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Original Article

Operational Excellence in Freight Logistics: A Lean Service Case Study Integrating Poka Yoke and Standardized Work

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***Abstract* - *The study examined the shortcomings of bulk freight logistics using Lean Service principles. Previous studies pointed to the need for these logistics' performance indicators and error avoidance tactics, but viable solutions for their combination were not available. This research built a model with the Poka Yoke and the standardized work tools with the intention of solving organizational problems. Notable outcomes were realized in the model, including a 47.54% diminution of delays and a 20%-time delivery increase; the model can enhance productivity and the dependability of the service, The results of the case study analysis, even though focusing on single Peruvian logistics company, show the model's versatility and practical application. The study also aided in achieving operational excellence and customer satisfaction by combining lean methodologies with technology such as GPS. These results reinforce the importance of further research structuring and establishing emerging technologies in IoT and AI to improve logistics systems. In the later research, the issues of time intervals and other dimensions and aspects of different industries should be targeted to ensure growth.*

Keywords* - *Lean Service, Freight Logistics, Poka-Yoke, Standardized Work, Operational Efficiency.

1. Introduction

The freight transportation industry is easily viewed as the backbone of any economy since it oversees the movement of necessary goods from producers to consumers. This sector is crucial not only for external commerce but also in creating jobs and stimulating the economy. If one focuses on the measurements of GDP, the industry over a quarter of economies indicates that freight transportation services are an important part of the economy [1]. In Latin America, the reality is more or less the same: the movement of goods is essential for trade within the region and the international market. However, the region has problems, such as a lack of infrastructure and excessive informality in the sector, leading to low efficiency and competitiveness. [2]. The agricultural and mineral exports are highly important to Peru's economy; mass transportation freight services are an integral sector in carrying out this function. However, it is surprising that the sector encounters notable issues that restrain any prospects for development [3].

In freight transportation organizations focusing on mass consumption, production problems vary and are multifaceted. Low productivity is one of the concomitant challenges in terms of excessive idle time and mistakes in the scheduling of freight services. Such problems reduce operational efficiency and profoundly hamper customer satisfaction [4]. Another major cause of inefficiency is loading products onto transportation units, which takes quite a long time. The cause of these delays can be attributed to the uncoordinated supply chain actors and poor logistical management [5]. In addition, the insufficient availability of transport units and the increased freight cancellations remain issues that threaten firms' fulfilment of the market requirements across the board [6].

Moreover, the lack of transport unit availability and the heightened freight cancellations are still problems, putting the firms at risk of failing to satisfy the market requirements. Solving these issues is vital for enhancing the competitiveness and sustainability of the sector. It is possible to optimize processes and eliminate idle time using Lean Service as an example of the continuous improvement approach [7]. Enhancing productivity while at the same time improving the quality of services provided to clients can be achieved by directing efforts to remove wastage and optimize business processes [8]. Furthermore, implementing modern technologies and staff training are important in addressing the current and future issues of the sector [9]. Furthermore, implementing modern technologies and staff training are important in addressing the current and future issues of the sector [10].

Notwithstanding the significance of these topics, a considerable gap appears to exist within the literature with respect to the use of Lean Service tools in mass consumption freight transport. While there has been empirical work concerning enhancing efficiency in other industries, such as the manufacturing sector, the particular use of Lean strategies in freight transport is still an under-researched area [11]. This research seeks to fill this gap by defining a production system integrating Poka Yoke and standardized work techniques. These techniques will assist in decreasing errors, enhance service quality, and designing more process efficient and sustainable systems [12]. The objective is to enhance the efficiency of the cargo movement and address the challenges by embedding these frameworks into transport logistics, thus ensuring the development of sustainability and versatility [13].

In summation, the quantitative freight distribution industry is essential to the national and international economy but is in need of some assistive engineering. The onboarding of Lean Service techniques into this sector can potentially provide solutions to the issues present. Nevertheless, additional inquiries are necessary to comprehend further how these tools might function in this case. This model will solve the existing issues and ensure sustainability for future perturbances in the sector.

2. Literature Review

2.1. Application of Lean Service Methodology in Logistics

The transport industry encompasses the mass cargo transportation sector, which offers great insights into the application of continuous improvement methodologies with regard to how such practices can enhance the logistical operations of the sector, as argued. Additionally, Mourato et al. [14] have conducted many studies on the Lean Service methodology, in which the transportation industries have also been included. The degradation in the operational efficiency of the processes involved in the internal logistics of bus manufacturing has been reduced and standardized after implementing the Lean techniques mentioned in Mourato et al. [14]. Additionally, Götz et al. [15] The research put forward a framework that aids in determining the most pertinent operational performance indicators specific to logistics, which in turn enables the effective accomplishment of the Lean strategies concerning freight transportation. Moreover, Rodrigues et al. [16] Research on Lean Logistics 4.0 indicates that it is possible to integrate advanced technologies that can complement lean methodology logistics [15]. Lastly, Khmelnitskaya and Bogdanova's [17] analysis of logistics system digitalization underscores the importance of adopting digital methods to improve logistics efficiency, complementing Lean practices.

2.2. Implementation of Standardized Work Methodology

The Standardized Work method is also an important technique for enhancing logistics processes. As per the research done by Piao et al. 2018, Piao et al. [18] further propose a variability efficiency index model for standardization in the context of supply logistics systems, which mainly assessed operational efficiency versus lack of standardization [18]. Moreover, Irfani et al. Elkhodary G. et al. [19] also propose a logistics performance measurement framework that incorporates standardization, which is the major consideration of companies as its scope applies to cargo transport companies with varied roles [19]. Chakrabarty's [20] research relates to the Logistics performance index and complementing or creating standards in various regions, including the transport industry [20]. Finally, Stefanova [21] elaborates on logistics quality and risk management, arguing that standards are vital for risk minimization and enhancing customer satisfaction.

2.3. Error Prevention with Poka-Yoke Methodology

The logistics sector has also taken an interest in the Poka-Yoke approach. The work of Jaiswal et al. on the tendencies of pollution in small and medium enterprises (SMEs) gives an example of how these systems can be useful for improving operational efficiency [22]. Other examples are provided by Saderova et al. [22], who studied the possibilities of influencing optimally formulated tasks for a storage system design using Poka Yoke tools while following certain logistic principles [22]. Kunz and Reiner [23] also add to this final aspect, which they extend to include error prevention in humanitarian logistics and, more evidently, in mass cargo logistics [23]. Finally, Tovma et al. [24] critique supply chain management evaluation practices and sing the praises of these practices for improvement of quality and efficiency in logistics [24].

2.4. Lean Manufacturing and Its Impact on Logistics

Research has widely covered the Lean Manufacturing methodology in developing efficiency in production and logistics. Cost and time savings are readily available in logistics if principles of Lean Manufacturing are in place, as Giner-Baixauli et al. [25] demonstrate in their research. Also, Moons et al. [26] delve into performance indicators selection within hospital supply chains and show that Lean Manufacturing techniques can also help with operational performance in the tanker transport sector [26]. Other researchers like Dybskaya and Sverchkov [27] also focus on one more dimension of their case and claim that lean practices can improve logistics within the distribution network conceptualization context [27]. Finally, Velásquez et al., in their work within regional planning, showcase how Lean Manufacturing implementation in Logistics processes leads to better resource use and sustainability [28].

2.5. Kaizen Philosophy and Continuous Improvement in Logistics

Finally, based on continuous improvement, the Kaizen methodology is essential for developing efficient logistics processes. Otter et al. [29] research on sustainability in logistics highlights how implementing Kaizen practices can reduce costs and improve service quality [29]. Additionally, Marques's [30] study on the linear combination of logistics variables underscores the importance of continuous improvement in optimizing logistics processes [30]. Norstad et al. [31] also suggest that evaluating logistics systems in offshore operations can benefit from the Kaizen philosophy, which is relevant to cargo transportation in complex environments [31]. Lastly, Khmelnitskaya et al. [32] work on building logistics information systems using digital economy methods emphasizes how continuous improvement can be enhanced by digitalization in the logistics sector [33].

3. Contribution

3.1. Proposed Model

The operations management model for the transportation of mass-consumption products, as depicted in Figure 1, is based on the principles of the Lean Service philosophy. This model sought to mitigate some of the critical inefficiencies that were previously established by adding Poka Yoke and work standardization as two primary elements in the mix. The philosophy underscores the necessity of eliminating mistakes from work processes and removing activities that do not add value to the work to support a systematic approach to continuous improvement.

Regarding the first component, Poka Yoke, service errors were to be embedded by a comprehensive analysis of past failures using value stream maps to isolate critical service times. On the other hand, operational tasks were to be redefined and analysed through work standardisation to enable clearly defined, efficient and repeatable processes. This component also identified non-value constituents and assessed value improvements with a new measure that instituted effective service delivery.

The model in question, at its core, sought to improve both productivity and service delivery, which would be in harmony with the client's needs and, more importantly, promote an organisational framework around process efficiency and operational excellence.

3.2. Model Components

The proposed operations management model, illustrated in the attached figure, was designed to address significant inefficiencies in mass-consumption products' transportation services. Rooted in the principles of Lean Service, the model aims to enhance productivity and service quality by systematically minimizing errors and eliminating non-value-adding activities.

This approach integrates two critical components—Poka Yoke and work standardization—that align operational processes with customer requirements while fostering a culture of continuous improvement. The relevance of this model lies in its practical application to transportation operations, offering a structured methodology to tackle delays, inefficiencies, and errors in a sector critical to supply chain performance. By focusing on the unique challenges of this service, the model contributes to the existing literature by demonstrating how Lean Service tools can be adapted and implemented effectively in transportation logistics.

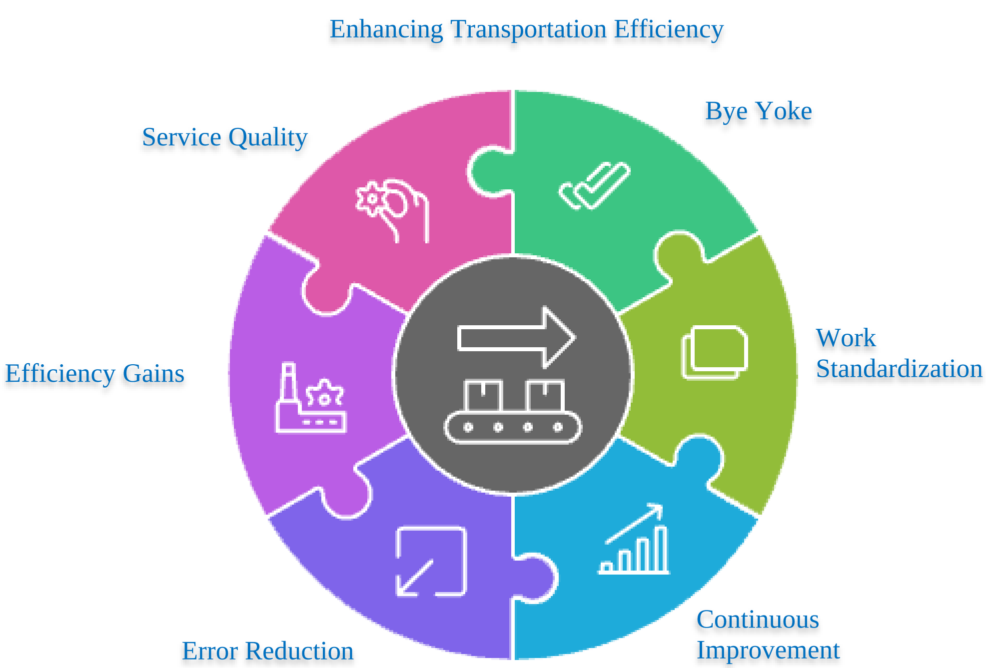

Fig. 1 Proposed model

3.2.1. Component 1: Error Prevention Through Poka Yoke

The Poka Yoke component aimed to rectify the errors that closely recurred in the transportation process and correct the inefficiencies. This component was first developed considering a diagnostic phase, which used Value Stream Mapping to indicate points of error. Then, the design of the component was proceeded with. The model's design was able to visualize the entire flow of the process, enabling them to identify the reasons for the bottlenecks in timings for loading and unloading and service scheduling inaccuracies.

Once the diagnostic process was complete, mechanisms that aided in preventing human errors were devised and out into practice. The actions devised were automated if likely to be prone to human error or further were adjoined with visual and process controls. The example used by the model to ensure this was the introduction of a color-coded system. This enabled the workers to place products into their correct categories and discouraged placing them into incorrect categories. Along with routine scheduling tasks that could easily be forgotten during a manual process solely dependent on human action, these tasks were reduced via automated reminders. These measures proved to be both cheap and easy to implement to professionals.

The regular feedback loops designed to enhance the solutions were integrated into the Poka Yoke techniques. These regular feedback mechanisms also underwent monthly audits that assisted in evaluating their effectiveness and, as required, making adjustments. This resulted in incremental improvements over time. Such a continuous and iterative improvement process ensured that the error-prevention measures were kept up to date with the changing needs of the transportation service. All in all, the Poka Yoke Component comprised one of the core foundations of the model, which rectified the causal factors of the inefficiencies and significantly established a framework through which errors could be mitigated.

3.2.2. Component 2: Enhancing Consistency Through Work Standardization

The second building block of the model describes the standardization of work processes with the goal of increasing the uniformity and productivity of all operational activities. This final stage commenced with an in-depth examination of the current operational activities. It utilized instruments such as the DAP to detail each element of the flow of transportation processes. This examination enabled us to operate on a finer granularity of activities and evaluate some of them as pure redundancies, non-value-added tasks or improperly performed processes.

After this analysis, more concrete measures were undertaken methodologically, first to remove the inefficiencies before standardizing operating procedures. These standards formulation was done in conjunction with the employees from every level of the enterprise to ensure these procedures were achievable while still reflecting ground realities. Specific operational activities like loading and unloading an item were divided into small, definite and consistent sequences of activities that could be repeated. Diagrams and written instructions were formulated for the execution of these chores to reduce the variation when performing the tasks and increase the reliability of the overall processes.

Further, this component also sought to address the need for staff training and capacity development alongside the standardization of the process. Such steps were deemed important because the employees were guided through the various aspects of the process that embraced the new authorities through various training programs.

This training was supplemented by performance appraisals aimed at giving employees constructive feedback and identifying areas for improvement to enhance their skills or abilities further.

Implementation of the standardized work types included selecting and incorporating the report tools. Indicators, such as task completion time and the error rate, were monitored and analysed, developing the best work policy for the economy of these procedures. With the sound and disciplined patters in the execution of the work, the necessary element of standardization further improved the business model by ensuring that best practices were in line with the set goals of efficiency and quality

3.2.3. Outputs and Expected Outcomes

The combination of Poka Yoke and work standardization elements generated several positive results, confirming the success of the proposed model. One of the major results obtained was a substantial decrease in operational wait times, especially during loading and unloading, which eliminates root causes and synchronizes processes. The model has demonstrated significant progress in the time needed to perform transportation services tasks.

Other important outcome was the decrease in errors, which had a positive effect on service reliability and customer satisfaction. Poka Yoke component enabled the reduction of errors from- punctual services: the new error prevention tools And Mechanisms implemented in this component Contributed to Lowering the Levels of Disruptions to Work And Keeping The Services As Planned. Such an improvement not only enhanced the relations with the customers reached but also made the organization explored in the case study more competitive within the transport industry.

There was also an improvement in the consistency of service offerings because of the standardization of job steps. These factors constructed by reducing uncertainty and the presence of operational standards will allow work to flow more smoothly, and forecasting will improve; therefore, the predictability and reliability of the model will improve. Along with the model's strengthening benefits, such standardization has fostered uniformity in other areas of service, such as service resources and employee efficiency.

3.2.4. Continuous Improvement and Sustainability

The proposed model's constantly evolving features were a central pillar that was highlighted as being of great importance to them. Given that the markets and the business problems are constantly in a state of dynamic flux, mechanisms of feedback were incorporated into it to make it suitable for the evolution of time. Employees' inputs and performance reviews were held constantly as well, which were key to the model's success and the fostering of constant collaboration or innovation.

Moreover, the details regarding the model's success were also aligned with the Lean Service principles projected that stressed the importance of minimizing waste and maximizing value. This long-term goal approach taken by the case study helped ensure that there is no reliance on short-term solutions and that all improvements are affirmative in nature and permanent. This approach ensured that the organization and the case study were always prepared for future problems and that their competitive standing in the market was never jeopardized, regardless of the situation.

As per the evidence presented in the case, the use of Lean tools in the transport industry has the potential to bring about meaningful change. With greater operational efficiency and competitiveness in mind, the case supports the claim that Lean tools can help the transport sector achieve savings and overall effectiveness. The functions of these tools, when combined with the principles of Lean Service in transportation logistics, can be considered a breakthrough in standardization error prevention and work standardization, all of which translates into improved productivity and service. For organizations that want to achieve perfection in service delivery and improve their operational performance, this framework is versatile. Its practicality and strong focus on sustainability render it even more useful.

3.3. Model Indicators

To evaluate the effect of the developed business management model on lean service-based operations in small and medium-sized enterprises offering mass consumer freight transport services, relevant metrics were designed to aid in monitoring and evaluating performance throughout the case study, which formed a basis for analysing critical aspects of the freight service, which is meant for mass consumer goods. This systematic approach assisted in performing in-depth analytics of key performance indicators for this sector. This general estimation enabled effective follow-up and helped to ensure that SMEs in this field further refined production processes.

3.3.1. Productivity

This indicator assesses the efficiency of the service against a certain standard based on daily productivity, comparing it with the standard productivity of the sector. It indicates the extent to which the company observes the industry norms and considers some aspects of its performance that need to be improved within the company to comply with the industry limits of competition.

$$\text{Productivity} = \frac{\text{Daily Productivity}}{\text{Sector Productivity}}$$

3.3.2. Product Loading Time

This indicator assesses the effectiveness of the loading activities by determining the fraction of the time spent on one grappling activity, which is the time used for the one grappling activity, to the whole time spent during the loading activity. It indicates wait times and aids in planning the allocation of resources.

$$\text{Product Loading Time} = \frac{\text{On-time Loading Hours}}{\text{Total Hours in Loading Process}}$$

3.3.3. Product Unloading Time

This measure evaluates the efficiency of the unloading stages, estimating the ratio of unloading hours that were completed on time to the overall unloading time. It pinpoints bottlenecks as well as acceleration possibilities for processes.

$$\text{Product Unloading Time} = \frac{\text{On-time Unloading Hours}}{\text{Total Hours in the Unloading Process}}$$

3.3.4. Correct Scheduling

This indicator measures service scheduling accuracy by calculating the proportion of correctly scheduled services over the total services rendered. It shows the trustworthiness and exactitude of timely planning processes.

$$\text{Correct Scheduling} = \frac{\text{Correctly Scheduled Services}}{\text{Total Services Performed}}$$

4. Validation

4.1. Validation Scenario

The validation scenario study was conducted as a case study for a freight transportation company based in Peru that specializes in mass-consuming goods. This organization operated in a very competitive environment and needed to improve its logistics services in order to meet the ever-increasing demand of its customers. The case study company had several important customers in the Peruvian industry, especially in the consumer goods market, and desired to increase its market share by providing them with reasonable rates and reliable means of transportation.

In addressing the problem, its key difficulty was enhancing poor operational level productivity, especially in the fields of service loading, service unloading, and service scheduling. Such problems were reason enough for high costs while the attainment of satisfied clients was compromised; the need for improvement in processes was clear enough. In achieving the above-stated objectives, the research posited the theory that Lean Service tools such as Poka Yoke and work standardization could reduce the identified productivity losses, enhance service quality and maximize return. These results provided a rationale for addressing these issues, particularly with reference to similar enterprises.

4.2. Initial Diagnosis

The evaluation that was undertaken to pinpoint the reasons for lacking productivity in the freight transport service of a Peruvian firm was systemized in nature. The analysis carried out sought Fok to include in its philosophy the ability to pinpoint factors that operate at a suboptimal level with the singular vision of effectively incorporating long-term solutions. To start, the low productivity issue in question costs the firm nearly 9.47% on average when looking at the annual earnings. If we categorize the issues into sets, 53% of the concerns can be classified under unproductive times, 43% fit dependencies with transport units and 4% with miscellaneous smaller factors.

Within the unproductive times, 27% were due to delays in unloading products, followed by 21% related to loading delays, and 5% attributed to mechanical failures in transportation units. On the other hand, logistical deficiencies included 21% due to service scheduling errors, 10% associated with the unavailability of transportation units, and 9% related to service cancellations. This diagnosis highlighted the importance of tools such as Poka Yoke and work standardization to address the root causes and significantly improve operational productivity effectively.

4.3. Validation Design

The proposed production model, which integrates the Lean Service tools, was validated by the pilot validation method. The application of this method lasted four months in the case study, covering all the techniques proposed. These pivots also incorporate the use of the Poka Yoke methodology as well as work standardization. Each of these instruments is elaborated further below.

The solved model was created to impact the inefficiencies observed in the transportation service of Peruvian logistics pertaining to mass consumption goods. Based on the principles of Lean Service, the model’s envisaged effect was to eliminate operational slack and loss of productivity and increase the efficiency of service processes. The design approached the problem at the strategic level, emphasizing the possible incorporation of Poka Yoke and work standardization instruments into the design, along with a systematic approach to eliminate problems deep at the roots. The significance of results-oriented focus, the developed solution, which included radical updates of tools and some amendments of processes, was accompanied by the ability in such contexts to replicate.

4.3.1. Component 1: Development and Implementation of Poka Yoke

This component was divided into three areas – the initiation, error analysis, and application areas. In the initiation area, the appropriate resources and personnel were grouped in accordance with the framework that had been drawn up after the leadership team's endorsement of the objectives of the project. The problem-solving phase employed tools such as Value Stream Mapping (VSM), which were employed to eliminate the constraints - it was established that 83% of the loading times were wasted or occupied by idling - this knowledge helped devise a geofencing, or location monitoring system, that decreased the number of booking errors by 45%.

Further investigation pointed out that certain process disturbances were due to human error in scheduling and a lack of clear communication between the dispatch centres and drivers. To mitigate these, a multi-tier automated scheduling system was deployed, which combined discovered route optimizing software with real time information. This ensured that unnecessary waiting times could be reduced by 25% as the ‘real time’ information provided the opportunity for and encouraged the needed changing of plans when appropriate. The practice of causing errors was also advanced through checklists and automated notifications. These ensured that critical tasks that were necessary to be done before the departure of the aircraft, such as load verification thorough document check completion, which enhanced task completion accuracy by 30%.

In the applied phase, telemetric devices with GPS integration were provided, ensuring location tracking in real time while auto-nabbing notifications. The operators were trained on how to work with these temperatures, which allowed timely measures to be taken when there were delays or disturbances. This multifaceted strategy not only improved operational efficiency but also strengthened accountability and transparency of the process, which led to a 20% improvement in on-time delivery and 15% less fuel usage. Heap rings feedback loops made sure that the strategist was constantly enhanced, with metrics alarms enabling deep-dive monthly reviews of business processes aimed at detection and minimization of resource losses.

Figure 2 depicts the steps employed in the Poka-Yoke system that was used in the transportation process. The following steps were involved: Learning the procedure through value stream mapping and Ishikawa diagrams, entry tracking and checks to identify service errors, activation of service alerts and reports to identify and control the errors detected and to keep the customers informed in a timely manner.

Figure 3 illustrates the implementation process of the Poka-Yoke system in transportation services. It is divided into three phases: initiation, error analysis, and application. Phase 1 identifies process activities and secures leadership commitment. Phase 2 focuses on identifying and selecting critical subprocesses. Phase 3 involves detecting errors, notifying operators, ensuring corrections, and updating the controlled system.

Fig. 2 Phases of the Poka-Yoke system

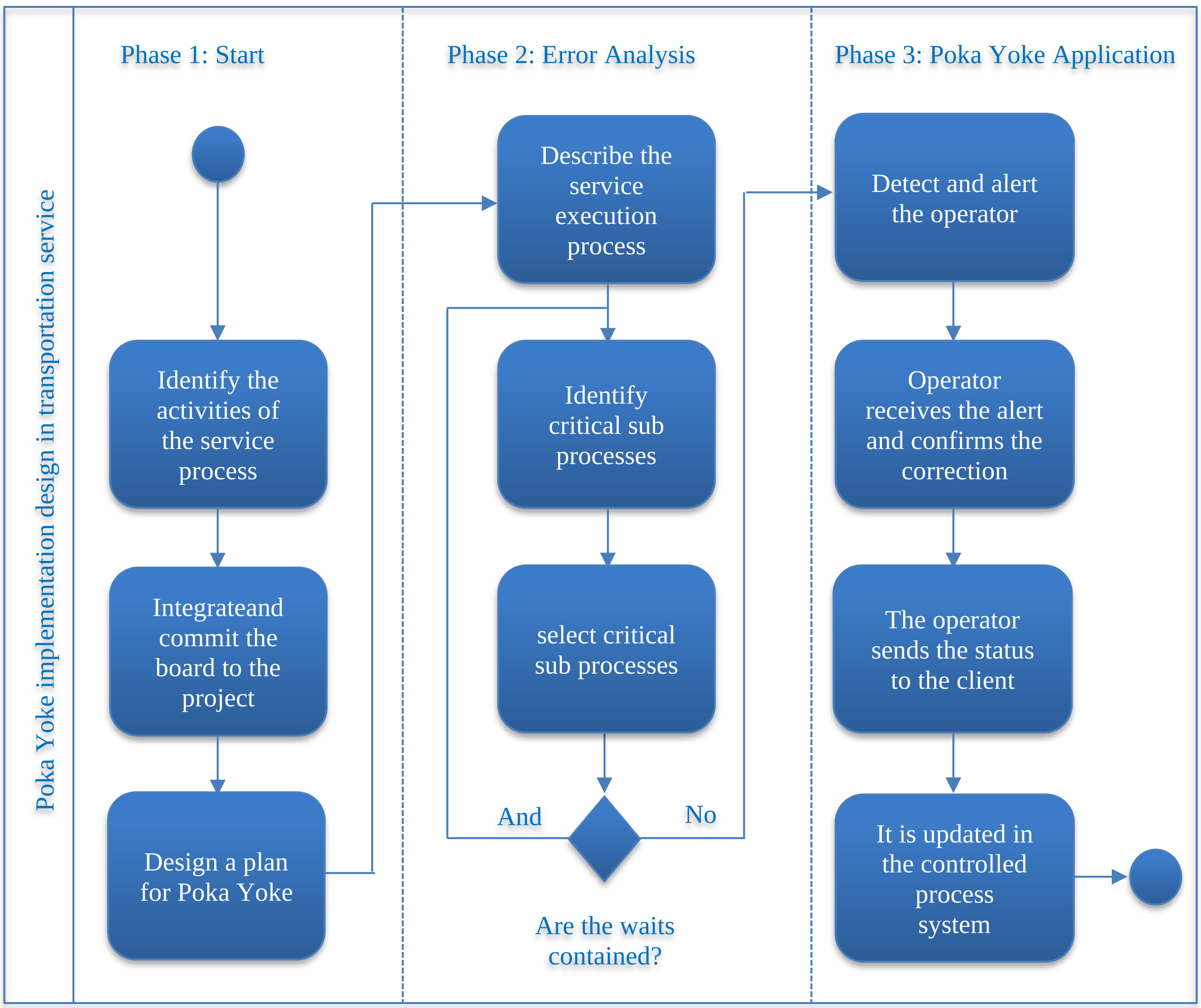

Fig. 3 The implementation process of the Poka-Yoke

Figure 4 illustrates the 2024 Monitoring and Control Model for the transportation service. It includes three main processes: timely arrival tracking (R1), vehicle tracking and verification (R2 and R3), and liquidation tracking (R4). The model aims to enhance fleet productivity by ensuring accurate origin and destination reports and efficient operation monitoring throughout the logistics cycle.

Figure 5 displays the GPS georeferenced location of the operation site in Huachipa, Lima, Peru. The highlighted area represents a warehouse dedicated to the loading and storage of goods. The visual emphasizes the strategic positioning of the facility, supporting logistics and transportation activities within a key operational zone.

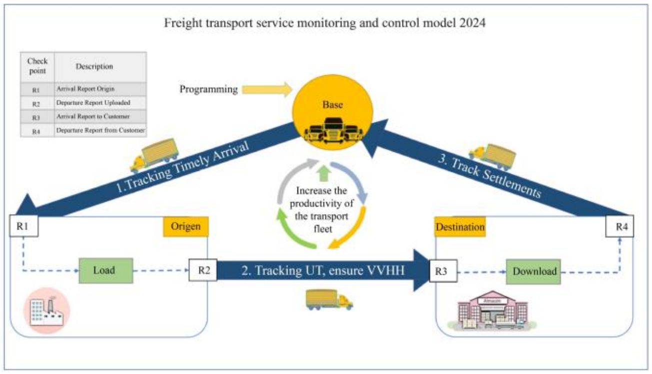

Fig. 4 Model of monitoring and control of the transport service

Fig. 5 GPS location

Table 1. Criteria for activating the Poka Yoke

Time (Hours)	Poka Yoke Status	Action
2.5	Deactivated	No action
2.5 to 4	Activated	Notifies the operator and requires sending a status update to the client.
4 to 6	Activated	Notifies the operator a second time and requires sending a status update to the client.
6 to 24	Activated	Notifies the operator and management.
More than 24	Activated	Notifies the operator, management, and senior leadership.

Table 1 describes the activation process of the Poka Yoke system based on elapsed time in hours and the corresponding actions to ensure operational efficiency and client communication. If the elapsed time is 2.5 hours or less, no action is taken as the system remains deactivated. For periods ranging between 2.5 and 4 hours, the system is activated, notifying the operator and requiring the immediate sending of a status update to the client. Between 4 and 6 hours, a second notification is sent to the operator, again prompting a status update to the client. When the time exceeds 6 but remains below 24 hours, the system escalates, notifying both the operator and management. Finally, for delays surpassing 24 hours, notifications are sent to the operator, management, and senior leadership, ensuring high-priority attention and accountability. This structure ensures proactive monitoring and responsive communication across all levels of the operation.

4.3.2. Component 2: Work Standardization for Consistency

The second component saw the introduction of procedure descriptions for all service activities in attempting to address the inconsistency in task performance within the organization. The employees also attended training workshops to be familiar with institutional regulations, which facilitated the proper execution of procedures. Notable developments comprised a 35 percent decrease in task execution time and a 40 percent increase in satisfaction with the procedures.

The very first action in a bid to standardize operations was a deep examination of the activities already in place, particularly the elimination of duplicate actions alongside the provision of more accurate execution orders. The corresponding analysis shows that such factors may lengthen task time by no more than of up to 28 percent. In order to address these concerns, the construction of technical documents involved aids such as diagrams, videos, and other media tailored to the specifics of the operational realm in question. Written procedure documents were also issued alongside oral details containing information on accurately performing routine operations.

However, such commitment could only be achieved with employee participation in the standardization program. Various focus groups were organized to find out what operational issues employees encountered on a daily basis. Such employee engagement not only brought about ownership of the new standards but also increased compliance with them by 25 percent. In addition, functional cross training of team members was also carried out to cultivate flexibility and prevent overreliance on certain individuals in certain roles.

The consistent evaluation and monitoring of processes and outcomes greatly bolstered the effectiveness of the standardization measures, allowing for their remaining benefits to be sustained. Dashboards were utilized to track performance and associated metrics, encompassing error rates and task completion, showing real-time measures of the efficiency of operations. Weekly meetings were held, which helped discover the problems and rectify them. As demonstrated in the documentation, the general rise and reduction in modification of tasks or activity, repeatedly over time, led to an approximate 50% decline in variance of the tasks. This is further attributed to the efficient functioning of the organization, enabling greater efficiency in workflows and setting a core for sustainability in excellence over the operations.

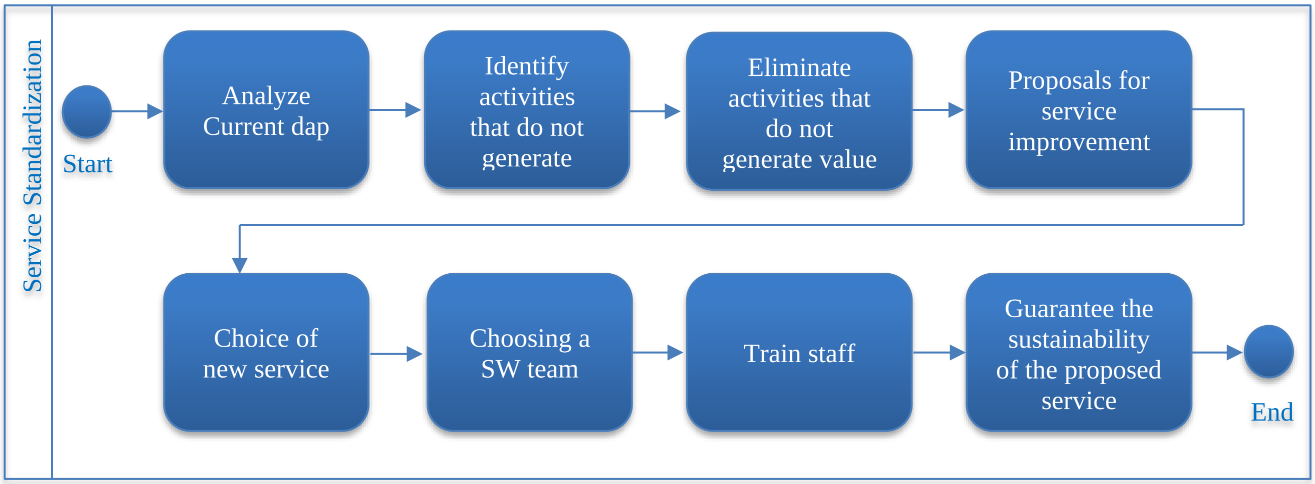

Fig. 6 General model for standardization of transport service

N° ACTIVIDAD	DESCRIPCIÓN	TIEMPO (MIN)	SIMBOLO ●	➡	D	■	▼
1	Solicitar el servicio con las características del servicio(peso, medida, VVHH)	2				X	
2	Recibir el correo con la solicitud	2		X			
3	Registrar el servicio de transporte el BBDD de servicios de transporte	1	X				
4	Verificar en la herramienta de estado de unidades de vehículo y selecciona el vehículo que cumpla con las características del servicio, se encuentre disponible y se encuentra más cerca del centro de carga.	18	X			X	
5	Comunicar vía llamada telefónica con el conductor para comunicar la asignación del servicio de transporte.	2	X				
6	Esperar en la llamada del conductor	2		X			
7	Recibir la llamada y confirma el servicio	2		X			
8	Confirmar la asignación del servicio por WhatsApp para que quede registrado	2	X				
9	Registrar en la BBDD la unidad de transportes y el conductor que va a realizar el servicio.	2	X				
10	Respondre la confirmación del correo con la información al cliente con los datos de las unidad y el conductor(documentos de identidad y licencia)	1	X				
11	Registrar en la BBDD el vehículo y datos del conductor que va a realizar el servicio.	4	X				
12	Actualizra en la BBDD "Servicio de transportes programado"	2	X				
13	Notificar al operador de seguimiento de servicio para que realice la ejecución.	1	X				
14	Presentar un informe al cierre de su jornada qué servicios se han realizado cumpliendo las VVHH solicitas por el cliente y cualquier incidencia en el turno.	3	X				
	TOTAL (MIN)	44					

Fig. 7 Current service scheduling process flow chart

The fundamental structure of transportation service standardization is illustrated in Figure 4. It starts with the assessment of the existing detailed activity process with the goal of determining activities that could be classified as value creating. These non-value-adding activities are then eliminated, and proposals are developed to improve the service. The next phase involves selecting the new service framework, forming a standardization team, and conducting staff training to ensure proper implementation. The process concludes by guaranteeing the sustainability of the proposed standardized service, ensuring long-term operational efficiency and alignment with organizational goals.

Figure 7 depicts the process flow chart for the current service scheduling system, illustrating 14 activities totalling 44 minutes. The process begins with requesting service details and ends with sending the final service status to the client. Key inefficiencies are observed in activity 4, which takes 18 minutes to validate vehicle characteristics, representing the most time-consuming task. Other steps involve communication through emails and calls, verifying task completion, and documenting service details. This flowchart highlights bottlenecks and serves as a baseline for identifying opportunities to streamline the scheduling process and reduce delays, aligning with operational efficiency goals.

Figure 8 presents a process diagram classified by Value-Added (VA) and Non-Value-Added (NVA) activities, highlighting a total duration of 18 minutes for vehicle scheduling tasks. Among the 10 activities, five are classified as VA, while the remaining five are identified as NVA, revealing significant inefficiencies. The most time-consuming activity is task 6, which involves the preliminary selection of vehicles and consumes 3 minutes, classified as NVA. Other NVA tasks, such as verifying the vehicle's location (task 5) and ensuring load status confirmation (task 8), together account for 7.5 minutes. On the other hand, VA actions such as sieving through possible cars and confirming the car allocation serve to achieve operational-nal objectives. The diagram gives a good visual representation of the Non-Value-

Adding and Value-Adding Activities. It thus provides a starting point for re-engineering the processes to reduce waste and improve efficiency.

			CLASIFICACIÓN	
Nº ACTIVIDAD	DESCRIPCIÓN	TIEMPO ACTUAL (MIN)	VA	NVA
1	Abre la herramienta de estado de unidades de vehiculo	1		
2	Filtrar los vehiculos disponibles	0.5		
4	Filtra los vehiculos que cumplan con las caracteristicas Fisicas solicitadas por el cliente	0.5		
5	Filtra los vehiculos que se encuentran más cerca del centro de carga	1		
6	Selecciona de manera preliminar 3 unidades de transportes para el servicio	3		
7	Verifica que el primer seleccionado no cuente con servicio previamente asignado.	9		
8	Verificar si el vehiculo cuenta con asignación	1		
8	En caso si tenga asignado una carga, solicita al supervisor que actualice su estado.	1		
9	Si no cuenta con servicio se le asigna el servicio	0.5		
10	Deja el sistema en stand by para proceder a llamar al conductor y comunicarle el servicio que se le está asignando	0.5		
	TOTAL (MIN)	18		

Fig. 8 Process diagram according to value-added classification

4.3.3. Integration of Technological and Procedural Enhancements

Blending procedural improvement with technology is the reason for the model's success, which can be seen when using GPS devices. This not only made it possible to monitor the undertaking in real time but also provided the necessary intelligence advanced for efficiency improvement. At the same time, people used standardized procedures to ensure the absence of operational inefficiency. Cumulatively, these pieces came together to form a resilient structure that could accommodate quickly changing logistical requirements.

4.3.4. Quantitative Outcomes and Validation

Such an implementation resulted in statistically meaningful improvements. Namely, the productivity index grew by 11% from 60% to 71%. Also, the time spent on loading and unloading was reduced by 47% and 58%, respectively. Turnaround time errors were reduced by 25%, resulting in improved customer satisfaction and service reliability. These measures were considered indicators of the effectiveness of the Lean Service model and raised the issue of its applicability to larger units.

4.3.5. Future Prospects and Scalability

To maintain the developments achieved, further education and constant evaluations were suggested. The application of forecasting models, along with sophisticated scheduling algorithms, can further improve the functionality of the model. Due to its robustness, flexibility and global nature, this framework serves as a metric for improving operational performance in other contexts.

4.4. Results

In Table 1, the impact of the operations management model based on the Lean Service philosophy is shown, demonstrating significant improvements in key indicators. Productivity increased from 60.00% to 71%, while loading and unloading times improved notably, achieving reductions of 58.33% and 47.54%, respectively. However, correct scheduling slightly decreased, reflecting a -3.26%, which suggests additional areas for optimization. This analysis confirms the effectiveness of the proposed model in addressing identified problems, significantly improving operational times and service levels, although some aspects still require further adjustments.

Table 1. Results of the pilot

Service Productivity Indicator	As-Is	To-Be	Results	Variation (%)
Productivity	60.00%	98.50%	71%	18.33%
Product Loading Time	60%	98%	95%	58.33%
Product Unloading Time	61%	98.50%	90%	47.54%
Correct Scheduling	92%	99%	89%	-3.26%

5. Discussion

The findings of this study support the existing literature by showing the positive effects of Lean Service and error-preventive techniques on operational activities. Similar to the findings of Mourato et al. [14], which showed the potential of Lean techniques for the uniformity of logistics functions for bus manufacturers, this study demonstrated the measured increases in service delivery alongside productivity through the application of Lean tools. Moreover, Götz et al. [15] drew attention to the importance of the performance indicators in the assessment of the performance of logistics frameworks; this research confirms those findings by providing hard evidence, such as the 47.54% improvement of the loading and unloading times. Moreover, Rodrigues et al. [16] stressed the role of modern technological solutions with the concept of Lean Logistics 4.0, a concept well demonstrated here by the application of GPS systems to improve current position and decision-making. Finally, the error prevention techniques of this research will be noted by the Jaiswal et al. [22] papers. They will demonstrate the importance of Poka-Yoke devices for reducing waste and errors in logistics processes.

5.1. Study Limitations

As encouraging as this research may be, it has a few shortcomings. First and foremost, the verification process was limited to a single logistics company in Peru; therefore, the results could not be replicated across other sectors or regions. Furthermore, the model was meant to be implemented and evaluated within four months, which nullifies the model for its lack of long-term impacts and sustainability. Furthermore, an overreliance on a specific set of tools proves to be problematic as a vast majority of SMEs may not have access to similar expert resources and or advanced technologies, which adversely affects scaling. Lastly, resistance from employees in terms of adopting any new practices turned out to be a problem, which might explain the level of compliance and adaptation, pointing to the need for more research in change management practices.

5.2. Practical Implications

The research is beneficial in a pragmatic sense for the professionals in the field of logistics. Firms can realize improvements in their productivity, ranging from 60% up to 71 %, by employing Lean Service techniques. Technologies such as GPS tracking devices and real-time data analytics not only provide enhanced operational visibility but also allow managers to make timely and accurate decisions in scenarios of service failure. In addition, the focus on error omission and standard work procedures provides a basis and opportunity for systematic application geared towards the reduction of variability and improvement of service delivery. Such practical aspects put the proposed model in a position to be relevant to SMEs in their quest to remain relevant in a fast-growing industry.

5.3. Future Works

Future studies should check the flexibility of the suggested model in different sectors and locations so that it can be fine-tuned to be more widely applicable. Additional investigative analysis is advised to confirm the durability of the architecture developed and quantify its prospective improvements. Supplementing technology like IoT and artificial intelligence may also assist in improving the flow of operations by providing a good structure for futuristic analytics and resource management. Bearing in mind the existing scenario, targeting employee perceptions and resistance to change may also have important implications for raising the adoption rate of the model and its operational efficiency within distinct organizational settings. Such kind of research can additionally tackle transformational issues in the logistic and operational management landscapes.

6. Conclusion

The research brings to attention the utilization of Lean Manufacturing and Total Productive Maintenance (TPM) tools, which can help resolve structural issues faced by small- and medium-sized textile enterprises. It emerges that there was a lowering of defect product rates by 77.63% and an improvement in the productivity of the work by 27.72%. In addition, work organization, determined by the extent of application of 5S rules, increased by 83.67%. These figures demonstrate the extent of success the organizational model designed would have in operational effectiveness, quality of products manufactured and maintaining the sustainability of the practices instituted. Moreover, in settings where SMEs are frequently short of resources, the model's ability to accommodate the specific needs and constraints of the diverse range of SMEs is vital.

This study demonstrates its significance in the industrial engineering discipline by contributing evidence on the applicability of these methods in a given context. The combination of Lean and TPM takes care of some of the managerial problems like defect reduction and equipment downtime and helps to change the culture of the organization. This mixed strategy, which involves machine and human factors, helps to keep the outcomes in good shape in the long run. In addition, the integrative nature of the framework supports the interpretation of how these tools can be transformed and used across a range of industries, including textiles, that have been limited in earlier research.

The key original contribution of this study is the specification and testing of an integrative model in which Lean and TPM tools are combined, which was developed specifically for the textile sector within SMEs. This model provides not only a solid basis for the development of processes in the company but also adds to the body of knowledge by giving an empirical evaluation of the practical aspects of the model. Such developments in quality, productivity, and changes in the organization's culture validate this model's logic and make the model practical and applicable to the niches associated with the operational problems of SMEs. In addition, the study notes how essential ongoing skill development for workers and their involvement in improvement activities is for the strategy over the medium and long term.

As a last remark, the research brings out diverse avenues for future research as well as application in other domains. Although the results are encouraging, I highly recommend attempts to investigate the reproducibility of the model across different sectors and geographies to test for its robustness. Besides, longitudinal studies would also be helpful in ascertaining the macroeconomic and operational effects over a period of time so as to enrich understanding of the benefits that might accrue. In addition, the impact that was achieved could also be improved using new technology, such as IoT sensors, for better operational management and improving operational efficiencies. Lastly, there is a need to explore in much detail the views and experiences of the employees on the use of these tools to gain a better understanding of their acceptance and success in different types of organizations.

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