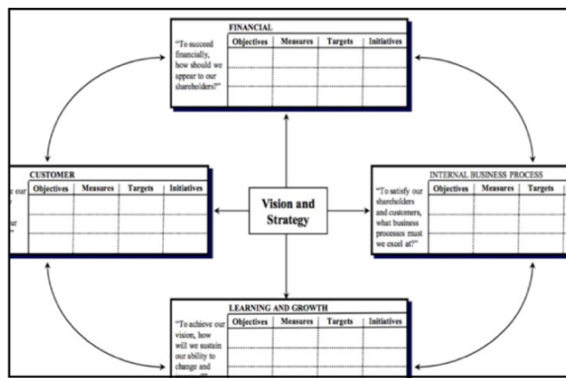


Figure 2. The Balanced Scorecard Model [2]

[8] in figure 2 pronounced the Balanced Scorecard (BSC) model as an authoritative performance measurement instrument, and it allows administrators to detect a composed understanding, where the researchers recommended four basic perceptions that administrators should observe and follow - financial, customer feedback, internal business processes & innovation and learning perceptions. The author demonstrated how SCM structure is connected in a balanced scorecard model where the BSC model is dominant in delivering managers with a comprehensive image of business performance. Nevertheless, it undergoes two elementary restraints. First, it is a top-down tactic. Hence, it is not participative and might miscarry to perceive prevailing collaborations between different procedure metrics [2].

BSC is devised as a monitoring and controlling tool rather than an improvement tool that gives direction for strategic level instead of functional or operational level. It delivers little guidance on how the appropriate measures can be identified, introduced, and ultimately used to manage the business. It does not reflect the market competition perspective. It does not stipulate any mathematical logical relationships among the individual's scorecard criteria. It is challenging to construct comparisons within and across firms. It is not effective for small and medium-sized organizations, because it requires a lot of skill and expertise of the management, time, and expenditure of money. It does not take into account the relation of cause and effect

over time, provides mechanisms for selecting the best measures of performance. BSC particularly refers to the internal corporate perspective. External factors like risk issues, government regulations, uncertainty, collaborations, sustainability is not considered and it does not also consider continuous improvement.

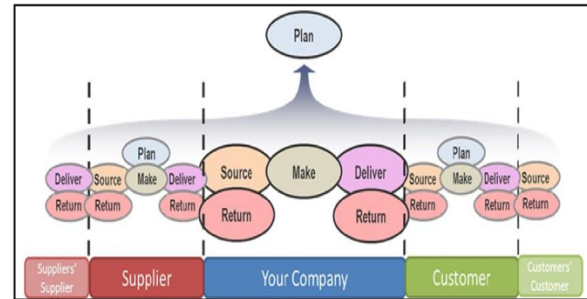


Figure 3. The SCOR model [9]

The SCOR model was formulated by the SC Council (SCC) to support businesses to enhance the effectiveness of their SCs and to deliver a process-based approach to SCM, where the SCOR model carries a common process-oriented language in communicating among its SC associates in Plan, Source, Make and Deliver, where SCOR model designate, measure and estimate any SC configuration. There are twelve performance matrices as part of the SCOR Model to evaluate process performance: delivery reliability, flexibility, responsiveness, costs, and an asset to derive a quantifiable SC performance measure [9].

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

3.1 Integrated Supply Chain Performance Measurement (ISCPM) Model

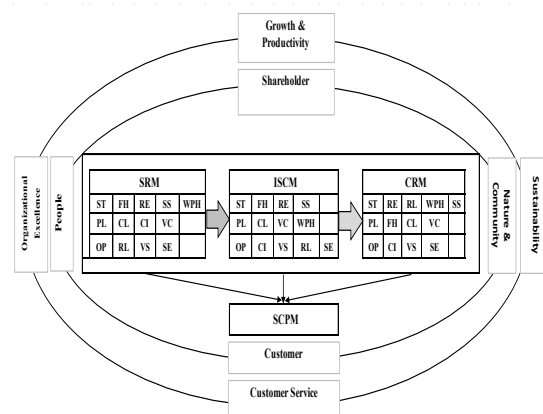


Figure 4. ISCPM Model [26]

The researcher in figure 4, classified ten performance measurement attributes to measure supply chain performance measurement. They are Financial Health (FH), Collaboration (CL), Velocity (VC), Reliability (RL), Visibility (VS), Resilience (RE), Continuous Improvement (CI), Work People Health (WPH), Sustainability (SS), and Service Excellence (SE).

In figure 4, Supplier Relationship Management (SRM) is classified as an Input, Internal Supply Chain Management (ISCM) is classified as Process and Customer Relationship Management (CRM) is classified as Output. All these ten attributes are then clustered at a strategic, planning, and operational level [26].

Supplier Relationship Management (SRM) at a strategic level consists of Financial Health (FH), Resilience (RE), Sustainability (SS), and Work People Health (WPH). The Supplier Relationship Management (SRM) at a planning level consists of Collaboration (CL), Continuous Improvement (CI), and Velocity (VC). And finally, the Supplier Relationship Management (SRM) at an operational level consists of Reliability (RL), Visibility (VS), and Service Excellence (SE) [26], [32], [33].

Similarly, Internal Supply Chain Management (ISCM) and Customer Relationship Management (CRM) have been classified. The researcher exhibits the ISCPM model, where the researcher classifies that an organization is ultimately responsible for its four stakeholders: shareholder, customer, people, nature & community. The first and foremost responsibility of an organization is to serve its shareholders' interests through continuous growth and profitability [24], [17], [20].

The shareholders are better served when an organization has the highest focus to serve its customers through ensuring customer service excellence. The shareholders and customers could be made satisfied when the people of the organization perform satisfactorily through ensuring organizational excellence. The last and most important for an organization is to be responsible for their stakeholder who is nature and community [23].

An organization should be responsible for its nature and its community to ensure that it is not engaging itself in any harmful activities through pollution of air, soil, or releasing toxic gas or substances to nature. Not only that, but an organization also has responsibility towards its people, its community through the eradication of poverty. Therefore, when a firm's performance is balanced to its four stakeholders, then and only true sustainability is achieved [21].

To measure the supply chain performance, there are several tools and methods which have been already discussed above. However, the Balanced Scorecard (BSC) model and the SCOR model have been widely been adopted and recognized as the two most successful tools. The study focuses on the comparative study of The Balanced Scorecard Model (BSC), the

SCOR model with Integrated Supply Chain Performance Measurement Model (ISCPM) model are as follows [27]:

4. Comparative Study of Performance Measurement Models

A comprehensive summary of the Integrated Supply Chain Performance Measurement (ISCPM) model, the BSC model, and the SCOR model is given below

Table 1. Performance Measurement Models Comparative [26]

	ISCPM Model	BSC	SCOR
1	Financial impacts in SC (FH)	Economic Performance Cost Budget Variance	Financial Asset Cost Did not discuss
2	Information Sharing and Partnership (CL)	Inventory Planning Variance Partnership	Did not discuss " " " "
3	Capacity and Speed in SC (VC)	Capacity Flexibility Speed Flexibility Consistency	Did not discuss " " " "
4	Disruption in SC (RE)	Global Risk Enterprise Risk Human Capital and Management Risk Supplier Selection & Appraisal	Did not discuss " " " " Did not discuss previously, but in SCOR 10.0 it added.
5	Dependability on Internal SC Operations (RL)	Be on Time Be on Specifications Be on Utilization	Did not discuss " " " "
6	Culture to Achieve and Excel Performance in SC (CI)	Process Standardization Culture for TQM Culture for Continuous Improvement Application of 5S Application of Lean Application of Total Productive Maintenance	Internal Business Process Did not discuss " " " " " " " "
7	Traceability in SC (VS)	Integration Traceability ERP Transactions	Did not discuss Did not discuss
8	Leadership & Corporate Governance (WPH)	Leadership Ethics, Integrity & Compliance Talent Attraction and Retention Health & Safety Culture, Value and Employee Engagement	Learning & Growth Did not discuss
9	Abstain to Damage Society and Nature (SS)	Sustainability to Nature Sustainability to Community Application of Green SC	Did not discuss Did not discuss
10	Technological Innovation & Service Quality (SE)	Innovation in Technology Customer Satisfaction Service Facilities & Technical Skills	Customer / Learning & Growth Did not discuss

BSC model addressed four perspectives – financial, internal business process, learning & growth, and customer, whereas the SCOR model argues on five perspectives – reliability, responsiveness, agility, cost, and asset. In contrast, the ISCPM model considers that to ensure a comprehensive analysis on SC performance measurement, the model demands to have ten attributes - financial health (FH), collaboration (CL), velocity (VC), resilience (RE), reliability (RL), continuous improvement (CI), visibility (VS), workplace health (WPH), sustainability (SS), and service excellence (SE).

5. Research Methodology

The study applied an exploratory study method based on primary and secondary data. A review of journal papers on the supply chain performance measurement model was made. The target population in this study was the Bangladesh manufacturing industry, which consists of twenty-four manufacturing sectors. Based on the analysis, twenty-four manufacturing sectors have around 7,570 manufacturing companies. Therefore, the population size is 7570. From the 7,570 lists of the respondent companies, 1,832 individual company-have been chosen randomly and emails have been sent to the supply chain heads to respond.

An individual company's supply chain professional has been considered as the unit of analysis. This study applied simple random sampling and used the Taro Yamane table at $\pm 7\%$ precision level, and confidence level at 95% the sample size of this research is 199. In this study, the researcher composed 207 respondents from the manufacturing industry. Hence, 207 respondents are the sample size in this study. Apart from these, the study also explored secondary data from Emerald, IJSCM, IGI, Nova publishers, etc.

6. Discussion

The 1st attribute of the ISCPM model is Financial Health (FH). The BSC model in its financial perspective did not elaborate its attributes rather it discussed in general cost structure, asset utilization, and long term shareholders value from the strategic perspective which requires extensive high-end leadership skills and business acumen to frame out, where the SCOR model discussed on cost and asset which can be segregated in the financial perspective.

Against the existing two models, the ISCPM model stretches far beyond the traditional views and segregates the financial attributes into three performance measurement indexes (PMI) – economic performance, cost, and budget variance where the budget variance is a performance measurement index (PMI) of financial health attribute, which has not been discussed in the BSC and the SCOR model and it addresses the planning

and actual deficiencies or surplus position in an organization - such as budget variance in customs duty, customs, penalty, demurrage, cost of

production, etc. Addressing Financial Health (FH) will bring efficiency and ensure growth and productivity in the organization. Hence, this will serve the interest of the shareholders [27], [28].

The 2nd attribute of the ISCPM model is Collaboration (CL) which describes Information Sharing and Partnership among its suppliers, internal operations as well as to its customers which helps the company to synchronize its operations. However, the BSC model and SCOR model did not address anything from this perspective.

In contrast, the ISCPM model further elaborates the attributes and segregates them into three performance measurement indexes (PMI) – inventory, planning variance, and partnership. As the organization excels towards collaboration, this will improve the operational efficiency and ignite to achieve the financial top and bottom-line [26], [25], [15].

The 3rd attribute of the ISCPM model is Velocity (VC) which describes Capacity & Speed with further segregation on Capacity Flexibility, Speed, and Flexibility Consistency. The BSC model did not cover this perspective whereas the SCOR model however clarified this attribute in Agility. As the company accelerates its velocity in its overall process, this will help the company to act agile and to keep the consistency to meet and retain the market share and satisfy its customers [26].

The 4th attribute of the ISCPM model is Resilience (RE) which describes Disruption in SC, and the model further elaborates into four performance measurement indexes (PMI) – global risk, enterprise risk, human capital & management risk, and supplier selection & appraisal. In the context of a highly complex and borderless economy, appraising Resilience is essential. However, the BSC and the SCOR model ignored this attribute. But, the SCOR 10.0 version has partially covered risk through overall value at risk under the subsection of Agility [25], [3].

The 5th attribute of the ISCPM model is Reliability (RL) which describes Dependability in SC, and the model further elaborates into three performance measurement indexes (PMI) – Be on Time, Be on Specification and Be on Utilizations. The BSC model does not cover in this perspective. However, the SCOR model elaborated this on Agility [22].

The 6th attribute of the ISCPM model is Continuous Improvement (CI) which describes Culture to Achieve, and Excel Performance in SC, and the model further elaborates into six performance measurement index (PMI) – Process Standardization, Culture for TQM, Culture for Continuous Improvement, Application of 5S, Application of Lean, and Application of Total

Productive Maintenance.

The BSC model discussed on Internal Business Process and highlighted Cycle time, Quality, Employee Skills, and Productivity in general but it did not cover in-depth the quality process, and its application to apply it in the manufacturing industry where the SCOR model is absent in this perspective.

Against these two models, the ISCPM model is very comprehensive and illuminates' issues related to the industry on the people, process, productivity, and the way forward [25].

The 7th attribute of the ISCPM model is Visibility (VS) in SC, and the model further elaborates into three performance measurement indexes (PMI) – Integration, Traceability, and ERP Transaction [14], [16], [18], [11].

To synchronize the company with the supplier, internal operations with the customer, visibility is important. Global companies have made a significant investment in infrastructure and capacity development, where the BSC and the SCOR model did not focus on addressing it, where the ISCPM model has covered major areas to ensure the seamless connectivity and full optimization of the SC efficiency [11].

The 8th attribute of the ISCPM model is Work, People & Health (WPH) which describes on Leadership & Corporate Governance in the overall organization bring SC efficiency and the model further elaborates into five performance measurement index (PMI) – Leadership; Ethics, Integrity & Compliance, Talent Attraction & Retention, Health & Safety; and Culture, Value & Employee Engagement. The BSC model discusses Learning & Development, where it clarifies companies' ability to innovate and learn new things aligning with the company's value. However, the explanations do not cover what should be their attribute or measurement tools for the functional and operational aspects [35]. The BSC model does not talk about the leadership, culture, motivation level of the employees. Therefore, it seems ambiguous and challenging for a mid-sized organization. Contrary to that, the SCOR model is completely absent from this perspective. Against these two models, the WPH elaborates comprehensively to ensure organizational excellence [26].

The 9th attribute of the ISCPM model is Sustainability (SS) which describes on Abstain to Damage Society and Nature and the model further elaborates into three performance measurement indexes (PMI) – Sustainability to Nature, Sustainability to Community, and Application of Green SC. The BSC and the SCOR model ignored this perspective whereas the ISCPM model strongly emphasized the sustainability for an organization to behave responsibly for the planet and the people [19].

The 10th attribute of the ISCPM model is Service Excellence (SE) which describes Technological Innovation & Service Quality, and the model further elaborates into three performance measurement indexes (PMI) – Innovation in Technology, Customer Satisfaction, and Service Facilities & Technical Skills [.]. The BSC model discussed on bird's eye perspective on technical innovation and its adaptability, but the SCOR model completely ignored this emerging issue where the ISCPM model elaborates and highlights in-depth to meet the current industry needs [37].

7. Conclusion

This study unlocks the frontier to have comprehensive analysis and a comparative study on supply chain performance measurement among different models, especially with the BSC and the SCOR model which are widely adopted and applied across the industries. And then these two models were compared in their attributes with the Integrated Supply Chain Performance Measurement (ISCPM) model. This study formulates Integrated Supply Chain Performance Measurement (ISCPM) model through the supply chain performance attributes in the outlook of input-process-output considering the BSC and the SCOR model at three decisions levels with an application of quantitative techniques to bring synergic effect to all stakeholder issues. A gap analysis was performed through literature reviews. The integrated model incorporates ten supply chain performance measurement attributes as supplier relationship management (SRM), internal supply chain management (ISCM), and customer relationship management (CRM). The model was then tested by 207 respondents from 24 sectors in the manufacturing industry of Bangladesh, through a simple random sampling. The ten attributes were ranked using Analytic Hierarchy Process (AHP), and the weight and fitness of the model, were validated using the Structural Equation Modeling (SEM) technique. The developed ten attributes reveal that the existing models such as the BSC and the SCOR models have limitations in the context of the current market dynamic changes.

8. Recommendation and Future Research

The integrated supply chain performance measurement (ISCPM) model was produced based on the primary data from the Bangladeshi manufacturing industry, however, it could apply to other manufacturing industries as well from across the world. As this research is validated empirically, therefore, it is suggested to apply this model in real-life applications, particularly in the manufacturing industry. In this study, the study illustrated the model for the manufacturing industry, though this is the limitation of this research. However, the study unlocks further frontiers for the service industry.

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