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An exploration of operational excellence methodologies implementation in the logistics sectors: a global study

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Abstract

Purpose: The aim of this study reported in this paper was to explore the application of operational excellence methodologies in a global context.

Design/methodology/approach: A qualitative interview approach was used to understand the current state, benefits, challenges, success factors, tools, and techniques of operational excellence methodology implementation with relevance to logistics companies worldwide. Sixteen interviews were undertaken with practitioners working in leading companies and with leading academics in Asia, Europe, Africa, North America, South America and Australia.

Findings: The findings show that operational excellence methodologies including Lean, Six Sigma, Lean Six Sigma, and Agile can apply in logistics firms to improve operations and productivity, and save costs. Top management support and involvement play an important role in the success of operational excellence projects in the logistics service.

Research limitations/implications: The findings will be of interest to top and middle managers and logistics practitioners, with a dual aim of improving logistics performance and saving cost.

Originality: The present study has been one of the first global study attempts to explore the implementation of operational excellence methodologies in Logistics sectors.

Keywords: Operational Excellence Methodologies, Logistics, Transportation, Lean Six Sigma,

1. Introduction

The popular and widely adopted operational excellence methodologies that have been applied by scholars and practitioners are Lean, Six Sigma, and Lean Six Sigma (Lameijer *et al.*, 2016). It is a key element in improving process performance in every organization. Such methodologies have been used in several sectors such as manufacturing, services, Small and Medium Enterprises (SMEs), education, services and public organizations (Antony *et al*., 2017). Previous studies have shown that the application of operational excellence methodologies can improve logistics operational performance, for example eliminate waste from logistics activities, reduce defects, reduce lead time and process time, improve customer satisfaction, and save costs (Trakulsunti *et al*., 2021).

Logistics and supply chain management (SCM) have been considered as the leading edge of industrial innovation (Lagorio e*t al*., 2020). Logistics is a part of supply chain management that involves the flow of materials, information, and services from the point of origin to the point of consumption to meet customers' requirements (Christopher, 2016). The key logistics activities are inventory management, transportation, warehousing, and storage (Stock and Lambert, 2001). Several studies suggest that logistics operations can be improved by the use of innovative technologies such as radio-frequency identification (RFID), Internet of Thing (IoT), Big Data Analytics, mathematical modeling, operations research, and simulations (Sternberg *et al*., 2013; Lagorio *et al*., 2020). Abushaikha *et al*., (2018) and Abhishek and Pratap (2020) proposed that logistics activities have been one of the areas in which operational excellence methodologies have been successfully implemented to improve logistics performance and gain significant benefits. The application of operational excellence methodologies with the associated tools and

techniques provides an opportunity to complement the existing improvement approaches (Garza-Reyes *et al*., 2016; Villarreal *et al*., 2016).

To date, there is little published research on the use of operational excellence methodologies in logistics, especially in developing countries. Previous studies such as Zhang et al. (2016) have mainly examined the benefit and challenges of Lean and Six Sigma in Singapore. Much of the literature has focused on the utilization of Lean rather than other operational excellence methodologies in logistics sectors. The concept of Lean, along with its tools has been applied to improve road transport operations (Villarreal *et al.*, 2016; Villarreal, Garza-reyes and Kumar, 2016; Garza-Reyes *et al.*, 2018) and warehousing (Oey and Nofrimurti, 2018; Abhishek and Pratap, 2020; Pereira et al., 2021). Remarkably, there is a lack of studies that investigate the integration of operational excellence methodologies with Industry 4.0 technologies to improve logistics operations performance (Trakulsunti *et al*., 2022). No study has focused on investigating the application of operational excellence methodologies in a global context. Moreover, operational excellence methodologies, particularly Lean, are mostly implemented in continents such as Europe, North America and Asia; however, the application of such methodologies in Africa is still in its infancy (Antony *et al* ., 2019; Trakulsunti *et al*., 2022). Thus an analysis of operational excellence methodologies implementation in logistics sector with academics and practitioners across the continents will complement different perspectives (Antony *et al.*, 2022). Therefore, this paper focuses on the application of five key operational excellence methodologies including Six Sigma, Lean, LSS, Agile, and Leagile in logistics (McDermott *et al.,* 2021) through a study with leading academics and practitioners across the continents and aims to answer the following research questions.

RQ1 What is the current state of operational excellence methodologies in the logistics industry?

RQ2 What are the benefits, barriers, and critical success factors of implementing operational excellence methodologies in logistics companies?

RQ3 What tools and techniques of operational excellence methodologies have been used to improve logistics operations?

RQ4 What innovative technologies have been integrated with operational excellence methodologies to improve logistics performance?

This paper contributes to the existing literature by providing a new understanding of how Industry 4.0 technologies can be integrated with operational excellence methodologies including Lean, Six Sigma, Lean Six Sigma, and Agile to improve logistics operations. This study adds to a growing body of literature on the application of Six Sigma, Lean Six Sigma, and Agile in Logistics sectors. The present study appears to be the first empirical investigation of the impact of applying operational excellence methodologies through a global study with different practitioners and leading academics. With regards to its practical contribution, the study and its results can benefit industrialists by providing guidance for a successful implementation of operational excellence methodologies in the logistics sector and a greater awareness of how operational excellence methodologies impact their business.

The remaining parts of this paper are structured as follows: the second section gives a brief review of operational excellence methodologies; the third section describes the research methodology used in this study; the fourth part discusses the significant findings and practical

implications; and the final section summarizes the key findings and suggests recommendations for future research directions.

2. Literature Review

2.1 Operational excellence methodologies

Operational excellence methodologies such as Lean, Six Sigma, Lean Six Sigma, Agile, and Leagile have been widely applied by scholars and practitioners (Lameijer *et al.*, 2016). The application of such methodologies can improve business processes (Abushaikha et al., 2018) and save logistics costs. Lean originated from the concept of Toyota Production System (TPS) in Toyota Motor Corporation, a Japanese automotive manufacturer. The term "Lean" was coined in the book entitled "The machine that changed the world" written by Womack, Jones and Roos in 1990 (Womack *et al*., 2007). It is a philosophy that focuses on the elimination of wastes from the process thus increasing speed, reducing costs (Trakulsunti *et al*., 2021) and adding customer values (Yadav and Desai, 2016). The principles of Lean are based on the assumptions that every process in the organization consists of three types of activities including value added to the customer, business non-value added and non-value-added (Womack and Jones, 2003). Therefore, non-value-added activity or waste should be eliminated from the process.

The concept of Six Sigma was introduced in 1980 by Bill Smith, an engineer at Motorola, and was then popularized by the General Electric (GE) company (Antony, 2006). Six Sigma is a business strategy and problem-solving methodology which aim to reduce variation within a process resulting in the reduction of defects and thereby enhancing process performance. Six Sigma methodology consists of key five phases: Define, Measure, Analyze, Improve, Control (DMAIC). By following these phases, the aim is to start with identifying a problem within the

process step, then implement solutions for the root causes and establish best practices to ensure that the improvement can be sustained in the long term (George *et al*., 2005).

Lean is appropriate for the first round of improvement with less data collection, while Six Sigma is suitable for complex problems which require advanced statistical tools. However, the integration of Lean and Six Sigma, called Lean Six Sigma (LSS), could contribute to better results than a separate implementation of each methodology (Salah *et al*., 2010; Bhat *et al*., 2014). Lean Six Sigma focuses on reducing variation within the process which is a source of defect and improving process flow resulting in improved customer satisfaction and bottom-line results (George *et al*., 2004; McDermott *et al*., 2021). The concept of agility aims for the organization to have flexibility, adaptability, robustness, an ability to manage demand fluctuations, variability, and a quick response to uncertain markets (Banomyong, 2008; Zielske and Held, 2021). As Lean is unable to deal with consistent change, Lean and Agile have been integrated as Leagile to achieve the advantages of both paradigms (McDermott *et al*., 2021).

2.2 Operational excellence methodologies in logistics

Logistics is the process of moving materials and information from the point of origin to the point of consumption (Ghiani *et al*., 2013). Logistics companies should continuously improve their operations to enhance customer satisfaction (Zhang *et al*., 2016), meet customers' requirements and increase business profitability. The key logistics activities include inventory management, transportation, warehousing, and storage (Stock and Lambert, 2001). These logistics activities such as transport operations can be improved by the use of mathematical modeling, operations research, simulations (Sternberg *et al.*, 2013), and innovative technologies (e.g. Radio Frequency Identification (RFID), Information Technology (IT), big data analytics and Internet of Things (IoT)) (Lagorio *et al.*, 2020). However, in recent years, logistics and supply chain have been the

areas that have received attention from academics in ways in which waste and defect reduction practices have been implemented successfully by operational excellence methodologies, especially in warehousing and transportation processes (Abushaikha *et al*., 2018). The application of operational excellence methodologies can be applied to supplement the existing improvement methods and techniques (Villarreal *et al*., 2016). Logistics companies with limited resources and capital investment can apply operational excellence methodologies to improve their operations, customer satisfaction, profitability (Shokri *et al*., 2014), and overall competitive position (Sharma and Shah, 2016). However, the barriers faced by most logistics companies when applying operational excellence methodologies are resistance to change, insufficient training and employees not understanding the reason for implementation (Zhang *et al*., 2016).

Thus far, a number of studies have applied operational excellence methodologies particularly Lean to eliminate waste from transport and warehouse activities resulting in reduced lead time and process time and improved warehouse operation performance (Abushaikha *et al*., 2018; Abhishek and Pratap, 2020). The concept of Lean and its popular tools such as Value Stream Mapping have been used to improve road transport operations (e.g. Villarreal *et al*., 2016; Villarreal, Garza-Reyes and Kumar, 2016; Garza-Reyes *et al*., 2018) warehousing (e.g. Chen *et al.*, 2013; Reis *et al*., 2017; Baby *et al*., 2018). The research to date (e.g. Nabhani and Shokri, 2009, Wei *et al*., 2010; Shokri *et al*., 2014) has implemented Six Sigma to reduce defects in the logistics process such as wrong sale orders, returned goods, traffic accidents, and shipping errors. There are relatively few studies that have focused on the deployment of Agile and Leagile in the logistics sectors. For instance, a recent studies by Zielske and Held (2020) and Zielske and Held (2021) explored the application of agile methods in logistics startups and logistics companies which resulted in the improvement of the reaction to the changing of the customers' requirements. Additionally, the study by

Banomyong *et al*. (2008) explored the impact of the Leagile on reverse logistics of an electrical appliance manufacturer based in Bangkok, Thailand.

However, Villarreal *et al*. (2016) and Trakulsunti *et al*. (2022) claimed that more research is required to identify the critical success factors (CSFs) when applying continuous improvement initiatives in the logistics sector. Moreover, to date, there appears to be no empirical research on the application of operational excellence methodologies in the logistics sector in a global context. Therefore, it is argued that more research regarding operational excellence methodologies is required to be performed in the field of logistics to bridge this gap.

3. Research Methodology

In order to address the research questions, a qualitative study was set up with operational excellence methodologies experts at a global level using an interview approach. Purposive sampling was used to select 16 participants from 10 different countries and six continents including Africa, Asia, Australia, Europe, North America and South America from logistics firms providing services covering transportation, warehousing, distribution, and supply chain solution. The study also involved leading academics who are recognized experts and leaders in operational excellence methodologies participated and contributed to the research (Antony *et al*., 2019). Table 1 summarizes participants' details and backgrounds. The positions of the participants included operations excellence manager, senior manager, and assistant general manager from developed and developing countries, alongside academics and company directors. The key responsibilities of the participants are to implement, lead and support the operational excellence projects and to build a continuous improvement culture in their organizations. The inclusion criteria for participants were 1) participants who have worked in managerial and process improvement positions related to key logistics activities for at least five years; 2) leading

academics in the field of operational excellence methodologies and 3) participants who were willing to participate in this study (Abushaikha *et al*., 2018).

Table 1 Participants Information

Participant	Academic	Non-academic	Organization	Position	Location
1		X	Thirds party Logistics Provider (3PL) covering warehouse and transport.	Operations Excellence Manager	Thailand
2		X	3PL provider - supply chain solutions - End-to-end transportation - Contract Logistics	Assistant General Manager	Thailand
3		X	3PL provider - Transportation and fulfilling - supply chain solutions	Logistics Process Excellence Expert	Thailand
4	X		St Joseph Engineering College	Professor, Lean Six Sigma Master Black Belt	India
5	X		University of the Witwatersrand	Senior Lecturer	South Africa
6	X		Federation University	Associate Professor, Lean Six Sigma Black Belt	Australia
7		X	Consultancy Company	Director	The UK
8	X	X	The São Paulo State	Director, Associate Professor	Brazil

			Technological Colleges		
9		X	3PL provider - contract logistics - freight forwarding - distribution and transportation management	Senior Manager, Business Process Excellence	Thailand
10		X	Consultancy Company	Director	The UK
11	X		Purdue University	Associate Professor, Six Sigma Black Belt	The USA
12		X	Thirds party Logistics Provider (3PL) covering warehouse and transport	Senior Manager, Head of Transport Operation Excellence	Thailand
13	X		RMIT University	Research Scholar	Australia
14		X	Thirds party Logistics Provider (3PL) covering warehouse and transport	Assistant Director, Head of Department - Operation Excellence	Thailand
15		X	A last mile shipping & delivery service	Process Improvement Manager	Germany
16		X	Consultancy Company	Managing Director	Bulgaria

3.2 Data collection

In this research, a semi-structured interview was used to capture the participants' views on the current state of benefits, challenges, and success factors in the use of operational excellence methodologies in logistics companies, tools and techniques used to improve logistics operation as well as the integration of innovative technologies and such methodologies. Using the medium of Microsoft Teams, the participants were asked if there were prepared to be interviewed, making it clear they can stop their involvement in the project at any time. At the beginning of the research, an email containing the interview questions and objectives was sent to the participants before the interview. Each interview lasted approximately 45-60 minutes. The researcher asked for permission from the participants for recording before starting the interview.

3.3 Data analysis

This study adopted thematic analysis to analyse the qualitative data gained from the interviews, leading to rich descriptions, explanations, and theorizing (Saunders *et al*., 2016). The study followed the key steps of thematic analysis proposed by Hussey (2014) and Saunders *et al*. (2016) as follows.

1) Preparing the data for analysis

   In this step, the interviews were audio-recorded and transcribed verbatim, then the transcriptions were sent back to participants for checking, editing, and approving (Psychogios *et al*., 2012).

2) Familiarization with the data

Familiarization with the data is an important element in analyzing qualitative data (Saunders *et al*., 2016). The researcher read and re-read the transcripts to become familiar with them. After that, all collected data were further reduced by the use of coding.

3) Coding

The researcher used a manual approach to code the data regarding the research questions. In this research, codes were developed based on the literature related to the benefits, challenges, and critical success factors, tools and techniques of operational excellence methodologies implementation in the logistics sector. After coding the data, the researcher checked the accuracy of all codes compared to the unit of data.

4) Identifying and refining themes

The codes were further grouped into categories and subsequently, main themes were generated (Collis and Hussey, 2014; O' Gorman and MacIntosh, 2015; Nilvarangkul *et al*., 2016). The researcher checked these themes against the extracted codes to ensure that they were related to each other after the themes were created (O'Gorman and MacIntosh, 2015). At this stage, the researcher was able to reorganise the extracted codes under the relevant themes or sub-themes (Saunders *et al*., 2016).

4. Key Findings

The following section presents the key findings from the implementation of operations excellence methodologies in logistics sectors. The first part explains the current status of operational excellence methodologies in the logistics industry in a global context**.** The next part describes the benefits, challenges, and success factors in the use of operational excellence methodologies in Logistics companies, followed by tools and techniques used for the improvement of logistics

services. Lastly, the final section explains the integration of innovative technologies with operational excellence methodologies to improve logistics performance. Table 2 summarises the KPIs used by Logistics companies worldwide, the benefits, challenges and success factors of operational excellence methodologies implementation in logistics sector.

4.1 The status of operational excellence methodologies in the logistics industry in a global context

The following presents the status of the applications of operations excellence methodologies in the logistics sector.

(1) The number of operational excellence projects implemented per year

Most participants reported that small projects (quick win & easy to implement) such as Lean and Kaizen projects have been executed out of approximately 20-70 projects per year. Middle and high-level projects such as Lean Six Sigma projects (with cost savings of more than 5,000 USD per year) have been executed through 10-20 projects per year. What emerges from the results reported here is that the logistic company in Thailand which has an operation excellence manager who is fully responsible to lead and support operational excellence initiatives could implement Six Sigma projects more successfully than the remaining companies.

(2) The Key Performance Indicators (KPIs) used by Logistics companies

The followings are the typical KPIs used in Logistics companies worldwide when implementing operational excellence methodologies which significantly focus on time, cost, quality and accuracy:

-receiving accuracy and on time;

-picking /packing accuracy and on time;

-delivery accuracy and on time;

-inventory accuracy;

-defect & customer complaints

-customer satisfaction;

-truck utilization;

-cost and time saving; and

-productivity

Interestingly, all participants stated that cost saving is a primary KPI when implementing operational excellence projects. As one of the participants said:

"In terms of organization, most projects must generate savings and we always considered how much money this project can make (P11)."

(3) The number of operational excellence methodologies training programmes

The training in operational excellence methodologies is divided into two levels: (1) supervisor and manager and (2) operatives. The results showed that about 5-10% of supervisors, assistant managers, and managers have been trained as Lean Six Sigma Yellow Belts in the organizations. Lean Six Sigma Green Belt (LSGB) is the upper level for management which has around 15 LSGB in the organization. Lean Six Sigma Black Belt (LSBB) is the advanced level and specializes in the operations excellence team who can lead and consult for the improvement project which has approximately five LSBBs in the organization. For LSS belts training is mandatory for supervisor and manager level due to a company's policy and is optional for support functions. Employees at the operative level receive at least the basic Lean methodology and training in its tools.

(4) Areas of implementation

Operational excellence methodologies have been mostly applied in warehouse and transportation processes. Key activities of warehouses operation include receiving, putting away, storage, picking, sorting, and packing (Chen *et al*., 2013). The results showed that palletizing and pallet loading/unloading were the main activities that have been improved by the use of Lean and Six Sigma tools and techniques. Moreover, the most commonly used tools such as values stream mapping have been applied to reduce transportation planning time which includes the activities that need to be performed before shipping goods. Participants explained about the areas of operational excellence methodologies implementation as follows:

"We implemented operational excellence methodologies to improve productivity in terms of reducing the time for planning the vehicle before shipping, for example, the process in which we gathered information before planning the vehicle. Before using operational excellence, there were wastes in the transport planning process; we then redesigned the process and used technology and different tools to reduce such wastes such as manual work (P9)."

In addition, the project team also executed the DMAIC methodology to reduce the incorrect shipment document (e.g. Bill of Lading, BOL). Participants stated:

"We applied the DMAIC methodology to solve the existing problem in logistics operations which can reduce h as incorrect shipping documents (P3 and P5)."

4.2 Benefits

The operational excellence methodologies including Kaizen, Lean, Six Sigma, Lean Six Sigma, and Agile have been applied to improve Logistics operations, especially in warehousing and transportation. The key benefits accrued from the application of such methodologies identified by the participants included:

(1) cost savings of more than 5,000 USD per year;

(2) increased customer and employee satisfaction;

(3) increased productivity, for example the number of pallets picking increased from 10 to 12 per hour;

(4) reduced waste;

(5) improved cycle time;

(6) improved delivery performance;

(7) reduced defects such as incorrect shipping documents

(8) supply chain and warehouse optimization

4.3 Challenges in the use of operation excellence methodologies in Logistics

The main challenges that the project team encountered when implementing operation excellence methodologies in logistics operations were a lack of employee involvement and a lack of training. These challenges are explained as follows.

(1) Lack of employee's involvement

All participants mentioned that the key challenge of applying operational excellence methodologies in logistics operations was a lack of employee involvement in the project. The middle managers who are responsible for leading, supporting, and implementing the operation excellence initiative encountered the difficulty of convincing employees to become involved in the implementation of such methodologies. The following described some participants' feelings.

"To convince people to be involved in the project was difficult (P4, P13 and P1)."

"It was difficult to approach employees to be involved in the projects; some of them have been working for a long time and they did not want to change (P3 and P15)."

(2) Lack of training

Another reported challenge encountered by the project team was lack of training. Not all of the project team members had received training for the company that had no operational excellence department. As a result, some of the project team members lacked understanding of operational excellence methodologies and its tools and techniques and lacked awareness of how such methodologies could improve their work. One participant argued that time management for training and implementation in each project was also a barrier when applying operational excellence methodologies. Besides lack of training, participants further identified that designing training for employees at each level was also difficult. participant suggested:

"It was difficult to design the operational excellence training to suit the employees at each level and we did not know what level the employees should be trained (P4)."

4.4 Success Factor

Two main themes emerged as important factors leading to the success of operational excellence methodologies implementation which included: (1) top management support and involvement and (2) project sponsor. Each theme is explained as follows.

(1) Top management support and involvement

All participants reported that top management support and involvement in improvement activities is a key factor leading to the success of the operational excellence project. The top management's perspective on implementing operational excellence methodologies and driving it to be the culture of the organization can make the project more successful. The participants mentioned several points regarding the support from top management as follows:

"The most important thing is the top management's perspective on implementing the operational excellence project. If they give importance to this matter and can drive it to be the culture of the organization, it will be possible for the project to succeed (P6 and P11)."

"The top management not only identify the policy, but are also involved with the employee to support the implementation of operational excellence projects (P9)."

There were some suggestions that top management needs to visit the site and see the improvement activities such as Kaizen to encourage the staff to continue implementing operational excellence methodologies. One participant suggested that there should be a particular department to drive companies' policy from top management level to down level.

(2) Project sponsor

A project sponsor is another factor that facilitated the implementation of operational excellence methodologies and contributed to the project's success. The project sponsor is a leader in the organization working with the Black Belt or Green Belt to define the scope, objective, and deliver the project. The role of the project sponsor is to ensure that resources are available for the project members and create buy-in from senior management (Keller, 2001). One of the participants described this:

"We should have a project sponsor who supports the project and can see the value of the projec (P3 and P7)."

"The project team must prepare information such as ROI if implementing operational excellence for the project sponsor to accept the project (P3)."

4.5 Tools and Technique

Table 2 presents tools and techniques of operational excellence methodologies used to improve logistics services. The most popular tools and techniques used by the project team included value

stream mapping, cause and effect diagram, brainstorming, and waste analysis. The results highlight that the tools and techniques used to improve logistics operations are non-statistical tools. Moreover, Lean and Six Sigma methodology were also applied by the project team.

Table 2 Tools and techniques used to improve Logistics operations

Most used tools and techniques	Least used tools and techniques
Value Stream Mapping (VSM) and Value Analysis	Control Chart
7+1 form of waste analysis	5S
Cause and Effect Diagram	Why Why analysis
Process redesign/reengineering	Workload balancing
Brainstorming	Poka-Yoke
Voice of the Customer (VOC)	Nominal Group Technique (NGT)
Root Cause Analysis (RCA)	SIPOC
Process Mapping	Pareto Chart
	New 7 QC tools
	ECRS
	7 Ways design
	Critical to Quality (CTQ)

Six Sigma methodology was also applied by the project team through the five phases of DMIAC which were used as a structured framework to improve logistics operations. The project team followed these phases to eliminate the root causes of the problems existing in the logistics process. Several tools and techniques from Lean and Six Sigma toolboxes have been applied in each phase of DMAIC methodology (Table 3). In the define phase, SIPOC was used to identify the scope of the project so that all the team members can understand a detailed overview of the

process. VOC was also used in this phase to understand customers' requirements and expectations of logistics services such as delivering at the right time and right place. In the measure phase, critical to quality and data collection plan were used to measure a service characteristic which was linked to the customer need as gathered from the voice of the customer (VOC) data collection (Antony *et al*., 2019). The next phase is the improve phase which aims to identify the root causes of the problems. The popular tools used in this phase included VSM, brainstorming, cause and effect analysis, and Why-Why analysis. To implement potential solutions for addressing root causes, poka-yoke, 5S and RPA were mostly used by the project team. Finally, a control chart was used in the control phase to sustain the process performance.

Table 3 tools and techniques applied in each phase of DMAIC methodology

Six Sigma methodology phases	Common tools and techniques
Define	SIPOC VOC
Measure	Critical to Quality
Analyze	Value stream mapping Brainstorming Cause and effect analysis Why-Why analysis
Improve	Poka-Yoke 5S
Control	Control Chart

4.6 Innovative technologies integrated with operational excellence methodologies

The participants reported that after the process has been analyzed to identify and remove wastes mostly using VSM, the innovative technologies were further applied to support logistics operations to increase productivity, improve real time tracking, short lead time to customers, cost saving, and low cost per unit to compete with other logistics companies. These technologies that the participant

applied can be classified into 1) high technology implementation costs such as Automated Storage/Retrieval System (AS/RS), RFID, and Warehouse Management System (WMS) and 2) low implementation costs such as Robotics Process Automation (RPA). Moreover, other Industry 4.0 technologies such as Internet of Things (IOT), Big Data, and Data analytics, have been adopted in logistics operations. One participant explained as follows:

"Industry 4.0 is quite dominantly used in the logistics segment. We can use data analytics to understand the behavior of logistics, predict the customers' needs to balance demand and supply and IOT can improve the real time tracking (P6 and P13)."

The key results showed that for internal resources, the participants improved the physical flow match with information flow by adjusting the warehouse management system (WMS) function to support operation, developing spreadsheet tools to create a report, dashboard, and developing an application to eliminate the manual task. Robotics Process Automation (RPA) was also applied to improve processes, logistics operations and increase productivity accuracy. On the other hand, for external resources, the participants studied the opportunity of new technology from various suppliers to apply with current and new forthcoming operations in the future, test technology, and study cost and benefit by the business case.

5. Discussion and Implications

The study has produced some interesting results. To answer the first research question, the study found that the project team mostly implemented small projects such as Lean and Kaizen projects in the transportation and warehouse processes. It can be suggested that the logistics company should encourage staff to get operational excellence methodology training especially LSS training to gain a better understanding of its toolkits. However, there is a lack of use of Agile and Leagile methods, especially in Asia, to improve logistics operations in Logistics companies.

With respect to the second research question, it was found that the use of operational excellence methodologies in the logistics sector in a global context contributed to considerable benefits which included: 1) cost-saving; 2) increased customer satisfaction; 3) increased productivity; 4) reduced waste and defects; and 5) improved process time and delivery performance. The finding is in line with several studies such as Villarreal (2016), Shokri et *al.* (2014), Zhang *et al*. (2016), and Abushaikha *et al*. (2018) who implemented operational excellence methodologies to improve logistics operations, particularly in warehousing and transportation. Moreover, these results are consistent with Trakulsunti *et al*. (2022) who conducted a systematic review of the application of operational excellence methodologies in logistics which showed that the key benefits of applying such methodologies are reduced wastes and defects from logistics activities, reduced lead time and process time, increased customer satisfaction and cost savings. In contrast to earlier findings, some benefits such as an improved responsiveness to meet unexpected needs did not emerge from this study. This might be due to the fact that few companies have applied Agile to improve their logistics operations. The findings of this study show that the main challenges of applying operational excellence methodologies in logistics companies were a lack of employee involvement and lack of training. These challenges have also been reported by several authors such as Gutierrez-Gutierrez et al. (2016), Zhang *et al*. (2016), and Kuvvetli and Firuzan (2019) regarding the application of operational excellence methodology in logistics services in The Netherlands, Singapore, and Turkey. It seems that a lack of employee involvement and lack of training are the common barriers when implementing operational excellence methodologies not only in logistics but also in manufacturing, education, and public services. The critical factors that lead to the successful implementation of operational excellent methodologies in Logistics companies worldwide are

top management support and involvement and project sponsorship. These factors are in line with those of previous studies (Shokri *et al*., 2014; Gutierrez-Gutierrez *et al*., 2016).

The third question in this research aimed to identify the tools and techniques of operational excellence methodologies that are commonly used to improve logistics services. The most obvious finding is that most of the tools used by the project team to improve logistics service are non-statistical such as value stream mapping, cause and effect diagram, and brainstorming. These results are in line with those of previous studies such as Gutierrez-Gutierrez *et al*., (2016) and Kuvvetli and Firuzan (2019). It can be considered that advanced statistical tools such as ANOVA, regression analysis and hypothesis testing, have not been applied in this study possibly because of lack of training and guidelines. In contrast to earlier findings, however, Agile tools such as scrum and Kanban, have not emerged from this study which might be because of a lack of application of Agile in Logistics companies.

The final research question was to identify the innovative technologies that have been integrated with operational excellence methodologies to improve logistics performance. The study found that technologies such as RFID, WMS, and RPA have been integrated with LSS tools to improve logistics performance and increase productivity accuracy. These results agree with Buer *et al.* (2018) who concluded that the integration between Lean and Industry 4.0 contributes to an increase in productivity and a reduction in waste and costs. The study also implies that the project team member such as Green Belts and Black Belts needed to be trained to apply industry 4.0 technologies such as big data analytics and machine learning with LSS tools and techniques (Chiarini and Kumar, 2021).

6. Conclusion and Future Research Direction

This study has shown that operational excellence methodologies including Lean, Six Sigma, Lean Six Sigma, Agile and Leagile can apply in logistics companies to improve their operations, productivity and save costs. The most obvious finding to emerge from this study is that value stream mapping is an effective non-statistical tool that can be applied to improve the logistics activities process. The results of this study indicate that top management support and involvement plays an important role in the success of operational excellence project in logistics service. The finding will be of interest to top and middle managers and logistics practitioners owing to the dual aim of improving logistics performance and saving cost. This present study has been one of the first global study attempts to explore the implementation of operational excellence methodologies in Logistics sectors. The findings from this study make several contributions to the current literature. First, this study adds to a growing body of literature on the application of Six Sigma, Lean Six Sigma, and Agile in the Logistics sectors, with Lean having the highest rate of implementation compared with other operational excellence methodologies in the logistics industry (Zhang *et al.*, 2016; Trakulsunti *et al.*, 2022). Second, this research highlights the potential usefulness of operational excellence methodologies and its tools and techniques to improve logistics operations. Prior to this study, few empirical studies have explored the use of operational excellence methodologies in logistics and the integration of such methodologies with innovative technologies to improve logistics performance. Finally, the study will prove useful in expanding a new understanding of how Industry 4.0 technologies can be integrated with operational excellence methodologies to enhance the competitive advantages of

logistics companies. A limitation of this study is that the number of participants from some continent such as Africa was low (Antony, Lizarelli and Machado Fernandes, 2022). This might be because only a small number of companies in Africa are implementing operational excellence methodologies such as Six Sigma (Antony *et al.*, 2019). Notwithstanding the relatively limited sample, this work offers valuable insights into the application of operational excellence methodologies to improve the performance of logistics operations. Future research should be undertaken to compare the application of operational excellence methodologies between the continents. Moreover, future research needs to explore more regarding the application of Agile and Leagile in other key logistics activities.

Disclosure statement

The authors report there are no competing interests to declare.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, [YT]. The data are not publicly available due to the privacy of research participants.

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Reviewers' comments/suggestions	Authors' responses/changes made
Reviewer 2	
1. In the research methodology section why 16 sample size was chosen, what was the rationale. Besides, what was the rationale to choose academic and nonacademic samples.	The authors have clarified these points in the research methodology section. (paragraph 1)
2. How was the data analyzed? Were there multiple raters? What was the interrater reliability? How did authors account for authors bias in qualitative study?	The authors have explained these points in the data analysis part.
3. This study has a lot of practical applications and hence I suggest a section on managerial implications should be added.	The authors have added a section on managerial implications in the discussion and implications section (paragraph 5).