An examination of multiple mapping techniques for supply chain optimisation: a case of the footwear industry

Marrium Noor, Asher Ramish* and Abdul Waheed

Dr Hasan Murad School of Management,
University of Management and Technology, Lahore,
C-II Johar Town, Lahore, 54782, Pakistan
Email: marriamnoor@gmail.com
Email: asher@umt.edu.pk
Email: abdulwaheed168@yahoo.com
*Corresponding author

Abstract: Lead time reduction is one of the targeted aims of any organisation as it is linked with process efficiencies and greater profitability. One of the most used tools in this aspect is lean manufacturing (LM). In order to be lean, organisations must analyse their processes to find out the waste and ways to reduce that waste. In this paper, we are using different mapping techniques to analyse the footwear supply chain processes, process breakdown structure (PBS), order fulfilment map, and pipeline mapping. The aim is to analyse the processes that have a small production capacity, and in order to fulfil the demand of the customers, it has outsourced its production and has opted for supplier-based production. Another goal is to differentiate the processes of in-house and supplier-based production on the basis of lead time for both cases. We highlight the value added (VA) activities, non-value added (NVA) activities, and other wastes in the supply chain (SC) processes. After analysing the process flaws, LM tools are used to improve the process. In order to improve the SC processes, the most important concept is the integration of SC processes. Integrated processes focus on strong linkages and communication with each other.

Keywords: footwear supply chain; mapping techniques; lean manufacturing; supply chain integration; case study; Pakistan; pipeline mapping; order fulfilment mapping; performance.

Reference to this paper should be made as follows: Noor, M., Ramish, A. and Waheed, A. (2024) 'An examination of multiple mapping techniques for supply chain optimisation: a case of the footwear industry', *Int. J. Information Systems and Change Management*, Vol. 14, No. 2, pp.146–175.

Biographical notes: Marrium Noor has completed Master in Business Administration (MBA) with distinction from University of Management and Technology, Lahore, Pakistan. She has an experience of more than a year. Her research interests include lead time reduction, mapping techniques, logistics management and supply chain management.

Asher Ramish is currently serving as an assistant professor in the department of Operations and Supply Chain. He has >22 years of experience both in academia and industry. His research interests are also extended towards the fields of services supply chain management, logistics, supplier relationship management, strategies in supply chain management, supply chain performance measurement, production and operations management and project management. He has been an AD-HOC member of reviewer board of 9 ISI impact factor journals and one ISI impact factor Taylor & Francis journal.

Abdul Waheed is a 'HEC Approved PhD Supervisor' and has years of teaching and research experience. He earned PostDoc (marketing) from Shenzhen University China and PhD (marketing) with distinction from AACSB and AMB accredited business school, USTB-China. He received 20+ research awards and has 100+ publications in the prestigious international journals, conferences, and books, indexed/ranked include FT-50, JCR-SSCI (Q1), SJR (Q1), and HEC (W, X, Y). The teaching and research interests include digital/ electronic marketing, brand management, consumer behaviour, and digital CSR.

1 Introduction

The whole process of supply chain focuses on 'integration of the process' (Yassien, 2020), that can be within the firm or with suppliers and end customer. Integration has been defined as the process of association between the working partners within their distinct arenas (Christopher and Towill, 2000). The communication and alliance between different players of SC plays the primary role (Papetti et al., 2019). Latest concepts like Industry 4.0 also require enhanced level communications between the stakeholders of supply chain (Carlsson et al., 2021). The immediate response and support of suppliers have a significant influence on the consumer's initial interpersonal trust in suppliers, indicating the importance of the communication between stakeholders (Liu et al., 2019). Better integration in processes helps the companies to get the competitive advantage and to reduce the wastes in the process that leads the organisations to move toward.

In this competitive environment, manufacturing companies have improved their ability to deliver the quality product at competitive price (Onesime et al., 2004). As the footwear sector is linked with the fashion industry that has shorter product life cycles and the differentiation is based on the product style and price (Macchion et al., 2018). Therefore, in order to cope with such volatile environment supply chains, must develop responsiveness. Dynamic capabilities is another important dimension, the supply chains need to adopt while looking for process optimisation (Yassien, 2020). Lean manufacturing plays pivotal role in achieving this target by focusing on lead time and waste reduction. Lean supply chain management practices have been investigated in many studies. Its application in one of the Pakistani FMCG industries was measured (Gilal et al., 2016). Different mapping techniques help to analyse the processes of the footwear organisation like business process re-engineering, pipeline mapping, and order fulfilment mapping. The main goal of these techniques is to identify the problem areas

that need to be studied in-depth with respect to time. This will ultimately help in lead time reduction and increase the efficiency and productivity of the chain.

This paper aims to analyse the processes of a footwear chain, that has small production capacity; and in order to fulfil the demand of the customers, it has outsourced its production and has opted supplier-based production. Another goal is to differentiate the processes of in-house and supplier-based production on the basis of lead time for both cases. This analysis is done based on these mapping techniques like business process re-engineering technique (BPR) which is process breakdown structure (PBS), pipeline mapping, and order fulfilment mapping.

The rest of the paper is ordered as follows. Based on the literature review the paper emphasises about the detailed analysis of advantages of lead time reduction, methods to carryout lead time analysis and identification of strategies for lead time reduction. Then the lead time of the company is presented with both cases and a hypothesised scenario is proposed that includes the improvements in the processes identified in the problem areas. Improvements in the processes are discussed in detailed along with the suggestions for each area. Final remarks and prospects are presented in the end.

2 Lean manufacturing and lead time reduction

Lean manufacturing is one of the leading techniques used by the companies in order to be competitive in the global market(Al-Araidah et al., 2010). The main aim of this approach is to go lean which mean eradicate the non-value-added (NVA) activities by pinpointing and eliminating the waste from each step of the supply chain process (Alsadi et al., 2023; Hines et al., 2023; Somboon and Tippayawong, 2018). The waste can be in any form like movement, resources, and energy (Nave, 2002). Lean manufacturing is the basically a Japanese business strategy that talk about identification and elimination of waste for the increased productivity and improved product quality (Somboon and Tippayawong, 2018). Different lean manufacturing tools can be used for the process of identification and elimination of the wastes like PBS, order fulfilment mapping and pipeline mapping. PBS talks about categorisation of the supply chain process by breaking the SC processes into processes, sub processes and activities (Hammer and Champy, 2009). Order fulfilment mapping provides the detailed process timeline in which each process time is depicted, and this will enhance the efficiency the process (Elazary et al., 2015). Value stream mapping is another technique used to identify value in the resource and identifies the non value added work in the process (Ghosh and Lever, 2020; Nadeem et al., 2023); also suitable to undertake planning based production process reengineering (Lu et al., 2021). VSM are also able to identify the core value streams (Komkowski et al., 2023). Pipeline mapping helps to identify the delays in the process, for this the whole supply chain process is mapped that include both VA and NVA with lead time (Gosling et al., 2013). All these mapping tools help to understand the SC processes and help to improve the performance of the complete supply chain of the organisation. Another concept of collaborative performance evaluation has been suggested while managing various stakeholders especially supplier (Zhu et al., 2016).

The first step is to quantify the lead time of the complete supply chain of the organisation from supplier to customer. In Pakistan the trend towards the in-house

production is low and companies prefer to outsource their production from suppliers that are producing a great share of shoe manufacturing. By analysing the in-house production lead time and vender production lead time a comparative analysis is made in terms of lead time reduction. Due to the competitive conditions the supply chains must improve their processes, supplier's development initiatives and logistics performances. All these call for the study of the complete supply chain process in terms of lead time analysis along with the value-added and NVA activities; and to identify the problem areas and suggest the improvements by using supply chain technologies (Thangarajoo and Smith, 2015). These technologies help the business processes to increase the efficiency and cost benefit. After real time process analysis and suggested improvements by these techniques they can analyse the faster response and actual lead time reduction that reduce the cost which is tangible benefit by removing the bottleneck and delays in processes (Melton, 2004).

In order to reduce the lead time, first thing is to identify the 'waste' that add cost to the process by increasing the process time in terms of NVA activities (Melton, 2005). The company should have to make efforts to eliminate the process wastes. The common wastes include inventory, delays or waiting time, errors or damages and transportation or logistics delays (Yusup et al., 2015). In order to analyse the processes of the company a technique known as business process re-engineering (BPR) (Forza and Vinelli, 1996) is used which comprises of; documenting all the processes involved in supply chain, quantifying time in each process, identifying the valued activities that add value to the customer, pinpointing the costs incurred due to NVA activities and identifying the relationship between lead time and customer satisfaction.

3 Theory of constraints

The theory of constraints (TOC) revolves around pointing out the constraint or the issue and then getting rid of that issue by systematically improving or eliminating the issue, until it is no longer the limiting factor. It is usually referred as bottleneck or the weakest link in the manufacturing industry. There are three goals of the TOC.

- *The five focusing steps*: a methodology for identifying and eliminating constraints.
- *The thinking processes*: tools for analysing and resolving problems.
- *Throughput accounting*: a method for measuring performance and guiding management decisions.

Dr. Eliyahu Goldratt conceived the TOC, and introduced it to a wide audience through his bestselling 1984 novel, "The Goal". Since then, TOC has continued to evolve and develop, and today it is a significant factor within the world of management best practices (Goldratt, 1990).

4 Lead time analysis

In this paper different mapping techniques will be used to analyse the lead time of the company. The measurement for evaluation of the processes is the basic step towards the

process improvement (Kassaneh and Workalemahu, 2018). The three major techniques used are PBS, order fulfilment mapping and pipeline mapping.

4.1 Process breakdown structure (PBS)

The PBS is described as breaking the process into different steps that can be categorised into the following steps (Hammer and Champy, 2009).

i to develop the comprehensive description of the processes of the company

ii in next step the time duration for each process is calculated

iii time analysis is made based on value added and NVA time

iv explore the different mapping techniques in order to reduce the lead time and to minimise the NVA time.

These steps develop the 'AS/IS' processes that comprises of three major categories; main processes identification with time analysis, sub processes identification with time analysis and activities identification with time analysis. Along with this value added and NVA activities in all these processes are marked (Melton, 2005). Value Added (VA) are the activities that contribute directly in the process in a way for which customer is willing to pay for them (Dadashnejad and Valmohammadi, 2019). VA activities can be packing, sampling, or production. Non-value-added (NVA) are the activities that don't contribute in the process and for which the customer is not willing to pay (Dadashnejad and Valmohammadi, 2019). NVA activities can be rework, delays, or movements. PBS will help to reduce the lead time by deducting the NVA activities in the processes. Necessary NVA are then activities that don't involve in the direct production process, but these are basically the unavoidable limitation of the process. Like logistics time which is required to transport the finished product to each shop. In Tables 1 and 2, the PBS for in-house production and supplier production of the footwear supply chain of Pakistan can be observed. Both the tables are showing all the processes, sub processes and activities with lead time, VA and NVA.

Table 1 PBS for in-house production

Process Breakdown Structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
1	Sampling					(7)		
		1.1	Sketching of new design			(1)	X	
				1.1.1	Defining new Model and Shape	(1)	X	
		1.2	Material selection			(1)	X	

Table 1 PBS for in-house production (continued)

Process Breakdown Structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
				1.2.1	Sole, Heel and accessories along with type of material selection whether leather or raxine	(1)	X	
		1.3	Sample development			(1)	X	
				1.3.1	New design proposal by Designers	(1)	X	
		1.4	Pattern cutting for sample			(1)	X	
				1.4.1	Prototype development	(1)	X	
		1.5	Approval by sourcing dept			(1)	X	
				1.51	Sample check for design and material	(1)	X	
		1.6	Approval from Director			(2)	X	
				1.61	Sample check by focus group	(1)	X	
				1.62	Sample check by BOD's	(1)	X	
2	Make vs. buy					(16)	X	
		2.1	Cost Evaluation			(8)	X	
		2.2	Quality Evaluation			(2)	X	
		2.3	Manufacturing time Evaluation			(4)	X	
		2.4	Meeting			(2)		X
3	Planning and forecasting					(13)		
		3.1	Shop wise inventory check			(4)	X	
				3.1.1	Existing stock check	(1)	X	
				3.1.2	Shop demand	(1)	X	
				3.1.3	Data analysis	(2)	X	

Table 1 PBS for in-house production (continued)

Process Breakdown Structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
		3.2	Inventory analysis gap			(5)	X	
				3.2.1	Analysing difference between demand and inventory	(4)	X	
				3.2.2	Quantify the gap	(1)	X	
		3.3	Inventory fulfilment			(2)	X	
				3.3.1	Adjustment of existing inventories within the shops	(1)	X	
				3.3.2	New order plan	(1)	X	
		3.4	Paper selection			(2)		X
				3.4.1	Difference in variants	(1)		X
				3.4.2	Difference in colours and Design	(1)		X
4	In-house Production					(11)		
		4.1	Sample received			(2)	X	
				4.1.1	Received by production dept.	(1)	X	
				4.1.2	Sample analyses	(1)	X	
		4.2	Raw material purchase			(7)	X	
				4.2.1	Suppliers analysis	(4)	X	
				4.2.2	Amount of material required	(1)	X	
				4.2.3	Cost of material BOP	(2)	X	
		4.3	Packaging			(1)	X	
		4.4	Order transfer			(1)		X

Table 1 PBS for in-house production (continued)

Process Breakdown Structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
5	Ware house receiving					(5)		
		5.1	Receiving in warehouse			(1)	X	
		5.2	Quality check			(1)	X	
		5.3	Product arrangement and bar code			(1)	X	
		5.4	Inventory stock			(3)		X
6	Distribution					(6)		
		6.1	Distribution plan			(2)	X	
		6.2	Shops distribution			(3)	X	
				6.2.1	Ensure the adherence to the plan	(2)	X	
				6.2.2	Distribution coordination with logistics	(1)	X	
			Delay			(1)		X
7	Logistics					(10)		
		7.1	Region transportation plan			(2)	X	
		7.2	Transportation			(6)	X	
		7.3	Product transfer			(2)		X
8	Receive at shop					(2)		
		8.1	Receive at shop and sorting			(1)	X	
		8.2	Delay			(1)		X
9	Showcase display					(8)		
		9.1	Display			(1)	X	
		9.2	Delay			(7)		X

Table 2 PBS for supplier-based production

Process breakdown structure (*Supplier based production*)								
PBS no	*Process*	*PBS no*	*Sub-Process*	*PBS no*	*Activity*	*Time* (Days)	*VA*	*NVA*
1	Sampling					(7)		
		1.1	Sketching of new design			(1)	X	
				1.1.1	Defining new Model and Shape	(1)	X	
		1.2	Material selection			(1)	X	
				1.2.1	Sole, Heel and accessories along with type of material selection whether leather or raxine	(1)	X	
		1.3	Sample development			(1)	X	
				1.3.1	New design proposal by Designers	(1)	X	
		1.4	Pattern cutting for sample			(1)	X	
				1.4.1	Prototype development	(1)	X	
		1.5	Approval by sourcing dept			(1)	X	
				1.51	Sample check for design and material	(1)	X	
		1.6	Approval from Director			(2)	X	
				1.61	Sample check by focus group	(1)	X	
				1.62	Sample check by BOD's	(1)	X	
2	Make vs. buy					(16)	X	
		2.1	Cost Evaluation			(8)	X	
		2.2	Quality Evaluation			(2)	X	
		2.3	Manufacturing time Evaluation			(2)	X	
		2.4	Meeting			(2)		X
3	Planning and forecasting					(13)		

Table 2 PBS for supplier-based production (continued)

Process breakdown structure (*Supplier based production*)								
PBS no	*Process*	*PBS no*	*Sub-Process*	*PBS no*	*Activity*	*Time* (Days)	*VA*	*NVA*
		3.1	Shop wise inventory check			(4)	X	
				3.1.1	Existing stock check	(1)	X	
				3.1.2	Shop demand	(1)	X	
				3.1.3	Data analysis	(2)	X	
		3.2	Inventory analysis gap			(5)	X	
				3.2.1	Analysing difference between demand and inventory	(4)	X	
				3.2.2	Quantify the gap	(1)	X	
		3.3	Inventory fulfilment			(2)	X	
				3.3.1	Adjustment of existing inventories within the shops	(1)	X	
				3.3.2	New order plan	(1)	X	
		3.4	Paper selection			(2)		X
				3.4.1	Difference in variants	(1)		X
				3.4.2	Difference in colours and Design	(1)		X
4	Supplier Planning					(5)		
			Material planning			(1)	X	
			Labour planning			(1)	X	
			Raw material purchase			(1)	X	
			Meeting			(2)		X
5	Supplier Production					(21)		
		5.1	Material receives			(3)	X	
			Arrangement			(2)		
				5.1.1	Raw material arrangements	(1)	X	
				5.1.2	Labour engagement	(1)	X	

Table 2 PBS for supplier-based production (continued)

Process breakdown structure (Supplier based production)								
PBS no	*Process*	*PBS no*	*Sub-Process*	*PBS no*	*Activity*	*Time* (Days)	*VA*	*NVA*
		5.2	Production			(14)	X	
		5.3	Packaging			(1)	X	
		5.4	Order transfer			(1)		X
6	Ware house receiving					(6)		
		6.1	Receiving in warehouse			(1)	X	
		6.2	Quality check			(1)	X	
		6.3	Product arrangement and bar code			(1)	X	
		6.4	Inventory stock			(3)		X
7	Distribution					(6)		
		7.1	Distribution plan			(2)	X	
		7.2	Shops distribution			(3)	X	
				7.2.1	Ensure the adherence to the plan	(2)	X	
				7.2.2	Distribution coordination with logistics	(1)	X	
		7.3	Delay			(1)		X
8	Logistics					(10)		
		8.1	Region transportation plan			(2)	X	
		8.2	Transportation			(6)	X	
		8.3	Product transfer			(2)		X
9	Receive at shop					(2)		
		9.1	Receive at shop and sorting			(1)	X	
		9.2	Delay			(1)		X
10	Showcase display					(8)		
		10.1	Display			(1)	X	
		10.2	Delay			(7)		X

4.2 Order fulfilment map

The order fulfilment process involves SC process from suppliers to the end customers (Närhi, 2021). It provides the detailed process timeline in which each process time is depicted. This will help to analyse the efficiency of each process. Along with this bottle necks and delays can also be identified. It starts with the order placement to the suppliers and ends with the delivered to customer (Elazary et al., 2015). The aim of this process is to reduce customer dissatisfaction by identify the process wastes like delays and waiting time (Wildman and Barry, 2008). Order fulfilment mapping helps in addressing all these issue by plotting the whole process and ultimately giving the graphical view of the process, due to which process flaws can easily be identified (Närhi, 2021). Order fulfilment map of the company under analysis can be seen in Figures 1 and 2 for in-house production and supplier-based production. Both the figures are showing the graphic view of all the SC processes of the company with their lead time.

Figure 1 Order fulfilment map (In-house production) (see online version for colours)

Figure 2 Order fulfilment map (Supplier-based production) (see online version for colours)

4.3 Pipeline mapping

Pipeline can be defined as the delays in the supply chain from suppliers to end customers (Mason-Jones et al., 1997). In order to analyse the delays in the process the whole supply chain process is mapped that include both VA and NVA with lead time. Good supply chain performances required well-designed supply chain from suppliers to end customers (Gosling et al., 2013; Scott and Westbrook, 1991). Pipeline mapping is basically the visual mapping technique that is used to depict the work processes in a flow (Scott and Westbrook, 1991). The map shows the lead time along with VA and NVA activities of the company.

After analysing the complete pipeline map, the company is able the analyse the delays in the process and performance of the SC process can be access (Gosling et al., 2013). It helps in considerate and refining the existing processes. Its main aim is to explore, define and reduce the process wastes. It helps to develop the 'current state' map of the company with the existing processes; information and time spend in each process. After implementing the suggested improvements, it also helps to develop the 'future state' map of the processes. The main idea behind this technique is to analyse the process wastes that can be in the form of NVA activities and eliminate them to reduce the lead time. The pipeline mapping of the company under analysis can be observed in Figures 3 and 4, in which all the SC processes are visually presented with value added time (VAT) and non-value-added time (NVAT). The whole process from supplier to the end customer is depicted in the figures that help to find out the flaws and bottle neck processes that need to be addressed (Behl, 2021).

It also identifies the inventory present all across the supply chain carried by multiple stakeholders. These inventories are shown as bars (Fawcett et al., 2007).

Figure 3 Pipeline mapping (In-house production) (see online version for colours)

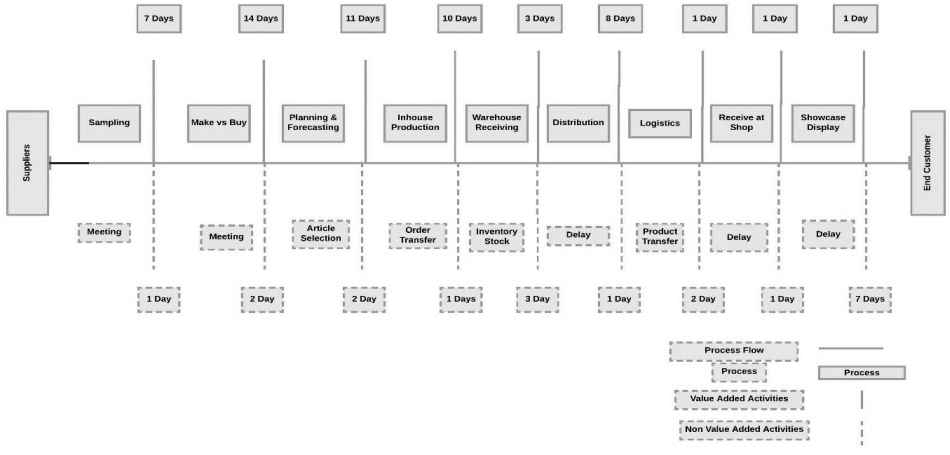
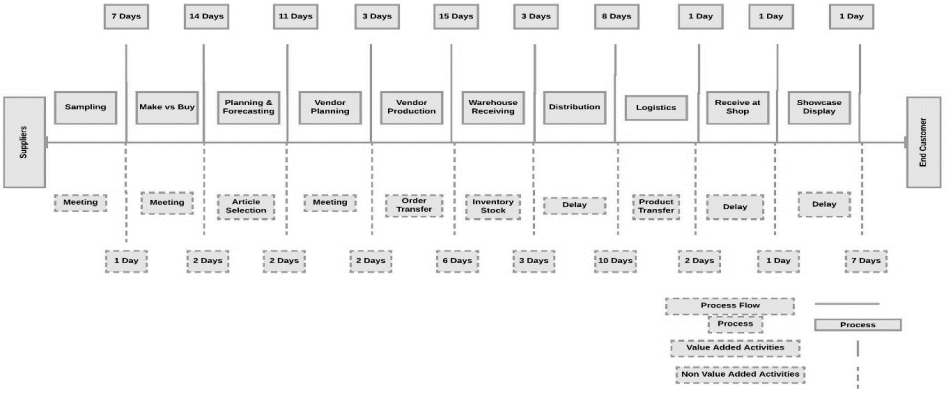


Figure 4 Pipeline mapping (Supplier-based production) (see online version for colours)



These tables and figures are developed based on data collected for the company through site visit and direct interview from managers of all the departments, such as sales marketing, operation, supply chain, logistics and shop manager of the company. According to Rahi (2017), convenience sampling describes the data collection process from a research population that is effortlessly reachable to the researcher. MacNealy (1999) defined a convenience sample as a sampling technique that requires the researcher to go to the public. In order to collect the desired data, interviews are designed in such a way that will help to exhaustively depict the complete supply chain process of the company. Firstly, all the processes that were involved in planning, manufacturing, marketing, distribution and logistics are discussed in detail. After analysing the process details lead timing regarding all the processes and activities were investigated.

From the information mentioned in tables and figures, our aim is to eliminate the NVA activities and necessary NVA activities that are due to the layout issue or due to system design to reduce the overall lead time of the company. By analysing the 'current' scenario for both in-house and supplier-based production, the total lead time and VA and NVA time is analysed as lead time for in-house production is 78 days in which the total VA time is 61 days and total NVA time is 19 days and total lead time for supplier-based production is 93 days in which the total VA time is 74 days and total NVA time is 19 days. From the above tables and figures, the flaws in the process or the areas for improvements can be analysed. The main purpose of the paper is to identify the wastes or NVA activities that costs to the company. After analysing the complete PBS, order fulfilment map and pipeline mapping of both scenarios following problem areas are identified.

5 Problem areas

From the above analysis the problems that the supply chain of the footwear industry is facing can be identified. These problems help the supply chain processes to pinpoint the issues and improve the performance after addressing these issues.

5.1 Lack of production facility

From the analysis it can be clearly observed that the organisation is lacking production facility due to which they must outsource their production. From the Tables 1 and 2 it can be observed in process 4 for inhouse production, and processes 4 and 5 for supplier-based production, in which the time for inhouse and supplier-based production time is 11 days and 26 days. So, the lead time for inhouse production is less as compared to supplier-based production, in this area company have the opportunities which it must have to achieve in order to be successful. We also noticed that the company is operating in an industry that is expanding and the growth is a potential advantage. Depending on the industry dynamics we believe that the company should reap from this advantage of growing industry and should go for expansion (Barua et al., 2020).

5.2 Logistics issues

From the analysis it can be observed in Tables 1 and 2, processes 7 for in-house and process 8 for supplier-based production takes about 10 days in logistics department, that need to be cut down. Transportation creates lots of problem in term of delivery of stock. Lots of transport errors occur by the logistics companies that need to be addressed in order to reduce the lead time. Damage rate is also very high due to incompetent logistics partners that add cost in terms of re-work. Supply chain disruption was reduced in one of the Indonesian retail chain (Timotius et al., 2022).

5.3 Issues with distribution process

The major issue company is facing in distribution process is that they have no proper systems regarding distribution process that causes the chaos, which in turn causes increase in lead time as shown in Figures 5–8. The company lacks proper SOPs, that no written standard operating procedures (SOPs) and key performance indicators (KPIs). Poor performance in warehouse to dispatch the stock and longer delivery time causes longer time to take decision of inter transfer of shops. Distribution issues are important to tackle in not only the product based companies but service based too (Paragliola and Ribino, 2024).

Figure 5 Improved order fulfilment map (In-house production) (see online version for colours)

Figure 6 Improved order fulfilment map (Supplier based production) (see online version for colours)

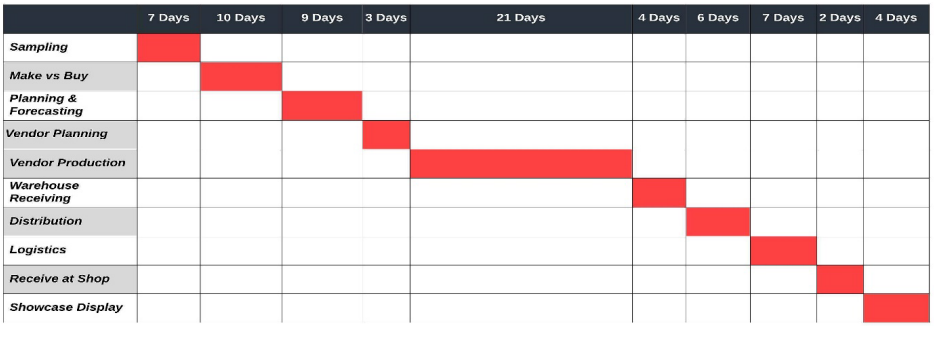


Figure 7 Improved pipeline mapping (In-house production) (see online version for colours)

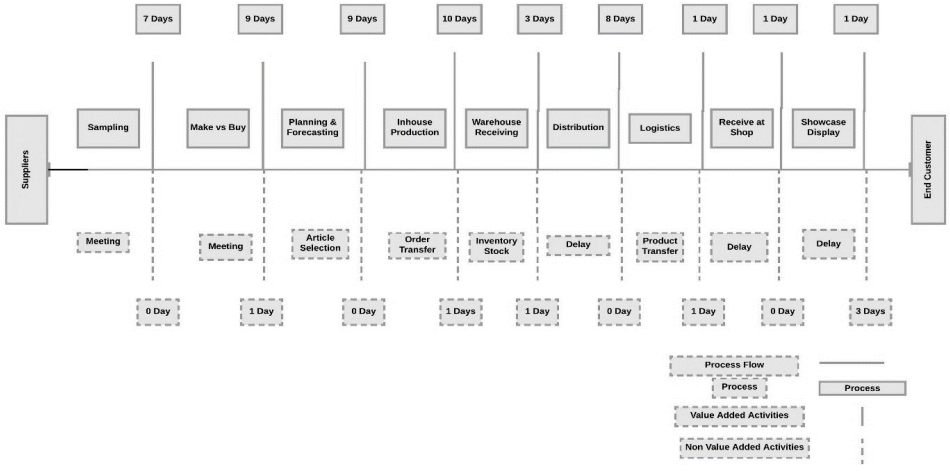
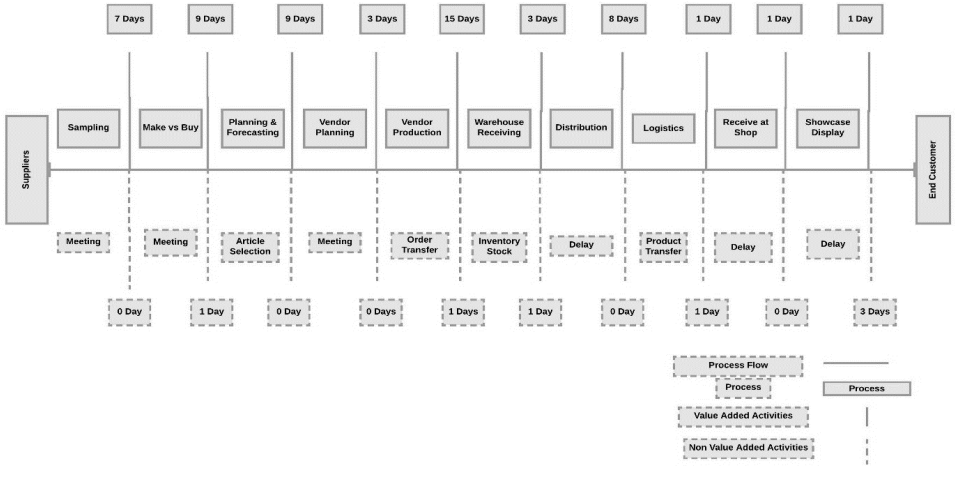


Figure 8 Improved pipeline mapping (Supplier based production) (see online version for colours)



5.4 Problems in warehouse design

From the PBS analysis, it can be observed that the company is incurring problems in warehousing the product that is designed in a way that creates the delay and wastage of time and labour. The warehouse was not according to the supportive frame work that causes delays and unfavourable working environment. The issue with the warehouse is that the inbound and outbound setup is through one entrance that causes obstacles in loading and off-loading. The receiving and dispatch is done through this one way that leads to chaotic condition which in turn causes longer waiting time. One of the study focuses on the problems of warehouse design, specifically related to order picking (Silva et al., 2020).

5.5 Barcodes assigning issue

Assigning barcodes problem is another problem that the company is facing (Rajora, 2022). In this case the company categorises the inventory after receiving from the suppliers; they keep the inventory at in lines to place the bar codes and differentiating the sizes and colours of each item. This process results in wastage of time, work force, delaying the processes. It increases the work load as the flow of inventory keeps on coming to the central warehouse.

6 Results and discussion

In order to develop the improvement plan for the company, the LM is applied. As LM focuses on eliminating wastes in all areas that creates delays in processes as communication, meeting, delays and transfers (Dadashnejad and Valmohammadi, 2019; Núñez-Merino et al., 2024). Different mapping techniques are used in order to improve the processes to increase the efficiency and decreased lead time in case of lean management (Oliveira-Dias et al., 2022).

After analysing the current state of the company through PBS, order fulfilment and pipeline mapping, a new PBS, order fulfilment and pipeline mapping is developed with reduced lead time. This new system is developed based on benefiting the company by new integrated SC which will reduce the inventory through ERP system that will increase the coordination between different departments and reduce the lead time (Tapping and Shuker, 2018). This will help the company by suggesting the supplier development program that will enhance their productivity and better-quality product. The more developed suppliers will work in collaboration of the company and reduce the supplier redundancy, reduce cost of re-work, improve response time (Caccialanza et al., 2023; Peterson, 2002).

One of the research identified Non Profit Organisations' capabilities for monitoring and controlling reverse supply chains for textile reusage (Zhuravleva, 2024). The overall process became quality oriented after the application of these mapping techniques. Other than this logistics partners development programs will also help in improvements in lead time and cost reduction. All these factors help in reduced costs, high responsiveness, and increased profitability of the whole SC (Dennehy et al., 2021). In one of the case study, the same mapping techniques were applied to get reduction in costs and high responsiveness (Tahir and Ramish, 2022). This new process not only reduces the NVAT but also worked on necessary non value added time. In this way they will be able to cope with the problems that the company is facing with the solution and improved PBS, order fulfilment and pipeline mapping.

6.1 Production facility expansion

The company should focus on the production facility expansion in this way they are able to create differentiation as they are producing their shoes by themselves this will reduce the chance of imitation by the competitors and this will also insure the quality of the shoes as machine made shows are more lasting and durable. Along with this, it will help in reducing the lead time as supplier-based production time is more than in-house production. It will also resolve the handling issues like the transportation costs re-work,

damage claims by customers which the company is facing by having their production from different suppliers that are producing products for many companies.

6.2 Logistics problem

Logistics problems which the company is incurring can be solved by addressing the agility issue. Agility problem can be solved by doing contracts with more than one company or they can go for their own transportation arrangements this will reduce their cost and increase the efficiency and improve the quality of services. For this issue, company have two options, firstly, they can hire more transportation companies that will be cost effective option, but the uncertainty factor can be reduced but not minimised; secondly, they can go for their own transportation arrangements, this will incur one-time expense that can be covered in long run as the daily transportation cost will be reduced by owning their transportation.

6.3 Distribution problems

Company is facing many issues regarding the distribution of the goods. In order to solve the distribution problems which, the company is incurring, we must take following steps.

i Proper SOPs should be defined for the working of distributors so that distribution process can be improved, and everyone should be able to perform their processes according to these standards.

ii KPIs should also be defined in order to evaluate the performance of the distributors and it will help in rewarding the distributors in order to improve the lead time and delivery time. So, SOP's and KPI's will also help in improving the lead time and delivery time as if the distributors are evaluated then they will improve their services.

iii Long time is to take decision of inter transfer of shops can be removed by using the ERP by all the channels and through which point of sales data can be used properly and this will reduce the decision time about the material transfer (Maroofi, 2012).

6.4 Warehouse layout

Company can resolve the issue of warehouse by taking following steps. They should look for at least two docking points (Apte and Viswanathan, 2000). One should be for receiving the goods from the suppliers and other for dispatching and distributing the products from the central warehouse. We believe that it will help them manage its inventory more effectively (Alpan et al., 2011). It will also reduce the time consumption in the warehouse and lessen the costs that arise due to old warehouse layout. This layout will help them to run its supply chain systems in a better way. The operations at the warehouse should have to be redesigned in a way that it will increase the efficiencies at the warehouse. Increase in efficiencies will reduce the cost, time and labour on the first place (Apte and Viswanathan, 2000).

6.5 Assigning barcodes

Assigning barcodes problem can be solved by following steps. This is a process that can be carried out at the supplier's place if there is even a single person that can be trained over there. So, this can be done with the help of supplier development program (Koberg and Longoni, 2019). They are also interested in doing so as this will reduce many issues related to inventory handling. Also, it will increase the collaborations among the company and the suppliers.

6.6 Supplier and logistics partners development programs

Supplier and logistics partners development programs helps the company in terms of product differentiation and cost reduction (Koberg and Longoni, 2019). This will also make the SC more efficient (Peterson, 2002). Both the parties work with the company in a collaborative environment and this will help to reduce the product imitation and costs that occurs due to the inefficacies of both supplier and transporter (Gosling et al., 2013).

By implementing all the possible solutions, the company will be able to reduce the lead time by eliminating the NVA from the processes (McLoughlin and Meehan, 2021). This will also help in smoothening of the processes by removing the wastes from the processes that is the major concern of LM. Different LM techniques help to reduce that waste by eliminating not only NVA but also reduce the necessary NVA. In Tables 3 and 4 this can be clearly observed that the time for different processes, sub processes and activities have reduced. The total lead time for in-house production reduced to 60 days in which total VA time is 53 days and total NVA time is 7 days. On the other hand, the total lead time for supplier-based production reduced to 70 days in which total VA time is 63 days and total NVA time is 7 days.

Table 3 Improved PBS for in-house production

Process breakdown structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
1	Sampling					(7)		
		1.1	Sketching of new design			(1)	X	
				1.1.1	Defining new Model and Shape	(1)	X	
		1.2	Material selection			(1)	X	
				1.2.1	Sole, Heel and accessories along with type of material selection whether leather or raxine	(1)	X	

Table 3 Improved PBS for in-house production (continued)

Process breakdown structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
		1.3	Sample development			(1)	X	
				1.3.1	New design proposal by Designers	(1)	X	
		1.4	Pattern cutting for sample			(1)	X	
				1.4.1	Prototype development	(1)	X	
		1.5	Approval by sourcing dept			(1)	X	
				1.51	Sample check for design and material	(1)	X	
		1.6	Approval from Director			(2)	X	
				1.61	Sample check by focus group	(1)	X	
				1.62	Sample check by BOD's	(1)	X	
2	Make vs. buy					(10)	X	
		2.1	Cost Evaluation			(6)	X	
		2.2	Quality Evaluation			(2)	X	
		2.3	Manufacturing time Evaluation			(1)	X	
		2.4	Meeting			(1)		X
3	Planning and forecasting					(9)		
		3.1	Shop wise inventory check			(3)	X	
				3.1.1	Existing stock check	(1)	X	
				3.1.2	Shop demand	(1)	X	
				3.1.3	Data analysis	(1)	X	

Table 3 Improved PBS for in-house production (continued)

Process breakdown structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
		3.2	Inventory analysis gap			(2)	X	
				3.2.1	Analysing difference between demand and inventory	(1)	X	
				3.2.2	Quantify the gap	(1)	X	
		3.3	Inventory fulfilment			(2)	X	
				3.3.1	Adjustment of existing inventories within the shops	(1)	X	
				3.3.2	New order plan	(1)	X	
		3.4	Paper selection			(2)		X
				3.4.1	Difference in variants	(1)		X
				3.4.2	Difference in colours and Design	(1)		X
4	In-house Production					(11)		
		4.1	Sample received			(2)	X	
				4.1.1	Received by production dept.	(1)	X	
				4.1.2	Sample analyses	(1)	X	
		4.2	Raw material purchase			(7)	X	
				4.2.1	Suppliers analysis	(4)	X	
				4.2.2	Amount of material required	(1)	X	
				4.2.3	Cost of material BOP	(2)	X	
		4.3	Packaging			(1)	X	
		4.4	Order transfer			(1)		X

Table 3 Improved PBS for in-house production (continued)

Process breakdown structure (In-house Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
5	Ware house receiving					(4)		
		5.1	Receiving in warehouse			(1)	X	
		5.2	Quality check			(1)	X	
		5.3	Product arrangement and bar code			(1)	X	
		5.4	Inventory stock			(1)		X
6	Distribution					(6)		
		6.1	Distribution plan			(2)	X	
		6.2	Shops distribution			(3)	X	
				6.2.1	Ensure the adherence to the plan	(2)	X	
				6.2.2	Distribution coordination with logistics	(1)	X	
			Delay			(0)		X
7	Logistics					(7)		
		7.1	Region transportation plan			(2)	X	
		7.2	Transportation			(4)	X	
		7.3	Product transfer			(1)		X
8	Receive at shop					(2)		
		8.1	Receive at shop and sorting			(2)	X	
		8.2	Delay			(0)		X
9	Showcase display					(4)		
		9.1	Display			(3)	X	
		9.2	Delay			(1)		X

Table 4 Improved PBS for supplier-based production

Process breakdown structure (Supplier based Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
1	Sampling					(7)		
		1.1	Sketching of new design			(1)	X	
				1.1.1	Defining new Model and Shape	(1)	X	
		1.2	Material selection			(1)	X	
				1.2.1	Sole, Heel and accessories along with type of material selection whether leather or raxine	(1)	X	
		1.3	Sample development			(1)	X	
				1.3.1	New design proposal by Designers	(1)	X	
		1.4	Pattern cutting for sample			(1)	X	
				1.4.1	Prototype development	(1)	X	
		1.5	Approval by sourcing dept			(1)	X	
				1.51	Sample check for design and material	(1)	X	
		1.6	Approval from Director			(2)	X	
				1.61	Sample check by focus group	(1)	X	
				1.62	Sample check by BOD's	(1)	X	
2	Make vs. buy					(10)	X	
		2.1	Cost Evaluation			(6)	X	
		2.2	Quality Evaluation			(2)	X	

Table 4 Improved PBS for supplier-based production (continued)

Process breakdown structure (Supplier based Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
		2.3	Manufacturing time Evaluation			(1)	X	
		2.4	Meeting			(1)		X
3	Planning and forecasting					(9)		
		3.1	Shop wise inventory check			(3)	X	
				3.1.1	Existing stock check	(1)		
				3.1.2	Shop demand	(1)		
				3.1.3	Data analysis	(1)		
		3.2	Inventory analysis gap			(2)	X	
				3.2.1	Analysing difference between demand and inventory	(1)	X	
				3.2.2	Quantify the gap	(1)	X	
		3.3	Inventory fulfilment			(2)	X	
				3.3.1	Adjustment of existing inventories within the shops	(1)	X	
				3.3.2	New order plan	(1)	X	
		3.4	Paper selection			(2)		X
				3.4.1	Difference in variants	(1)		X
				3.4.2	Difference in colours and design	(1)		X
4	Supplier Planning					(3)		
			Material planning			(1)	X	

Table 4 Improved PBS for supplier-based production (continued)

Process breakdown structure (Supplier based Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
			Labour planning			(1)	X	
			Raw material purchase			(1)	X	
			Meeting			(0)		X
5	Supplier Production					(21)		
		5.1	Material receives			(3)	X	
			Arrangement			(2)		
				5.1.1	Raw material arrangements	(1)	X	
				5.1.2	Labour engagement	(1)	X	
		5.2	Production			(14)	X	
		5.3	Packaging			(1)	X	
		5.4	Order transfer			(1)		X
6	Ware house receiving					(4)		
		6.1	Receiving in warehouse			(1)	X	
		6.2	Quality check			(1)	X	
		6.3	Product arrangement and bar code			(1)	X	
		6.4	Inventory stock			(1)		X
7	Distribution					(6)		
		7.1	Distribution plan			(2)	X	
		7.2	Shops distribution			(3)	X	
				7.2.1	Ensure the adherence to the plan	(2)	X	
				7.2.2	Distribution coordination with logistics	(1)	X	
		7.3	Delay			(0)		X

Table 4 Improved PBS for supplier-based production (continued)

Process breakdown structure (Supplier based Production)								
PBS no.	*Process*	*PBS no.*	*Sub-Process*	*PBS no.*	*Activity*	*Time (Days)*	*VA*	*NVA*
8	Logistics					(7)		
		8.1	Region transportation plan			(2)	X	
		8.2	Transportation			(4)	X	
		8.3	Product transfer			(1)		X
9	Receive at shop					(2)		
		9.1	Receive at shop and sorting			(2)	X	
		9.2	Delay			(0)		X
10	Showcase display					(3)		
		10.1	Display			(3)	X	
		10.2	Delay			(1)		X

7 Conclusion

This paper has analysed the SC lead time of shoes manufacturing company and assessed it using LM techniques. It uses different mapping techniques like PBS, order fulfilment map and pipeline mapping to analyse the processes and lead time of the company along with VA and NVA. The paper suggests different LM tools to reduce the lead time and other process improvements that increase the SC process efficiencies. In order to analyse the SC processes of the company, two possible scenarios, in-house production and supplier-based production is studied. This helps to analyse the difference between the lead time for both scenarios, in which in-house production is better which has shorter lead time.

From the analysis carried out on SC processes of the company, following results have been deduced. Firstly, the LM tools play an important role in reducing the lead time of the company as by eliminating the wastes of the processes like meeting, delays, transfers, waiting. By removing all these NVA and other necessary NVA by using LM helps the company to have more efficient and effective process flows. Secondly, the integration between different SC is improved by the using ERP and programs like supplier development. Thirdly, the in-house and supplier-based production scenario helps to clarify the processes at both in company and at supplier-based production site. It also helps the company to analyse the current scenario and the benefits to shift from supplier based to in-house production.

8 Limitations and future research

The results provided by the study, creates the opportunities for the future research direction. Firstly, this study focused on single manufacturing company and the analysis cannot be generalised for the whole industry. Thus, future work may attempt to analyse the whole industry along with both scenarios for in-house and supplier-based production. Secondly the study focuses on lead time reduction by reducing the NVA and some of the necessary NVA. This will reduce the lead time, but the process can be improved further by suggesting the lean tool that makes the VA time more efficient by making designed changes that reduces the VAT. Thirdly, cost benefit analysis of in-house and supplier-based production is missing that makes the implementation of the expansion of production facility somewhat ambiguous. The detailed analysis in this regard can make things clear. In future this issue can be addressed and proper plan for implementation can be developed.

References

Al-Araidah, O., Momani, A., Khasawneh, M. and Momani, M. (2010) 'Lead-time reduction utilizing lean tools applied to healthcare: the inpatient pharmacy at a local hospital', *Journal for Healthcare Quality*, Vol. 32, No. 1, pp.59–66.

Alpan, G., Ladier, A-L., Larbi, R. and Penz, B. (2011) 'Heuristic solutions for transshipment problems in a multiple door cross docking warehouse', *Computers and Industrial Engineering*, Vol. 61, No. 2, pp.402–408.

Alsadi, J., Antony, J., Mezher, T., Jayaraman, R. and Maalouf, M. (2023) 'Lean and industry 4.0: a bibliometric analysis, opportunities for future research directions', *Quality Management Journal*, Vol. 30, No. 1, pp.41–63.

Apte, U.M. and Viswanathan, S. (2000) 'Effective cross docking for improving distribution efficiencies', *International Journal of Logistics*, Vol. 3, No. 3, pp.291–302.

Barua, P., Hossain, N., Chowdhury, T. and Chowdhury, H. (2020) 'Commercial diesel application scenario and potential of alternative biodiesel from waste chicken skin in Bangladesh', *Environmental Technology and Innovation*, Vol. 20, p.101139.

Behl, L. (2021) *Role of Supply Chain in Construction Industry*, Doctoral dissertation.

Caccialanza, A., Cerrato, D. and Galli, D. (2023) 'Sustainability practices and challenges in the meat supply chain: a systematic literature review', *British Food Journal*, Vol. 125, No. 12, pp.4470–4497, doi: 10.1108/BFJ-10-2022-0866.

Carlsson, L., Hattinger, M., Olsson, A.K. and Snis, U.L. (2021) 'Desperately seeking industrial digital strategy: a dynamic capability approach', *International Journal of Information Systems and Change Management*, Vol. 12, No. 4, pp.345–364.

Christopher, M. and Towill, D.R. (2000) 'Supply chain migration from lean and functional to agile and customised', *Supply Chain Management: An International Journal*, Vol. 5, No. 4, pp.206–213.

Dadashnejad, A-A. and Valmohammadi, C. (2019) 'Investigating the effect of value stream mapping on overall equipment effectiveness: a case study', *Total Quality Management and Business Excellence*, Vol. 30, Nos. 3–4, pp.466–482.

Dennehy, D., Oredo, J., Spanaki, K., Despoudi, S. and Fitzgibbon, M. (2021) 'Supply chain resilience in mindful humanitarian aid organizations: the role of big data analytics', *International Journal of Operations and Production Management*, Vol. 41, No. 9, pp.1417–1441, doi: 10.1108/Ijopm-12-2020-0871.

Elazary, L., Parks, I.D.F. and Voorhies, R.C. (2015) *Autonomous Order Fulfillment and Inventory Control Robots*, U.S. Patent No. 9,120,622, U.S. Patent and Trademark Office, Washington, DC.

Fawcett, S.E., Ellram, L.M. and Ogden, J.A. (2007) *Supply Chain Management: From Vision to Implementation*: Pearson Prentice Hall Upper Saddle River, NJ.

Forza, C. and Vinelli, A. (1996) 'An analytical scheme for the change of the apparel design process towards quick response', *International Journal of Clothing Science and Technology*, Vol. 8, No. 4, pp.28–43.

Ghosh, S. and Lever, K. (2020) 'Development of value stream mapping from L'Oreal's artwork process', *Journal of Business-to-Business Marketing*, Vol. 27, No. 3, pp.293–309.

Gilal, F.G., Gilal, R.G., Jian, Z., Gilal, R.G. and Gilal, N.G. (2016) 'Supply chain management practices as a contemporary source of securing competitive advantage and organisational performance: evidence from the FMCGs of Pakistan', *International Journal of Information Systems and Change Management*, Vol. 8, No. 3, pp.246–267.

Goldratt, E.M. (1990) *Theory of Constraints*, North River Croton-on-Hudson.

Gosling, J., Naim, M. and Towill, D. (2013) 'A supply chain flexibility framework for engineer-to-order systems', *Production Planning and Control*, Vol. 24, No. 7, pp.552–566.

Hammer, M. and Champy, J. (2009) *Reengineering the Corporation: Manifesto for Business Revolution, A*: Zondervan.

Hines, P., Tortorella, G.L., Antony, J. and Romero, D. (2023) 'Lean industry 4.0: past, present, and future', *Quality Management Journal*, Vol. 30, No. 1, pp.64–88.

Kassaneh, T.C. and Workalemahu, R.N. (2018) 'Performance measurement and improvement method for leather footwear industries', *Journal of Engineering, Project & Production Management*, Vol. 8, No. 2, pp.97–104.

Koberg, E. and Longoni, A. (2019) 'A systematic review of sustainable supply chain management in global supply chains', *Journal of Cleaner Production*, Vol. 207, pp.1084–1098.

Komkowski, T., Antony, J., Garza-Reyes, J.A., Tortorella, G.L. and Pongboonchai-Empl, T. (2023) 'Integrating lean management with Industry 4.0: an explorative dynamic capabilities theory perspective', *Production Planning & Control*, Vol. 1, pp.1–19.

Liu, X., Yuan, C. and Hafeez, M. (2019) 'The initial trust in the sharing economy from the perspective of consumer and supplier', *International Journal of Information Systems and Change Management*, Vol. 11, Nos. 3–4, pp.228–255.

Lu, Y., Liu, Z. and Min, Q. (2021) 'A digital twin-enabled value stream mapping approach for production process reengineering in SMEs', *International Journal of Computer Integrated Manufacturing*, Vol. 34, Nos. 7–8, pp.764–782.

Macchion, L., Da Giau, A., Caniato, F., Caridi, M., Danese, P., Rinaldi, R. and Vinelli, A. (2018) 'Strategic approaches to sustainability in fashion supply chain management', *Production Planning and Control*, Vol. 29, No. 1, pp.9–28.

MacNealy, M.S. (1999) *Strategies for Empirical Research in Writing* (No Title).

Maroofi, F. (2012) 'The effect of information and communication technology (ICT) application in the shoes industry', *African Journal of Business Management*, Vol. 6, No. 11, pp.4079–4087.

Mason-Jones, R., Naim, M.M. and Towill, D.R. (1997) 'The impact of pipeline control on supply chain dynamics', *The International Journal of Logistics Management*, Vol. 8, No. 2, pp.47–62.

McLoughlin, K. and Meehan, J. (2021) 'The institutional logic of the sustainable organisation: the case of a chocolate supply network', *International Journal of Operations and Production Management*, Vol. 41, No. 3, pp.251–274, doi: 10.1108/IJOPM-11-2020-0773.

Melton, P. (2004) 'To lean or not to lean? (that is the question)', *The Chemical Engineer*, Vol. 759, pp.34–37.

Melton, T. (2005) 'The benefits of lean manufacturing: what lean thinking has to offer the process industries', *Chemical Engineering Research and Design*, Vol. 83, No. 6, pp.662–673.

Nadeem, S.P., Garza-Reyes, J.A. and Anosike, A.I. (2023) 'A C-Lean framework for deploying circular economy in manufacturing SMEs', *Production Planning & Control*, Vol. 1, pp.1–21.

Närhi, A. (2021) *Collaborative Partnerships in Process Improvement of Import/Export Supply Chains in Retail and Wholesale Companies: Case: Inex Partners and the Customs*, Retrieved from https://lutpub.lut.fi/handle/10024/162810

Nave, D. (2002) 'How to compare six sigma, lean and the theory of constraints', *Quality Progress*, Vol. 35, No. 3, pp.73–80.

Núñez-Merino, M., Maqueira-Marín, J.M., Moyano-Fuentes, J. and Castaño-Moraga, C.A. (2024) 'Quantum-inspired computing technology in operations and logistics management', *International Journal of Physical Distribution & Logistics Management*, Early view.

Oliveira-Dias, D.D., Maqueira Marín, J.M. and Moyano-Fuentes, J. (2022) 'Lean and agile supply chain strategies: the role of mature and emerging information technologies', *The International Journal of Logistics Management*, Vol. 33, No. 5, pp.221–243, doi: 10.1108/IJLM-05-2022-0235.

Onesime, O.C.T., Xu, X. and Zhan, D. (2004) 'A decision support system for supplier selection process', *International Journal of Information Technology and Decision Making*, Vol. 3, No. 03, pp.453–470.

Papetti, A., Marconi, M., Rossi, M. and Germani, M. (2019) 'Web-based platform for eco-sustainable supply chain management', *Sustainable Production and Consumption*, Vol. 17, pp.215–228.

Paragliola, G. and Ribino, P. (2024) 'Exploring heterogeneous data distribution issues in e-health federated systems', *Biomedical Signal Processing and Control*, Vol. 92, p.106039.

Peterson, H.C. (2002) 'The', learning', supply chain: pipeline or pipedream?', *American Journal of Agricultural Economics*, Vol. 84, No. 5, pp.1329–1336.

Rahi, S. (2017) 'Research design and methods: a systematic review of research paradigms, sampling issues and instruments development', *International Journal of Economics and Management Sciences*, Vol. 6, No. 2, pp.1–5.

Rajora, N. (2022) 'Dynamics of pharmaceutical drugs serialization', *Universal Journal of Pharmacy and Pharmacology*, Vol. 13, No. 2, pp.43–49.

Scott, C. and Westbrook, R. (1991) 'New strategic tools for supply chain management', *International Journal of Physical Distribution and Logistics Management*, Vol. 21, No. 1, pp.23–33.

Silva, A., Coelho, L.C., Darvish, M. and Renaud, J. (2020) 'Integrating storage location and order picking problems in warehouse planning', *Transportation Research Part E: Logistics and Transportation Review*, Vol. 140, p.102003.

Somboon, J. and Tippayawong, K.Y. (2018) 'Improvement of used shoes supply chain by lean concept', *Veridian E-Journal, Silpakorn University* (*Humanities, Social Sciences and Arts*), Vol. 11, No. 5, pp.179–196.

Tahir, S. and Ramish, A. (2022) 'Xarasoft (Pvt) ltd – vision 2027 to implement a digital supply chain for industry 4.0', *Emerald Emerging Markets Case Studies*, Vol. 12, No. 1, pp.1–22, doi: 10.1108/Eemcs-05-2021-0180.

Tapping, D. and Shuker, T. (2018) *Value Stream Management for the Lean Office: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements in Administrative Areas*, Productivity Press, USA.

Thangarajoo, Y. and Smith, A. (2015) 'Lean thinking: an overview', *Industrial Engineering and Management*, Vol. 4, No. 2, pp.2169–0316.1000159.

Timotius, E., Sunardi, O., Soenandi, I.A., Ginting, M. and Sabini, B. (2022) 'Supply chain disruption in time of crisis: a case of the Indonesian retail sector', *Journal of International Logistics and Trade*, Vol. 20, No. 2, pp.78–101, doi: 10.1108/JILT-05-2022-0004.

Wildman, T.A. and Barry, D.W. (2008) *Mobile Order Fulfillment: Google Patents*, retrived from https://patents.google.com/patent/US20080040233A1/en

Yassien, E. (2020) 'The challenges of capability maturity model integration application in the dynamic environment', *International Journal of Information Systems and Change Management*, Vol. 12, No. 1, pp.17–34.

Yusup, M.Z., Mahmood, W.H.W., Salleh, M.R. and Ab Rahman, M.N. (2015) 'The implementation of cleaner production practices from Malaysian manufacturers' perspectives', *Journal of Cleaner Production*, Vol. 108, pp.659–672.

Zhu, Y-X., Lee, S-J. and Zhang, J-Q. (2016) 'Performance evaluation on supplier collaboration of agricultural supply chain', *International Journal of Information Systems and Change Management*, Vol. 8, No. 1, pp.23–36.

Zhuravleva, A. (2024) 'Reverse supply chains of non-profit organizations for textile reuse', *Journal of Humanitarian Logistics and Supply Chain Management*.