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Performance Measurement System Through Supply Chain Management to Lean Manufacturing

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Abstract: This paper discusses the relationship between Performance Measurement Systems in Supply Chain Management and Lean Manufacturing. Nowadays, companies regard Lean Manufacturing as a role model for optimizing production and survival in a globally competitive market. Supply Chain Management is a key element of Lean Manufacturing that covers strategic, tactical and functional levels in companies. Planning, human resources, product realization and customer delivery are different processes of a supply chain. A Performance Measurement System is very important for analyzing improvement and achieving goals. Creating a Performance Measurement System in Supply Chain Management for measuring Supply Chain performance in Lean Manufacturing is a success factor for managers and stakeholders. The results of this study show that if the performance of Supply Chain Management can be measured and be exactly based on pre-determined goals to create a Lean Supply Chain, then it can direct the system toward Leanness and business excellence.

Key words: Supply Chain Management · Performance Measurement System · Lean Manufacturing

INTRODUCTION

Excellence in supply chain (SC) performance is a key element in an organization's success. A SC is: on time production, on time delivery and all the costs from supplier to the customer. Implementation of a supply chain performance measurement system (SCPMS) can improve performance because it can be an effective factor in the production path, aid on time delivery and reduce costs.

According to Lee and Billington [1], most organizations have problems determining performance measurement (PM) metrics and even those who have metrics have problems in their regular control. Performance measurement in SC is a process that reduces costs, reduces risk and improves facilities in the production process.

Effective management of SCs is one of the main factors for an organization's survival [2] and it leads to comparative differentiations between modern organizations [3]. The market is exerting increasing pressure on suppliers in terms of flexibility, variability, time and value [4]. The main credits of performance measurement systems (PMS) are to achieve organizational goals and to provide important feedback related to organizational strategy successes. Moreover, a PM framework not only crystallizes the behaviors of managers in charge of development in comparative conditions but also includes all the executive personnel; so, the PM concept can lead to the achievement of strategic objectives.

Lean manufacturing (LM) is a new approach that aims to reduce waste and it considers customer satisfaction and long-term profitability. A PMS in the SC ensures that decision making, appraisal and performance control occur within a systematic framework. Therefore, optimization of a SCPMS is an effective help to LM approaches.

This paper presents a conceptual framework for investigating the relationship between SCPMS and LM and attempts to better understand SC performance and to develop the concepts further, it therefore includes an investigation of measurement and LM.

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Background of Supply Chain Management and PMS: In recent years, organizational PM and metrics have received much attention from researchers and practitioners. The role of these measures and metrics in the success of an organization cannot be overstated because they affect strategic, tactical and operational planning and control [5]. Schmitz and Platts [6] believe that structural and managerial PMSs are the lost circle between strategic and executive cases and PM is the basic motivation for organizational primary activities. According to Chow [7], the following should be identified to recognize logistic performance: efficiency, effectiveness and quality, working living quality, profitability, productivity, innovation and budgeting. So, in the framework of PM there should be exclusive metrics to crosscheck metrics to guarantee that performance meets the strategic objectives of an organization.

Some authors claim that centralization on segment spans causes failure in organizing the executive system therefore PMS, instead of segment approach, should follow a process approach [1, 8]. Naylor [9] studied the Lean approach in the SC for market needs and he claims that the Lean approach plays a major role in the market and in costs. Christopher [10] mentions that it is the SCs that compete not the companies. Coopervalerm (cited in Feizabadi [11]) produced a comparative study between supply chain management (SCM) and satisfactory and moderated performance. He claims that effective management of SC has numerous advantages, for example: fewer costs, more profit, higher productivity, minimum inventories and more customer loyalty, shorter delivery time, more improved ability to demand variability; these are the same as some LM objectives [11]. In 2003, the studies of Neely *et al.* [12] showed that more than 20 metrics were used in the design of PM. Dickson (cited in [13, 14]) proposed 23 metrics for the choosing of suppliers. Garvin [15] proposed five metrics for PM: quality, cost, delivery at time, services and flexibility. Kaplan and Norton [16] presented frameworks of PM such as: Balance scorecard, PM matrix and Performance pyramid. They quote Herbert's stages of appraisal of SC value:

- Establishing team and identifying existing conditions.
- Analyzing information and extracting of performance critical metrics.
- Covering weaknesses of Stage 2.

According to Kaplan and Norton [16], four dimensions: customer, stakeholders, internal process and innovation, should be considered in PMS. Instead of being oriented towards final results a PMS should cover all of the executive personnel [17-19]. Beamon [20] enumerates the characteristics of an effective system for logistic PM: coverage, generally, measurement capability and suitability. A recent study by "van der Vaart" and "van Donk" [21] shows that there are important differences in the factors and constructs used to measure SC integration. Their detailed analysis shows that, at the level of items, three categories can be distinguished: attitudes, practices and patterns [21].

Metrics and PM have an important role to play in setting objectives, evaluating performance and determining future courses of actions [5]. Holmberg identifies problems with measurement such as: the weak link between strategy and actions, a heavy reliance on financial measures causing reactive behavior and confusing multiple of isolated measures. Li *et al.* [23] propose six dimensions of SCM practices: strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices and postponement. Lee and Billington [1] refer to deficient performance measures existing among industries for appraisal of the complete SC. So, all of the members in a SC should have comprehensive measurement systems in which the models and analysis of PM should be implemented for measuring organizational objectives and attainment. De Toni and Tonchia [24] show that there are four distinct performance dimensions and so types of indicators: costs/productivity, time, flexibility and quality. There was mixed support for the impact of SC relationship dynamics on manufacturing performance [25]. Fiennes and colleagues' [26] findings indicate SC relationship quality has a positive impact on design quality but not on conformance quality. Their findings also provide empirical support for partnership models in both the operations management and marketing disciplines [26].

Bhatnagar and Sohal [27] propose a framework that includes qualitative factors concerning plant location decisions, SC uncertainty and manufacturing practices. They argue that a joint consideration of such factors helps explain SC competitiveness and their results largely support the assertion that there is a significant relationship between qualitative plant location factors such as labor, infrastructure, business environment, political stability, proximity to markets, proximity to suppliers, key competitors' location, SC uncertainty and broad manufacturing practices and the operational competitiveness of SCs as measured by quality, flexibility, inventory turnover and responsiveness [27]. Chan [28] describes some problems of PMSs in the SC context: the lack of a balanced approach to integrate financial and non-financial measures; the lack of system thinking, in which a SC must be viewed as a whole entity and the measurement system should span the entire SC; and the loss of the SC context.

Chan [28] also) identifies seven categories for PM of which quantitatively, cost and resource utilization are the main concerns. Beamon [29] identifies a number of PMs of supply and classifies them as qualitative and quantitative. Qualitative Performance Measures are customer satisfaction, flexibility, information and material flow integration, effective risk management and supplier performance. Quantitative Performance Measures are based on cost and customer responsiveness. Chan [28] describes the feedback or information on activities with respect to meeting customer expectations and strategic objectives. The feedback reflects the need for improvement in areas with unsatisfactory performance and thus efficiency and quality can be enhanced. Qualitative Measures include quality, flexibility, visibility, trust and innovativeness. Quantitative Measures include cost, resource utilization and measurement.

SCM: Nowadays, SCM is a key strategic factor for increasing organizational effectiveness and efficiency regarding the enhancement of competitiveness and achieving organizational goals to customer satisfaction / care and increased profitability. To enhance the performance of an individual organization and the complete SC, SCM clarifies the strategic nature of coordination between trading partners [30]. An SCM helps organizations capitalize on their SC ability and resources with regard to bringing products and services to the market faster and in the best conditions (lowest cost, highest value, suitable product/service characterization) [31]. Integration of SC has become one of the major elements in enhancing performance [21]. By the way, SCM is defined as mixture of skill and knowledge that goes into improving the way in companies find the raw components that needs to make a product or services and deliver it to customer. A simple model of SCM is shown in Figure 1.

PMS: Performance measurement enables companies to: measure their performance against their objectives, check adherence to legal and standards' requirements, plan for new improvement targets [32]. A PMS plays an important role in managing a business because it provides the information necessary for decision making and actions [22]. Performance metrics play a vital role in guiding and shaping organizational behavior [33]. A PMS can be defined as the process/metric/the set of metrics used to quantify both the efficiency and effectiveness of actions [34]. Mohammad *et al.* [32] and Zutshi and Sohal [35] propose some activities that can be implemented:

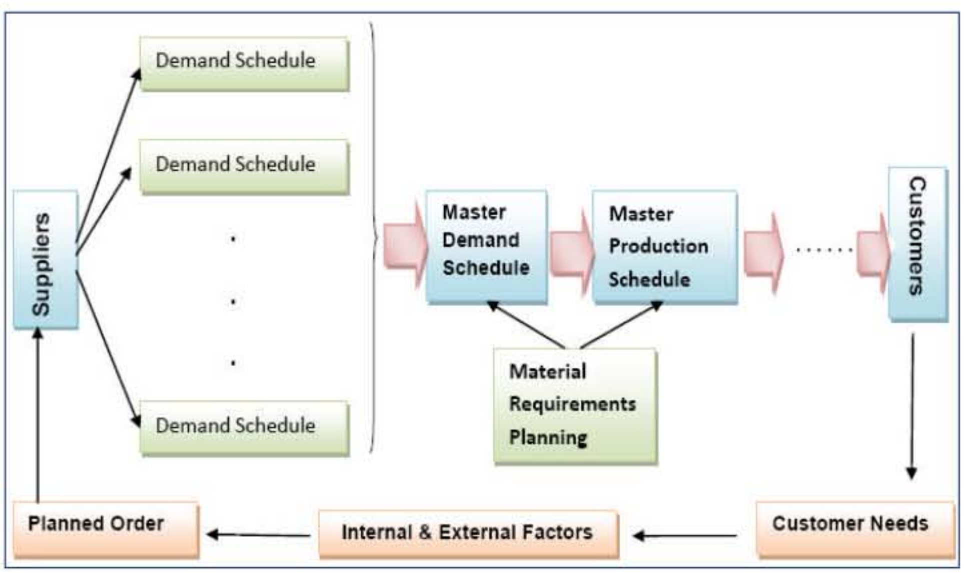

Fig. 1: A Simple Model of SCM

- PM of system processes and products/services, compared to the business objectives.
- Developing performance standards or checklists and a schedule for monitoring the progress of each system and process.
- Benchmarking company performance (e.g. market share and profit) among the companies in the same line of trade.
- Carrying-out internal and external IMS audits to identify non-conformances in the systems and processes.

Gunasekaran *et al*. [5] state: all functions of SCM are as old as commerce itself - seeking goods, buying, storing and distributing them, at the operational level. According to Kaplan and Norton [16], some researchers and organizations / companies have focused on financial performance measures whereas others have focused on function measures. For productive PM and improvement, the measurement of goals should be in terms of goals of organizations / companies and the metrics selected should return a leveling between financial and non-financial measures that can be connected to strategic, tactical and function levels of decision making and control [5]. The focus within an organization will then be on what the objectives are, rather than on how the workforce is to achieve its goals; "what's" of organizational behavior, rather than the "how's" [24]. In order to pledge effective and efficient PM, an extensive control system will be essential from the beginning of the SC, but it must not be done in such a way as to excessively border the decision-making authority of managers in participating organizations [5].

There are three approaches to the major mechanisms of PMS. The first approach is strategic planning, resources (choosing suppliers), manufacturing (all the activities for producing goods), delivery and return (creating a network to provide responses to the customers' problems). According to the second approach, the major SC includes: coordination of production, inventory and transportation among mechanism of SC with regard to getting the best possible integration of responsibility, accountability and efficiency. So, the major mechanisms of SC are production, inventory, location, transportation and information [36]. According to the third approach, it is necessary to have effective management of SC in three areas: strategic, tactics and operations and to act within a framework of four processes: strategic planning, order of supply, production and delivery to customer [5]. According to Beamon [20], there are three types of PM that are necessary in a SCPMS: resource, output and flexibility. The nature of the relationship between measures of manufacturing performance has been addressed by two dominant theories: the cumulative theory and the "trade-off" theory [25]. Berrah and Clivillq [37] propose a model to break down the objectives of the company along four levels: company, business units, business operating units and departments and work centers.

It is a belief that organizations that are successful in implementing performance metrics deploy a strategy that reflects business factors that are crucial to meet the needs of the marketplace they serve [33]. The effectiveness of performance metrics is frequently related to an organization's ability to integrate three approaches: first, matching the measurements with business strategy; second, balancing of the products, process and financial measurements; and third, creating metrics that relate and correspond to every level of the organization [33]. An important component in SC design and analysis is the establishment of appropriate performance measures. A performance measure, or a set of performance measures, is used to determine the efficiency and/or effectiveness of an existing system, or to compare competing alternative systems. Performance measures are also used to design proposed systems, by determining the values of the decision variables that yield the most desirable level(s) of performance [29]. One important reminder is that there could be more than one way of measuring performance, for example on a time or cost basis. However, a company should adopt only one kind of measurement that is most related to the particular characteristic of the company [28].

PM and Metrics in SCM: Kleijnen and Smits [38] recommend five performance metrics in SCM: fill rate, confirmed fill rate, response delay, stock and delay. Effective SCM has become a potentially valuable way of securing competitive advantage and improving organizational performance because competition is no longer between organizations, but among SCs. [30]. A correct measurement of performance metrics enables an organization to anticipate corrective actions and practices as soon as the indicator scores a value below an acceptable threshold [39]. Performance of SC attributes include: reliability, flexibility, responsiveness, costs and asset management [39].

In recent years, a number of firms have realized the potentials of SCM. However, they often lack the insight for the development of effective performance measures and metrics needed to achieve a fully integrated SC.

Moreover, such measures and metrics are needed to test and reveal the viability of strategies without which a clear direction for improvement and realization of goals would be highly difficult [31]. Bhagwat and Sharma (cited in [40]) grouped performance metrics and measurement of SCM into three broad types: the order entry method, order lead-time and the customer order path. Metrics provide the following three basic functions: control, communication and improvement [40]. Folan and Browne [41] stated some requirements in relation to measurement evolvement, systems design and improvement and a framework for PM:

- They should be according to the organization policy and strategy;
- They should be easy, cognizable and imaginable;
- Suppliers should be evaluated according to quality and performance delivery;
- Indicators should be found and gathered that enable personnel to understand the effectiveness of the requirements on business;
- They should be utilized in strategic decision making;
- They should report to different levels of organization on their feedback.

LM and SCPMS: A common theme in the literature is that a relationship exists between the structure of the supply relationship and the supplier's performance level in LM. Also, other research indicates that a relationship also exists between the supplier's performance level in LM and the occurrence of advanced environmental management practice [42].

In the Lean Construction theoretical framework, PM plays an important role in terms of providing process transparency. It makes visible attributes that are usually invisible and helps the employees to see how they are performing and this creates conditions for decentralized control to be implemented [43]. The success of LM is dependent on coordination in the SC; coordination in the SC is impacted by the very structure of the supply relationship [42]. The application of Lean Production concepts and principles to construction demands a change in production management in which PM plays an important role. Measures are important in terms of providing process transparency and the necessary information for continuous improvement [43]. The concepts underlying Lean consumption can be reduced to six simple principles that correspond closely to those of Lean Production [44]:

- Dolve the customer's problem completely by insuring that all the goods and services work and work together;
- Don't waste the customer's time;
- Provide exactly what the customer wants;
- Provide what's wanted exactly where it's wanted;
- Provide what's wanted where it's wanted and exactly when it's wanted;
- Continually aggregate solutions to reduce the customer's time and hassle.

Because the concept of Lean Production grew out of significant observed competitive advantage and the whole principle is based on the existence of a free market, arguments for the inclusion of non-Lean elements in systems (slack) can only be accepted when expressed in terms of adding to competitive advantage in a general, long-term sense [45]. In 2004, Razmi *et al.* [46] pointed to some of the techniques and methodologies in which LM, Total Quality Management, Just-in-time (JIT) and so on, are effective in the improvement of SCs. The fundamental principle of Lean supply is that the effects of costs associated with less than perfect execution of a sub-process are not limited to the location of the execution [45]. Although in theory it is an absolute; in practice, it may be acceptable to be Leaner than competitors while never achieving total "Leanness". At the level of overall operation (or total SC) it might be impracticable to achieve such philosophical perfection. At the level of a specific point in a SC, however, it should always be possible to identify whether or not the current practice is Lean and perhaps how far towards total Lean operation it might be possible to move [45].

The Lean Production philosophy can be separated into four separate bundles of practice: JIT, preventive maintenance of equipment, quality management and human resource management [47]. Management of the supply relationship is a crucial part of Lean Production. The supply function in Lean Production "Lean supply" does not recognize the traditional positions of customer and supplier and expects that its suppliers are active in their independent yet integrated search for the rooting out of all forms of waste [48]. A Lean supply arrangement should provide a flow of goods, services and technology from supplier to customer (with associated flows of information and other communications in both directions) without waste [45]. There are several basic measurements that are predominant in support of a Lean Metric System: quality, cost, delivery reliability, lead-time, flexibility, employee relationships and safety [33].

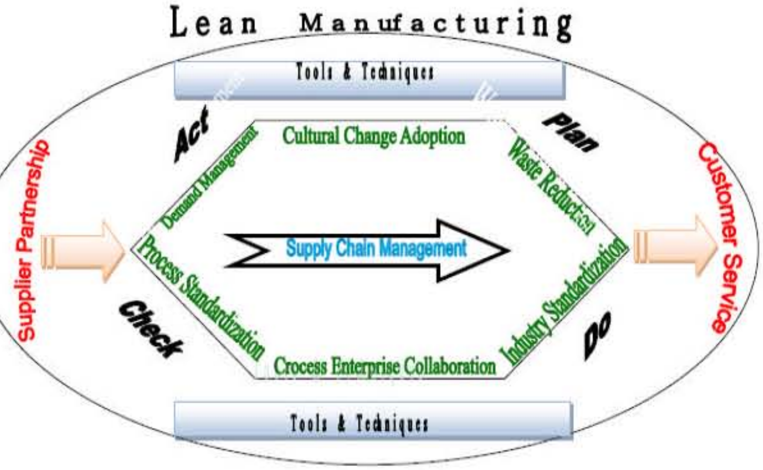

Fig. 2: A scheme of SCM in PMS toward Leanness through LM

In summary, trust, commitment and continuity are the three major success factors of relationship management and measurement. As a result, PM of SCM, with attributes of Lean SC, "from the supplier to manufacturer right through to the retailer and the final customer" in a framework of LM creates synergy (Figure 2).

DISCUSSION AND CONCLUSION

Performance measurement selection is a crucial step in the design and evaluation of an organization because optimal performance of SC has a major role in the success of an organization by providing constant access to organizational objectives and therefore implementation of SCPMS for continuous performance improvement is necessary. Ability in PM is one of the most important improvement and development pillars in various levels of SC. The SC concept represents new management thinking with heavy emphasis on customer service. For managers and companies the tools and styles of traditional analytical systems will not be able to satisfy world SC problems. SCM needs to move from basic administration of transaction data into the coordination of a set of decision-making elements that provide business people with the necessary visibility on how operations are proceeding, on how products are flowing in the network, on how partners are behaving and cooperating and on how value is being built within the wider ecosystem of material and information flows [39].

Consequently, based on the mentioned issues, performance indicators in SCM can be divided into three levels of aspect hierarchy: strategic, tactical and functional. PM indicators are divided into two main groups: key performance indicators (nature of internal organization) and outcome measures (nature of external organization); furthermore, performance indicators are divided into financial performance indicators and nonfinancial. Most companies do not have a balanced structure for measuring financial and nonfinancial performance. However, most indicators such as effectiveness, efficiency, productivity, quality, flexibility and so on are used nowadays. Financial performance indicators are significant in strategic decision making and nonfinancial performance indicators are significant in daily controls and supply operation. There are four main activities and processes in SCM: plan, resource, manufacturing / assembling and delivery. In fact SCM is regarded as managing the planning, organizing, coordinating and controlling areas in companies. However, both groups of indicators are important because the essence of LM and SCM are considered on the basis of two views of internal and external organization.

Today most managers have found that to improve the SCM in LM, they need to create a SCPMS because excellent performance of SC plays a key role in organizational success. Thus, capability, skill and ability of PM are considered as the most important tools to improve SCM. These tools should be selected as excellence indicators otherwise an improper selection of indicators would lead to reduction of SCM as well as LM. Therefore, the selection of SCMPM indicators as SC planning, resources management in SC, product positivism (manufacturing) and delivery to customer is necessary. Hence, what indicators are suitable and necessary for SCPMS in a company should be investigated.

SCM covers the entire value-added chain, starting from the supplier to manufacturer through to retailer and finally to the customer. SCM follows three major goals: reducing inventory, increasing the speed of transaction through exchanging data in real time and increasing sales through satisfying customers' needs more properly. In short, SCM tends to reduce lead time/cost by applying many different methods.

Lean is defined to be a systematic approach for determining and eliminating waste (non-value added activities) through maintaining frequent improvement. So, it is observed that all the objectives and applications of SCM originate from LM. So, it can be concluded that SCM plays a significant role in the success of LM. Consequently, due to the importance of SCM, if the performance of SCM can be measured and be exactly based on the pre-determined goals to create a Lean SC, then it can direct the system toward Leanness and business excellence.

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