Supply Chain Management: The Influence of SCM on Production Performance and Product Quality

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***Abstract*—The primary purpose of this empirical paper is to examine the importance of incorporating supply chain management (SCM) in the Malaysian manufacturing industry and investigate its impact on production performance and product quality. Further, the study also attempts to investigate the mediating influence of production performance in the relationship between SCM and product quality. A measurement Smart PLS model is developed and refined with reliability and validity tests. The study employs a quantitative survey method and data are collected from 250 manufacturing companies. The survey instrument tries to measure senior production or SCM managers' perceptions of SCM implementations and the level of performances in their manufacturing companies. SCM has a positive and significant effect on production performance. In addition, SCM also has a positive and significant effect on product quality. The result also provides evidence that the production performance construct partially mediates the linkage between SCM and product quality. Among the SCM practices, 'new technology and innovation' emerges as the most important factor that enhances production performance and product quality, and it is followed by 'strategic supplier partnership', 'quality information exchange' and 'lean production'.**

***Index Terms*—Supply chain management, production performance, product quality, smart PLS.**

I. Introduction

Volatility of the demands and sales of manufactured products has created intense global competition. The rapid rate of change in global markets has coerced many manufacturing companies to be more responsive to customers changing needs and requirements for higher value-added products and services [1]. In the recent competitive market, producing value-added, high quality and innovative products have emerged as the most vital strategy for manufacturing companies to survive. Many manufacturing companies in Malaysia have adopted numerous improvement programs and developed new operating philosophies to enhance the way they operate to stay competitive. However, among those improvement programs, SCM has become an integral part of corporate strategy and its adoption in manufacturing companies has steadily accelerated since the 1980s.

Supply chain management (SCM) includes the integration of vision, culture, process and strategy to organize an optimal flow of high-quality, value-for-money raw materials, or components from reliable and innovative suppliers and ultimately providing customers with high quality products they designed and manufactured at competitive prices [2]. SCM also encompasses ''all the activities involve to get the right product into the right consumer's hands in the right quantity and at the right time" in the supply chain [3], [4]. SCM has gained increasing importance in the production processes and strategic planning of global manufacturing companies, and it is considered as a contemporary topic of competitiveness [5]. Increasing global competition and the rising costs of natural resources today as well as customers' demands for higher product quality, greater product selection, and better customer service have created new challenges for manufacturing companies. Companies today are increasingly dealing with suppliers and buyers locally and from all corners of the globe. The new global business scenario has led many Malaysian manufacturing companies to adopt SCM in order to minimize wastage and defects, enhance business performance and to sustain or improve overall firm performance. The increased importance placed on SCM is because it is considered a powerful driver and a significant strategic tool for firms striving to achieve competitive success [6], [7]. Therefore, SCM is increasingly being viewed by scholars to be having the ability to contribute to the enhancement of performances [6], [8], [9].

This paper tries to investigate the magnitude and direction of SCM measures and attempts to provide some recommendations to the manufacturing companies. To address this issue, the main objectives of this paper are: a) To empirically discover whether SCM has a significant impact on production performance; b) To empirically determine whether SCM has a significant impact on product quality; c) To empirically investigate whether production performance has a significant mediating role in the linkage between SCM and product quality, and d) lastly to assess the importance of each SCM variable on performances. The paper is structured as follows. First, it presents a brief introduction. Second, it highlights the explanation of the SCM literature review; third, it highlights the conceptual framework and hypotheses. Fourth, it discusses the methodology adopted. Fifth, it highlights the result of the statistical analyses. Finally, the overall results are then discussed and implications highlighted.

II. Literature Review

SCM is seen as a business philosophy that strives to

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integrate the dependent activities, people, and resources from the points of origin and ultimate destination in supply channels[10]-[12]. Mentzer et al. [10] define SCM as a systemic, strategic coordination of the business functions, processes and transactions within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole. Svensson [13] argues that SCM is a business philosophy that simultaneously should address the overall dependencies of activities, SCM partners, and resources on an operational, tactical, and strategic level, from the point of origin to the point of consumption in and between supply channels. Agus [9] proposes a conceptual framework which incorporates the program theory, as well as empirical findings for enhancing the understandings of the importance of implementing SCM and its influence on business performance. SCM seeks to enhance performance by closely integrating and coordinating the internal functions within a company and effectively linking them with the external operations of suppliers and customers. A firm must achieve a relatively high degree of integration to implement SCM successful, which involves integration, coordination and collaboration across organizations and throughout the supply chain [9].

Today's era of global competition has created increasing challenges for manufacturing companies. Manufacturing companies that do not keep up with SCM would lose out to competitors. Nowadays, manufacturing companies do not only compete on prices but also on who would first introduce new technological, creative, innovative and high quality products to enable them to be market leaders and ultimately gain higher profits. SCM has the potential to assist the organization in achieving both cost and a value advantage [11], [14]. Several researchers claim that SCM can result in better performance [14], [15], but maybe none or few empirical studies have been carried out to investigate the magnitude and impact of SCM practices on production performance and product quality simultaneously in the Malaysian context.

III. Conceptual Framework

This section explores the conceptual model which explores the relationships between SCM, production performance and product quality within the context of the Malaysian manufacturing industry. In addition, hypotheses of the study are also discussed.

A. *The Conceptual Model*

The conceptualization in this paper involves two tasks: (1) preparing a diagram (conceptual model) that visually represents the theoretical basis of the relationships in the study and (2) specifying hypotheses and directions. The proposed conceptual model, as depicted in Fig. 1, is based on three main constructs investigated in this study, namely: (i) supply chain management (SCM); (ii) production performance (PPERF); and (iii) product quality (PQUAL). The hypothesized model in the paper demonstrates that SCM is important in enhancing performances and it is the duty of managers to utilize and make the best use of them. The conceptualization of the model aims at understanding the significance of SCM in a better way. The framework consists of four manifest variables of SCM, two variables of production performance and three indicators of product quality. Incorporating ideas, theories and studies from the literature, four main SCM variables included in the study are:

1) *Strategic Supplier Partnership (MN1SSP):* Strategic supplier partnership involves developing trust and collaboration among supply chain partners as well as customers [16], [17].
2) *Lean Production (MNB5LS):* Lean production is associated with the continuous pursuit of improving the processes, a philosophy of eliminating all non-value adding activities and reducing waste within an organization [12], [17], [18].
3) *Quality Information Exchange Between Supply Chain Partners (MNB6QIE):* Many industries focus on improving their efficiency of their supply chains. One key initiative that is commonly mentioned is quality information exchange/sharing between partners in a supply chain [19]. SCM emphasizes the overall and long-term benefit of all parties in the chain through cooperation and quality information sharing between supply chain members [20].
4) *New Technology and Innovation (MB7TEC*H): Tremendous change in the technological developments and globalization has formed significant impact on the nature of work where the advanced use of technology is a necessity in order to compete in the global arena [21]. New Technology and Innovation in this study refers to the application of the latest scientific or engineering discoveries to the design of operations and production processes in SCM [9], [22].

Several studies have identified performance improvement constructs that are commonly associated with the SCM program [23]-[26] such as production performance and product quality. Production performance in this study is operationalized by 'Production Effectiveness' (EFFECT) and 'Production Efficiency' (EFFICIEN). The descriptions of the two variables are as follows:

1) *Production Effectiveness* (EFFECT). A study indicated that SCM would improve operational efficiency and the production effectiveness [27]. Production Effectiveness refers to the overall effectiveness of a process and is the extent to which the outputs expected from the process are being obtained, and is therefore a first measure of the basic adequacy of the process and its capability to fulfill the logical and reasonable expectations of the process uses and operators [28].
2) *Production Efficiency* (EFFICIENT). Production efficiency is associated with the ability to produce a product using the fewest resources possible [29]. Production efficiency refers to a production level at which the manufacturing company can no longer produce additional amounts of a good without lowering the production level of another product. This will happen when an entity is operating along its production possibility frontier. Efficient production is achieved when a product is created at its lowest average total cost. Production efficiency measures whether the system is producing as much as possible without wasting precious

resources. Because resources are limited, being able to make products efficiently allows for higher levels of production [30].

On the other hand, product quality is a very important bottom-line outcome and in this paper product quality construct is being operationalized by indicators, namely 'Product Conformance', 'Product Performance' and 'Product Reliability'[9].

1) *Product Conformance (CONFORM).* Conformance quality is the degree to which a product's design and operating characteristics meet established standards. It reflects whether the various produced units are identically made and meet the specifications [31].
2) *Product Performance (PERFORM).* Performance quality is the primary product characteristics. Performance quality refers to the levels at which the product's primary characteristics operate. Buyers will pay more for better performance as long as the higher price does not exceed the higher perceived value [31].
3) *Product Reliability (RELIAB).* Reliability is a measure of the probability that a product will not malfunction or will operate properly within a specified time period or the consistency of performance over time during which it is subjected to a given set of environment and/or mechanical (vibration, shock, abrasion etc.) stress [32].

B. The Effect of SCM on Production Performance (H1)

In investigating the influence of SCM on production performance and product quality, the Smart PLS is utilized to evaluate and analyze the magnitude and direction of the linkages between these constructs. Firstly, the study attempts to investigate the main research hypotheses regarding associations between SCM and production performance. The goal of SCM processes is specified as adding value for products at reduced overall costs [33]. The value added should first be reflected in production performance, such as in the form of production effectiveness and production efficiency. Based on the theoretical justification and supporting empirical evidence, the first hypothesis proposes that SCM has a positive effect on production performance.

H1: SCM is positively related to production performance.

C. The Effect of SCM on Product Quality (H2)

Bowersox et al. [34] highlight in their study that high SCM implementers exhibited significantly higher scores for the quality performance outcomes. Agus [9] indicates that SCM has positive associations with quality related performance. Therefore, the second hypothesis suggests that SCM has a positive impact on product quality.

H2: SCM is positively related to product quality

D. The Effect of Production Performance on Product Quality (H3)

Finally, the third research proposition suggests that improving production performance would have a positive effect on product quality. Justification for the hypothesis is based on the argument that production performance evaluation of SCM processes will become closely linked to enhanced product quality [35].

*H*3: Product quality performance is positively related to product quality.

E. The Mediating Effect of Production Performance in the Linkage between SCM and Product Quality (H4)

In addition, this study also tries to test (the fourth hypothesis) whether production performance acts as a mediator in the linkage between SCM and product quality.

H4: Production performance mediates the linkage between SCM and product quality.

In investigating the effect of SCM on performances, it is also pertinent to determine the loadings of each SCM dimension, namely 'Strategic supplier partnership', 'Lean production', 'Quality information exchange' and 'New technology and innovation' (H_{1A}, H_{1B}, H_{1C} and H_{1D}).

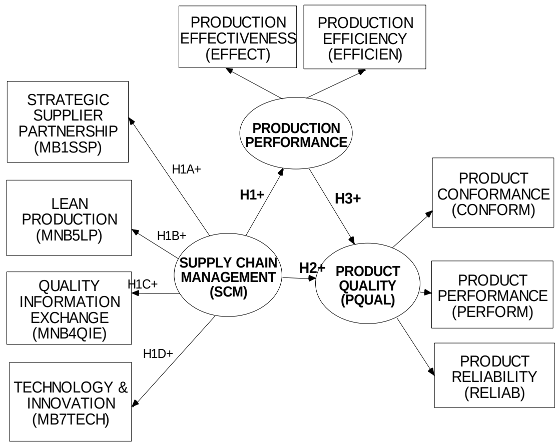

Fig. 1. The conceptual model linking SCM, production performance and product quality.

IV. Research Methodology

This paper formed part of a larger study on SCM with the inclusion of product quality aspects. The instrument used in this study was a structured survey questionnaire, which was designed to assess the manufacturing companies in term of the described dimensions. The instrument developed in this study consisted of two major parts. The first part comprised several variables measuring SCM practices, and the second part comprised several performance measurements including production performance and product quality. To enable respondents to indicate their answers, seven–point interval scales were used in the questionnaire. Several items of SCM, which had been widely referred, were extracted. Similarly, the mediating and the dependent constructs, namely production performance and product quality also used a seven-point interval scale, representing a range of agreement on a statement, whether over the past three years these performances were high relative to competitors after implementing SCM.

The sample unit of analysis in this study was Malaysian manufacturing company (the sampling frame was derived from the Federation of Malaysian Manufacturers Directory-FMM) and each company was represented (the respondent) by either senior production or SCM manager. Two hundred and forty five responses were received and analyzed. The primary purpose of the research was to measure senior production or SCM managers' perceptions of SCM processes and to gain insight into the benefits of implementing SCM in the Malaysian manufacturing industry.

The goal was to understand and determine measures of SCM that can enhance production performance and product quality. Face to face interviews with the SCM managers were carried out to ensure the information accuracy, validating the outcome of the analysis and developing an understanding of the practical aspects of SCM processes, principles and adoption.

Validity and reliability tests were used to select and assess the final items of the independent constructs that were used for statistical testing. Since data for the study were generated using a multi-scaled responses, it was necessary to test for reliability [22], [36]. The internal consistency of each factor was examined using Cronbach Alpha reliability analysis. Items that did not significantly contribute to the reliability were eliminated for parsimony purpose. The result indicated that the Cronbach's alpha measures for the three main constructs exceeded the threshold point of 0.70 suggested by Nunnally [37]. Alpha coefficients for SCM, production performance and product quality ranged between 0.847 and 0.938 after the alpha maximization process were carried out, indicating internal consistency. As a result, nine items for the three constructs were retained for the analysis phase (See Table I).

In addition, the face-content validity of the measures was also investigated in this study. Content validity represented the sufficiency with which a specific domain of content (constructs) was sampled [37], [38]. The critical variables of SCM and two performance constructs in this study had content validity because an extensive review of the literature was conducted in selecting the measurement items and the critical constructs; and all the items and factors had been evaluated and validated by professionals in the area of operation management or SCM. In addition, the draft questionnaire was pre-tested with academics to check its content/face validity and terminology and was modified accordingly [9]. Statistically, convergent validity derived from the findings was also considered satisfactory (loading values > 0.700, *t*-statistics > 1.96, square root of AVE > 0.800, composite reliability > 0.890) [9].

TABLE I: MODEL RELIABILITY AND VALIDITY

Latent SCM & Performance Constructs	Cronbach's Alpha	Square Root of Average variance Extracted (AVE)	Composite Reliability (CR)
Supply Chain Management (SCM)	0.847	0.828	0.897
Production performance (PPERF)	0.890	0.949	0.948
Product quality performance (PQUAL)	0.938	0.943	0.960

In addition, discriminant validity refers to the extent to which a certain construct is different from other constructs. The constructs in the study needed to be tested for discriminant validity so that it can verify that the scales developed to measure constructs, were indeed measuring different constructs [9], [10], [37], [38]. There are two ways to test discriminant validity. Firstly, the average variance extracted (AVE) must be greater than squared correlations between constructs (AVE > squared correlations). Alternatively, discriminant validity can also be confirmed when the square root of AVE is greater than the correlations between constructs (see Table II). [9], [10], [37], [38]

TABLE II: CORRELATIONS BETWEEN LATENT CONSTRUCTS AND SQUARE ROOT OF AVERAGE VARIANCE EXTRACTED (DIAGONAL)

Latent constructs	1	2	3
SCM	**0.828**		
Production performance	0.712	**0.949**	
Product Quality	0.690	0.712	**0.943**

V. RESULTS

Pearson's correlation analysis was conducted to establish associations between SCM practices, production performance and product quality. The results (as seen in Table III and Table IV) indicated that most of the SCM variables specifically 'Strategic Supplier Partnership', 'Lean Production', 'Quality Information Exchange' and 'Technology and Innovation' had high and significant correlations with production performance and product quality variables. For example, production effectiveness and efficiency had strong & significant correlations with new technology and innovation (r = 0.510 and r = 0.535) as well as lean production (r = 0.509 and r = 0.534). Likewise product conformance, product performance and product reliability also had positive and significant correlations with SCM variables. These findings were consistent with several previous studies that proclaimed better organizational transformations as a result of SCM initiatives [9], [12], [16].

TABLE III: CORRELATIONS BETWEEN SCM AND PRODUCTION PERFORMANCE

SCM Practices	Production Effectiveness	Production Efficiency
Strategic supplier partnership (MNB1SSP)	$.347^{**}$	$.444^{**}$
Lean production (MNB5LP)	$.509^{**}$	$.534^{**}$
Quality Information Exchange (MNB4QIE)	$.466^{**}$	$.449^{**}$
New technology & innovation (MB7TECH)	$.510^{**}$	$.535^{**}$

Notes: $*p \leq 0.05$; $**p \leq 0.01$ (all *t*-tests are one-tailed)

TABLE IV: CORRELATIONS BETWEEN SCM AND PRODUCT QUALITY

SCM Practices	Product Conformance	Product Performance	Product Reliability
Strategic supplier partnership (MNB1SSP)	$.530^{**}$	$.506^{**}$	$.489^{**}$
Lean production (MNB5LP)	$.593^{**}$	$.576^{**}$	$.593^{**}$
Quality information Exchange (MNB4QIE)	$.487^{**}$	$.481^{**}$	$.516^{**}$
New technology & innovation (MB7TECH)	$.516^{**}$	$.523^{**}$	$.548^{**}$

Notes: $*p \leq 0.05$; $**p \leq 0.01$ (all *t*-tests are one-tailed)

The result of the Smart PLS algorithm indicated that the path from SCM to production performance (PPERF) was relatively high with the loadings of 0.619 and a significant with a *t*-value of 13.122. Thus, Hypothesis 1 was fully supported. The path of the Smart PLS algorithm model also showed that the impact of SCM on product quality performance was moderately high with a loading of 0.404 and was also significant with a t-value of 6.683. Therefore, Hypothesis 2 was accepted. Fig. 2 also illustrated that production performance had a positive (loading = 0.462) and a significant effect (*t*-value = 7.603) on product quality performance. Hence, the result strongly supported Hypothesis 3.

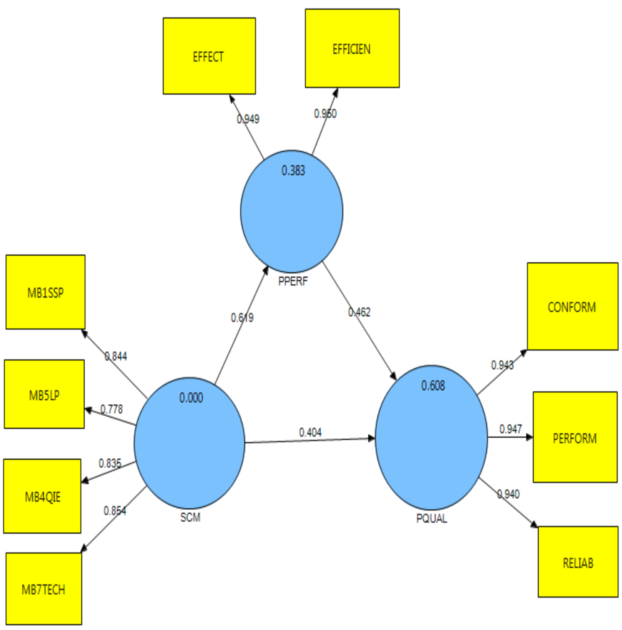

Fig. 2. The Smart PLS (algorithm) model showing the relationships between SCM, production performance and product quality.

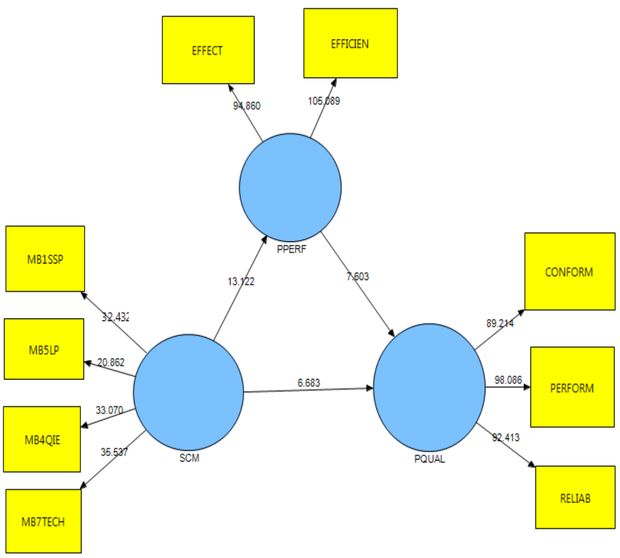

Fig. 3. The smart PLS (bootstrapping) model showing the relationships between SCM, production performance and product quality.

To identify the extent to which production performance mediated the linkage between SCM and product quality, an additional model that directly linked SCM and product quality was estimated. The result indicated that SCM demonstrated significant effects directly and indirectly (through production performance) on product quality. Hence, production performance partially mediated the linkage between SCM and product quality. To further validate the mediating relationship, the Sobel test [39] was conducted to examine the significance of the mediating effect since Mackinnon *et al.* [40] suggest that the Sobel test is superior in terms of power and intuitive appeal. The Sobel test lends additional support for the mediated relationships hypothesized through a change in the significance of the direct effect. The result of the Sobel test (t-value = 5.133, 0.001) provided support for the partial mediating effect of production performance in the relationship between SCM and product quality. Thus, the result strongly supported Hypothesis 4, suggesting that production performance mediated the linkage between SCM and product quality (H_4). In addition, it was essential to reaffirm that SCM can ultimately improve product quality of manufacturing companies in Malaysia.

TABLE V: THE STRUCTURAL AND MEASUREMENT RESULTS OF THE SMART PLS

Constructs and indicators	Loadings	Mean	Std Error	t-statistic (bootstrapping)
Supply chain management (SCM):				
Strategic supplier partnership (MB1SSP)	0.844	5.183	.0616	32.432*
Lean production (MNB5LP)	0.778	4.999	.0884	20.862*
Quality Information Exchange (MNB4QIE)	0.835	5.213	.0688	33.070*
New Technology and Innovation (MB7TECH)	0.854	4.941	.0799	35.537*
Production performance: (PPERF)				
Production effectiveness (EFFECT)	0.950	5.232	.0730	94.860*
Production Efficiency (EFFICIEN)	0.949	5.236	.0729	105.089*
Product quality performance: (PQUAL)				
Product conformance (CONFORM)	0.943	5.488	.0690	89.214*
Product performance (PERFORM)	0.947	5.564	.0651	98.086*
Product Reliability (RELIAB)	0.940	5.600	.0673	92.413*
Exogenous/endogenous Path				
SCM→ PPERF [H_1 is supported]	0.619	-	0.061	13.122*
SCM → PQUAL [H_2 is supported]	0.404	-	0.077	6.683*
PPERF → PQUAL [H_3 is supported]	0.462	-	0.081	7.603*
SCM → PPERF →PQUAL [$H4$ is supported – partial mediation]	Indirect effect (.619x.462) = 0.298 Total Effect (.404 + .298) = 0.702			5.133*

*Significant t-statistics > 1.96 at the 95 % level of confidence.

Looking at the contributions of each SCM variables (Fig. 2 and Table V on the main construct, the result demonstrated that 'new technology and innovation' (loading value = 0.854) had the highest contribution towards SCM implementation.

This was followed by 'strategic supplier partnership' (loading value = 0.844), 'quality information exchange' (loading value = 0.853) and lastly lean production (loading value = 0.778). All of these indicators had significant probability values (*t*-values ≥ 1.96 as exhibited by Fig. 3), giving statistical evidence that the contributions of these variables towards overall SCM construct were significant and positive (H_{1A}, H_{1B}, H_{1C} and H_{1D} were supported). The findings also suggested that SCM had high influences on production performance indicators specifically 'production efficiency' (loading value = 0.950) and production effectiveness (loading = 0.949). The Smart PLS result also demonstrated the SCM variables had significant contributions toward product quality indicators, namely 'product performance' (loading value = 0.947), 'product conformance' (loading value = 0.943), and 'product reliability' (loading value = 0.940).

VI. Discussion and Implications

Moving the manufacturing companies toward genuine SCM requires management commitment and changes in strategic direction and planning [41], [42]. An initial step of integrating suppliers in the process also requires a major adjustment to internal processes and procedures that must be accepted throughout the organization before SCM can be successfully implemented [43], [44].

A good implementation of SCM can produce positive outcomes such as excellent product quality, low operating costs, on-time deliveries, and reduce wastage and inventory [45]. The result demonstrates a new discovery of how important (magnitude and direction) is new technology and innovation as well as quality information exchange. By adopting new technical and innovative machineries and tools, production efficiency and effectiveness can be enhanced. In addition, quality products can be produced effectively with maximum utilization of precious and limited resources. The quality information exchange and collaboration among supply chain partners are very crucial in achieving long term benefits. To achieve high performance in SCM, manufacturing companies need to integrate their SCM partners into their operations. Therefore, participation and the operational commitment of all supply chain members and interchannel management are very pertinent for the success of SCM [46]. However, considering the complexity of today's supply networks, it is very challenging to successfully execute SCM concepts due to increased communication requirements among the supply chain partners [47]. Despite these challenges, the proper and effective implementation of SCM with the emphasis on technology & innovation, quality information exchange, strategic supplier partnership as well as elimination of waste under a lean production would improve production efficiency and effectiveness and ultimately product quality. For instance, having effective internal assessment systems in place that enable companies to choose and evaluate suppliers and allow suppliers to actively participate in the supply chain can have a positive effect on product quality, among other measures of company performance [48]-[50]. When the supply management function integrates its decisions and operations with suppliers, they enable supply management to establish close relationships where appropriate with suppliers to improve the quality and delivery of materials to customers [51]. Adopting early supplier involvement, operational activities, such as product development projects, can offer more cost-effective design choices, and select best available components and technologies, resulting in smoother production, improved product quality and reduction in lead time [6]. Through strategic supplier partnerships, organizations can work closely with suppliers who can share responsibility for the success of the products [52]. Such strategic supplier partnerships should enable successful SCM.

In addition, lean production system makes worker production responsibility central to the continuous improvement of productivity and quality [53] which will improve productivity through reduced lead times and elimination of waste [54]. Moreover, by establishing effective inbound and outbound logistics systems, and managing lean production successfully across the supply chain, companies can secure high quality raw materials from few reliable suppliers as well as improve product quality by avoiding production wastage and error; and reduce unnecessary spoilage and non conformance [49]. As a results company will have a stronger focus on maximizing productivity as well as production efficiency and effectiveness [53] that leads towards ultimate performances [53], [55].

Many of the improvements in SCM would not have been possible without similar improvements in the technology and innovation as well as quality information exchange that are the backbone of the most well-run supply chains. New technology and innovations as well as information systems are changing the way supply chains perform. Internet, intranet and other electronic communications can synchronize a firm's supply chain with those of its supply chain members in producing, merchandising and transporting products more efficiently. Production collaboration using new technological decision support systems manages design across the lifecycle of a product, from introduction to service support, by having suppliers become part of the design process. This helps cut design and production times, improves product quality, and achieves a faster time-to-market. Achievement of these benefits requires changes in the way companies design and develop products and production processes using new technological tools. Using the latest design technology, the manufacturing companies may save huge amounts of time and money in bringing newly developed quality products to market faster [9], [56].

This paper is relevant to practitioners, SCM managers and academic researchers because the conceptual framework and findings may provide significant information, magnitude and direction regarding SCM practices that can be used to solve implementation challenges and prioritization in order to improve performances with the maximum utilization of limited resources.

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