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USING LEAN MANAGEMENT TO ADVANCE SUPPLY CHAIN EFFICIENCY

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ABSTRACT

Lean management has been traditionally used in the manufacturing world but recently there has been a move to apply lean manufacturing principles in the supply chain management. There is an ever-growing pressure for organisations to achieve shorter lead times, lower costs, and better quality. Lean provides a systematic approach to optimize value stream from suppliers to consumers through elimination of non-value adding activities. This paper looks at the benefits of implementing lean in supply chain, supply chain performance review tools, evolution of lean in other sectors out of manufacturing and how it can be implemented in an integrative manner with other approaches such as Industry 4.0. It further reviews the peer reviewed case studies where lean has been implemented successfully and how can the results be amplified further.

Keywords: Lean management, Lean Supply Chains, SCOR

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1 INTRODUCTION

The term 'lean' was used in 1980's as authors attempted to describe the success of Japanese manufacturing corporations, the most prominent being the Toyota Production System (TPS) [1]. In general, the literature defines lean management as a set of tools and methods that improve customer value through the reduction of non-value adding tasks and actions at an operational level [2]; [3], maintained by a strategic organisational philosophy of continuous improvement and culture [4]; [5] and [6].

Lean management offers a customer-centric philosophy grounded on five ideologies (define value, identify the value stream, flow creation, introduce pull to customer and pursue perfection) with the goal of waste reduction from of the process [6].

Traditionally lean has been used in the manufacturing world but recently there has been a move to apply lean manufacturing principles in the supply chain management. The indication by Santos [7], further stresses the point that lean thinking organisations have lean manufacturing with the aim of eliminating waste in production processes.

Waste can take form of anything over than the minimum required amount of equipment, materials, parts, and working time that are essential to production [7]. The types of wastes that are being reduced are, overproduction, waiting, transporting, overprocessing, unnecessary inventory, excess motion, defects as described by Fercoq et al. [8].

The aim of this paper is to highlight the implementation of lean management in supply chain, and it further reviews the successful cases of lean supply chain and importance of supply chain performance tools. The critical key performance indicators are presented as a blueprint/template for organisations to adapt. The paper looks at integrative approach of implementing lean management as there have been major advances in business management philosophies, practices, and industrial revolutions such as Industry 4.0. The implementation of these new advances is being adopted while there are existing business improvement approaches such as lean management, and there is a need for an integrated approach.

2 METHODOLOGY

For this study, a qualitative approach was adopted. This type of research enables the researcher to focus in a particular area and gather information through various means. The use of secondary research was adopted, to analyse the existing data and connect with the objectives of the new study. In this case study, data was collected through the review of existing literature.

3 LEAN MANAGEMENT IMPLEMENTATION IN THE SERVICE INDUSTRY

Lean management has been implemented dominantly in the manufacturing sector. However, there have been successful implementation of lean management in other sectors such as the higher education sector. Kazancoglu and Ozkan-Ozen [9], investigated the eight wastes in higher education institutions (HEIs). The authors utilized a decision-making method which included fuzzy decision-making trial and evaluation laboratory. The study identified that most occurring wastes in business schools were repeated tasks, unnecessary bureaucracy, errors because of communication problems, excessive number of academic units and creation of an excessive amount of information.

According to Robinson and Yorkstone [10], the University of St Andrews (UK), saved over £130 000 pounds by developing a new software for process management. As one of the outcomes manifested by implanting lean, the university also saved money by removing job adverts from external websites. The resources used to procure job-advertising services were redirected to the university's treasury. The internal staff benefited by being capacitated with new skills to manage this process.

Arlbjørn et al. (Arlbjørn, Freytag, & de Haas, 2011) investigated the lean practices in the Danish municipal sector through two questionnaire surveys and three case studies and to elaborate on whether it makes sense to apply the lean concept in a service SCM context. They found out that customers' demands in the municipal sector are driven by public political processes such as elections that shape the customer value and add more complexity when compared to the private sector.

In their exploratory study, Habib and Jungthirapanich [11], found out that there is not much literature addressing the supply chain management for the universities let alone research supply chain as a major element in the academic supply chain for the universities. They provided a new dimension to understand the contribution of supply chain management for prosperity of university processes. They further developed a conceptual model focusing on two main contributions to the end customer of the university such as the society including human resource contribution and research contribution.

Kress and Wisner [12], analysed a supply chain for a library with the view to assess and improve its efficiency. The authors employed an action research methodology to map the supply chain of the University of Nevada, Las Vegas Lied Libraries' information resources. They then developed a supply chain model, analysing it and developing linked performance measures. The major advantage of this journal article is that the model was developed and implemented successfully.

These cases confirm that lean has been implemented successfully in many sectors that are not involved in traditional manufacturing. This shows that lean has evolved from the conventional applications and can be transferred as an enterprise model that can be emulated by the non-automotive and non-Japanese environments based upon the premise that manufacturing problems and technologies were "universal problems" facing management [13].

4 LEAN SUPPLY CHAIN

Lean has been implemented in many organisations and there is a wealth of knowledge within published in journal articles. The focus of this literature review will be on lean in supply chain related activities. There is growing pressure for organisations to achieve shorter lead times, lower costs, and better quality. This is supported by the research conducted by Al-Aomar and Hussain [14], where the principles of lean management have been incorporated into the supply chain integrative approaches in the hotel industry.

Therefore, in supply chain, lean provides a systematic approach to optimize value stream from suppliers to consumers through elimination of non-value adding activities. Iyer et al. [15] suggest that firms need to focus on the determinants of superior supply chain performance to be more cost efficient and responsive to dynamic business targets.

a. Lean Supply Chain Cases

Lean supply chains are constituted by a set of organisations directly linked by upstream and downstream flows of materials and data that work in a concerted manner to reduce costs and waste through efficient focus on customer needs [16]. It is important to further look into how lean has been implemented in the supply chain environment as it will assist in grounding the research to the concept of lean supply chain. This section will provide a highlight of case studies where lean supply chain was implemented successfully.

In a study by Chen et al. [17], lean inventory management was used to realize increased inventory leanness by 60.90% through cost efficient procurement. Inventory leanness is a company's minimization of its inventory comparative to counterparts in the same sector [18]. In this case, customer service levels were also increased with ominously less inventory costs. The total operation time was reduced by 81% by using lean initiatives and radio frequency identification (RFID) technologies to improve the efficiency and effectiveness of the supply chain process. Major tools such as value stream mapping (VSM) were used in this case.

In the aerospace industry, there has been many cases where lean has been implemented effectively and benefits realized. Garre et al. [19] published a paper where the benefits of lean were tabled. The cycle time for the welding process was reduced by 25% for pressure vessel capacity of 500 L (from 48 min to 36 min) and by 26 % for 220L pressure vessel (from 54 min to 40 min.)

In a study by Rahman et al. [20], a manufacturing company through implementing the Kanban system (one of the lean tools), reduced operational costs, wastes and scrap. The company minimized losses and overproduction of stock was controlled with flexible workstations. Although this study was completed when the company was still on the infant stages of implementing lean, it demonstrated the benefits of using lean to optimize the value stream of the company.

In their paper, Afonso and Cabrita [21], proposed a conceptual framework for management of lean supply chains which focused on integrating monetary and non-monetary performance dimensions. This conceptual framework expands the current data on lean supply chains and provides indication of how lean supply chain performance assessment [21].The proposed framework was implemented in a small medium enterprise operating in the fast-moving consumer goods (FMCG) sector in order to better understand the suitability of this conceptual framework.

A study by Farsi et al. [22] validated an optimization framework for improving service supply chain performance using DMAIC cycle. They used a bespoke service provider to test the applicability of the framework. This included identifying KPIs for different supply chain elements and links. This study contributed to the current research by developing a performance optimization framework for service supply chain using DMAIC cycle. In another study, Acero et al. [23] used value stream mapping and DMAIC to reduce the order processing time.

5 BENEFITS OF IMPLEMENTING LEAN IN SUPPLY CHAIN

Lean manufacturing has been used effectively by organisations as a wholly new way of thinking the organisations roles in the value chain and improve organisational performance [24]. The lean management strategies are aimed on how to deliver cost effective good quality products quickly [25]. Successful lean management approaches include

- Toyota's TPS (Toyota Production System)
- Nestlé's NCE (Nestle Continuous Excellence)
- Heineken's World Class Manufacturing

Further research has shown that there are great benefits for supply chain when it adopts lean techniques; such as sustainability of the industries increasing unit outputs with less inputs through elimination of non-value-added activities to maintain effectiveness and profitability [26]. Gunasekaran et al. [27] also studied the e-procurement adoption in the small medium enterprises (SME's) in the South Coast area of Massachusetts. The survey employed revealed that when the SME's adopted greater use of e-procurement, there were visible benefits and positive organisational performance such as improved process efficiency, revenue increase and process effectiveness. This affirms that the e-procurement is an important component of general procurement in a supply chain hub.

Arif-Uz-Zaman and Nazmul Ahsan [28] proposed a set of metrics, based on lean management, to evaluate supply chain performance. The study used a fuzzy model to assess the performance of cost competitive supply chains [28]. This further shows that, when implemented supply chains, lean provides measurable benefits.

In their study, Wee and Wu [29] investigated how value stream mapping supports lean supply chain. The study further identified opportunities for continuous improvement for waste elimination [29]. These opportunities include

- Standardized operations
- Improved overall equipment efficiency
- Reduced inventory costs and variability.

6 SUPPLY CHAIN PERFORMANCE REVIEW TOOLS: SCOR OVERVIEW

Mazzola et al [30], suggested that the supply chain review tools such as, Supply Chain Operations Reference (SCOR) and lean management are successful methodologies that have a common objective of achieving customer satisfaction, through optimization of processes, while ensuring that the business is profitable. While each aspect of these philosophies operate on different organisational levels, their objectives are similar [30]. This suggests that they can be integrated together, through the SCOR supply chain strategic methodology [30].

Research by Anham et al [31], used a SCOR model as a medium of performance measurement metrics that control the implementation of lean supply chain management. This further supports that there is a causal relationship between lean and supply chain review tools in supporting successful implementation of lean supply chain.

The Supply Chain Operations Reference (SCOR) is naturally a tool released by the Supply Chain Council (SCC, now APICS) in 1996 to integrate business process reengineering, benchmarking, operations measurement into a an integrated framework for businesses to use [32]. The model offers a logical method for identifying, evaluating, and monitoring supply chain performance. According to Huan et al. [32], the framework contains the following aspects:

- Standard descriptions of management process
- A framework of relationships among the relationships
- Standard metrics to measure process performance (e.g., inventory turnover, productivity ratio, customer fill rates, order to cash cycle time etc.
- Management processes that produce best in class performance
- Standard alignment to software features and functionality

As described by Apics [33], SCOR identifies five core supply chain performance attributes: reliability, responsiveness, agility, costs, and asset management. SCOR model contains a modelling tool, a set of Key Performance Indicators (KPI's) and benchmarking. The model's generic scope has five distinct process elements for management activity namely:

- Plan
- Source
- Make
- Deliver
- Return

Curbelo and Delgado [34] stated that there is a need for a proper management of supply chain, and this will assist businesses to improve their competitiveness by increasing supply chain efficiency, through optimal use of resources that fulfil customer needs. They further stated that better accuracy in planning and control of flow of materials and data in the whole value chain, improves relationships among segments of the chain, reduce inventory levels and shorten delivery time. The typical traditional categories of supply chain performance measures of the company include 3 metrics such as service measurement, cost measurement,

and return-on-assets [35]. These metrics are described as short-term financial performance measures. In the 2000's Brewer & Speh [36], stated that there is a need to achieve the balance between non-financial and financial results across short-term and long-term time horizons.

Then SCOR model provides a unique framework that links business processes, management indicators, best practices and technologies in a unified structure to support communication between partners in the supply chain and improve the effectiveness of management and supply chain improvement activities [34]. The SCC has a large number of companies including Collins Aerospace, Weir, Express Point, DuPont and many others which are utilizing the SCOR model for strategic performance [37]. The table below shows examples of key performance indicators that can be integrated in the SCOR model, as a cascading to the operational level of the company. These are based on a case study looking at the procurement system of research equipment for an HEI in South Africa.

Table 1: Typical Key Performance Indicators for Procurement in an HEI

Key Performance Indicator	Frequency	Tracking Level	Person Responsible
Number of reminders sent to researchers	Quarterly	Tactical	Procurement Department Head
Number of queries solved via the chatbot	Weekly	Operational	Procurement Officers
Number of requisitions and orders with incorrect specifications	Weekly	Operational	Procurement Officers
% Accuracy for requisitions and orders	Weekly	Operational	Procurement Officers
Number of unsigned requisitions on the ERP System by Management	Every 2 days	Operational	HOD in which the requisition is raised as per delegation system
The time between capturing of the approved requisition system to when there it is converted to a purchase order.	Biweekly	Tactical	Procurement Team Head of Sections
% incomplete requisitions	Weekly	Operational	Administrative Staff for respective department
% of orders completed via digital ITSS module	Monthly	Tactical	Procurement Team Head of Sections
% of manual orders completed	Monthly	Tactical	Procurement Team Head of Sections
possible KPI's to be tracked: time take to complete the requisitions	Monthly	Tactical	DMAIC Project Team

Key Performance Indicator	Frequency	Tracking Level	Person Responsible
number of requisitions with incomplete quotations	Fortnightly	Operational	Procurement Performance Analyst
number of requisitions with incomplete documentation (excluding quotations)	Fortnightly	Operational	Procurement Performance Analyst
Number of workflows not approved within the day	Daily	Operational	Procurement Performance Analyst
Time between capturing of the approved requisition system to when there it is converted to a purchase order.	Weekly	Operational	Procurement Officers
Time taken to release purchase order to supplier after entry	Weekly	Operational and Tactical	Budget Officers, Procurement Officers, Finance Managers for respective heads
% Tagged Items on the items	Daily	Operational	Maintenance Team
% Untagged Items on the items	Daily	Operational	Maintenance Team

7 INTEGRATIVE IMPLEMENTATION OF LEAN AND INDUSTRY 4.0

There have been major advances in business management philosophies, practices and industrial revolutions. This includes Industry 4.0. The implementation of these new advances is being adopted while there are existing business improvement approaches such as lean management, and there is a need for an integrated approach. There is a need to do more research on this area of lean management and Industry 4.0 as to provide ways for organisations to implement both these initiatives without interrupting supply chain objectives and focusing on efficiencies needed.

There has been a vast attentiveness in government and private sector approach in 4IR. However, there are existing management approaches in organisations. Therefore, it is important to identify synergies in implementing both Industry 4.0 and lean management as to avoid contrasting actions.

Sony [38], proposed models where lean management and Industry 4.0 can be integrated. They are vertical integration and lean management, horizontal integration and lean management and end-to-end engineering integration and lean management.

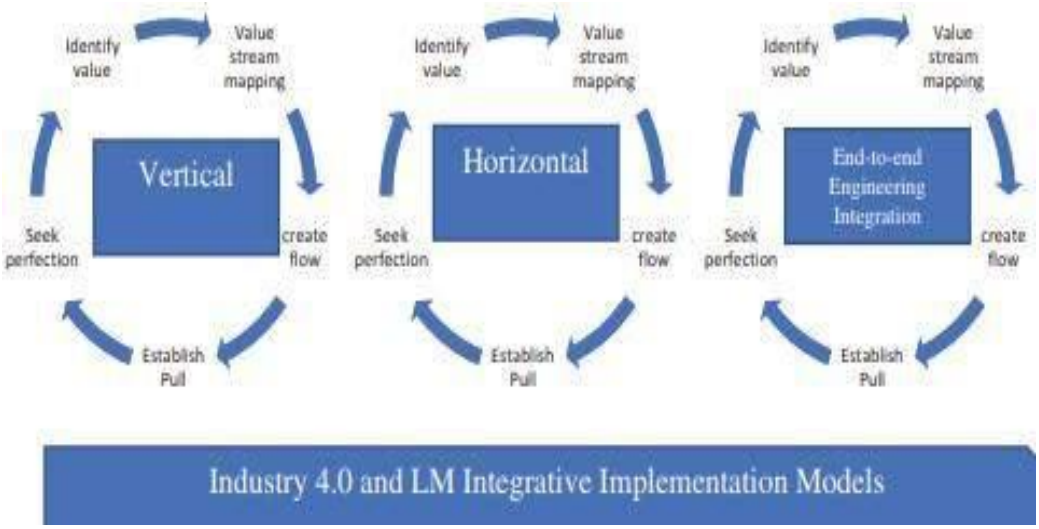

Figure 1: Lean Management and Industry 4.0 Integration

Source: [38]

Sony [38] proposes a model of integrations for lean and Industry 4.0 and propositions for implementation to test its robustness. The 15 propositions provide a solid base for implementation and recommendation on how these integrations can assist the business with a blueprint for implementing both lean and industry 4.0 simultaneously. They are further presented in Table 2 below.

Table 2: Integration models of Industry 4.0 and Lean with propositions **Source:** [38]

No	Proposition by M Sony 2018	Integration
1	While designing the vertical integration architecture through Industry 4.0 for implementing Industry 4.0, defining the value in terms of customer needs for products and services will form the underlying principle for vertical integration [38].	Vertical Integration and Lean
2	Value stream mapping of products and services before designing architecture for vertical integration thorough Industry 4.0 of hierarchical subsystems within an organisation will help in removing waste in the integration of Cyber Physical Systems (CPS) which will represent all machines, products, and resources within the organisation [38].	
3	The vertical integration of various hierarchical subsystems within the organisation will create a smooth flow process leading to cross-functional cooperation between departments by integration of CPS within each department in a strategic manner using a self-regulated system [38]	
4	The vertical integration though Industry 4.0 of hierarchical subsystems within the organisation will drastically reduce the time taken to bring the product into the market enabling a customer created pull system [38].	
5	The vertical integration of hierarchical subsystems should create a continuous improvement culture within the overall integrating	

No	Proposition by M Sony 2018	Integration
	subsystems within the organisation to improve value to the customer [38].	
6	Horizontal integration of various organisations is designed based on the common and mutually agreed perception of the customer value among the integrating organisations, which the commonly agreed integration strategy is supposed to accomplish [38].	
7	The horizontal integration mechanism can be designed by incorporating Value Stream Mapping (VSM), to map the value to the customer by identification of waste (Muda) in the horizontal integration mechanism [38].	Horizontal Integration and Lean
8	The horizontal integration mechanism using industry 4.0 will improve the flow across the cooperating organisation to deliver value to the customer by incorporating smart coordination and regulation systems[38].	
9	The horizontal integration mechanisms using Industry 4.0 will enable the delivery of customized products and services in a shortest possible time based on customer created a pull system resulting in new industry level benchmarks[38].	
10	Continuous improvement culture should be the benchmark across all the horizontally integrated organisations to create a perfect system to deliver optimum customer value by using minimum resources [38].	
11	End -to-end engineering integration requires identifying the value of the product in terms of customer requirements which are further translated into the CPS requirements[38].	End-to-end engineering integration
12	For end-to-end engineering integration the value stream of CPS system requirements using the product-service-system will help to identify the non-value added activities [38].	
13	For end-to-end engineering integration the data from the smart products can be used to design the smooth flow using the CPS [38].	
14	The data from the smart products can be used to create a pull system design using end-to-end engineering integration in a shortest possible time within and external to the organisation[38].	
15	The self-regulating mechanism through smart data from the products in end-to-end engineering will create a culture of continuous improvement[38].	

The integration model of lean and Industry 4.0 proposed by Sony [38] is built on Wang et al. [39] model, and includes integration points of lean management with all the three integration of industry 4.0 which are vertical, horizontal integration as well as end-to-end engineering integration models. Sony's theoretical model is more structured and robust. The application of this model industry may be modified for practical implementation since organisations have

already implemented lean management, they may adopt the digitalization solutions that come with Industry 4.0. The propositions provide in Table 2 can be used to implement lean and Industry 4.0 applications in an integrated manner.

8 DISCUSSION

Lean management has evolved from being manufacturing based and has been implemented successfully in many sectors that are not involved in traditional manufacturing. This positions lean management as a transferrable enterprise model that has been largely emulated by many organisations in service. These include higher education institutions that have realised major monetary savings and supply chain process efficiency. The case studies presented in this review, show that lean management has had a major positive impact in large multinational companies' supply chains.

Although lean and SCOR are different management philosophies, they have one common goal of profitability and customer service prioritization. With each aspect of these philosophies operating on different organisational levels, their objectives are similar [30]. Therefore, it is important that an organisation focuses on integrative implementation of these philosophies for amplified supply chain efficiency.

An important dimension is that there has also been in industrial revolutions and advancement of Industry 4.0. The implementation of these new advances is being adopted while there lean and supply chain review tools are integral business improvement philosophies, and this raises a need for an integrated approach. Sony [38] proposes a model of integrations for lean and Industry 4.0. This integration model with its propositions for implementation provide a solid base for implementation both lean and industry 4.0 simultaneously. When implemented in a supply chain environment as an integrated business management philosophy, there are good prospects for improving the supply chain efficiency, and this can be measured through key performance indicators in the SCOR model.

9 CONCLUSION

In this paper, we look at the evolution of lean management from being a philosophy linked to manufacturing, to being transferable to almost any type of industry, whether service or manufacturing. The cases reviewed confirm that lean has been implemented successfully in various sectors that are not involved in traditional manufacturing. This shows that lean has evolved from the conventional applications and can be transferred as an enterprise model in all sectors.

The paper further looks at successful implementation of lean management supply chain environments and quantifiable results in supply chain efficiency improvement. The importance of an integrative approach of lean management and supply chain review tools such as SCOR is highlighted as there is a causal relationship between both constructs in improving supply chain efficiency. While implementing lean management and SCOR in an integrative approach, there is a compelling need to further integrate Industry 4.0 initiatives, as the world is moving towards digitalization. The integration models by Sony [38] form a critical foundation that an organisation can implement lean and industry 4.0 initiatives. Future work for this paper includes a practical utilisation of this model of integration.

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