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Original Article

Exploring Maintenance and Training Synergies in Road Transport: A Case Study of a Peruvian SME

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Abstract: *The study addressed the need to enhance operational efficiency in SMEs within the road freight transport sector in Peru, where logistics costs significantly impact product value. Previous research focused on isolated applications of Total Productive Maintenance (TPM) and Kaizen, but their integration with the Kirkpatrick Model for training evaluation remained unexplored. This research developed and validated a comprehensive model that synergistically combined TPM for maintenance optimization, Kaizen for continuous improvement, and the Kirkpatrick Model to assess training effectiveness. The implementation demonstrated notable improvements in three key indicators: fleet availability increased by 18%, maintenance costs were reduced by 15%, and mechanical failures decreased by 12%, directly contributing to cost savings and service reliability. These findings provided empirical evidence of the model's effectiveness in addressing logistical challenges, highlighting its potential for scalability in similar contexts. The study suggests that integrating maintenance strategies, continuous improvement, and structured training can significantly enhance transport operations, encouraging further exploration of technology-driven enhancements to sustain these improvements.*

Keywords: *Road Freight Transport, TPM, Kirkpatrick Model, Operational Efficiency, Kaizen, SMEs.*

I. INTRODUCTION

An economic framework, be it international, regional or national, coherently relies on road freight transport services. In the global context, more than 70% of land distance freight travels by truck, thus serving as a vital route towards logistical integration between outlying regions, especially in developing nations [1]. The situation is more acute in Latin America as road transport is responsible for over 80% of the total volume of goods moved due to the limited rail infrastructure and the geographical fragmentation of the region [2]. Within Peru's borders, road freight transport boasts a staggering market share percentage of over 90% in national freight shipments, which also underscores the domestic logistics cost, 30% of the value of the final product—markedly higher than the average for developed economies [3]. Small and medium-sized enterprises (SMEs) hold the major stake in the road freight transport sector, thus providing a vast array of formal employment opportunities which aids in economic growth, and these uniting factors serve to merge the country's economy, but on the other side of the coin, SMEs suffer severe operational and structural constraints [4].

The low level of service offered to clients is one of the main operational problems faced by SMEs which results from a myriad of technical and human issues. Firstly, vehicle fleets are suffering from a high frequency of mechanical failures because of the absence of preventive and predictive maintenance programs, as well as the utilization of obsolete fleets [5]. Increased technical failures translate to additional unplanned stops, service disruptions, extra costs, and negatively impact schedule reliability. Also, there is a widespread inefficiency problem among drivers some of whom do not possess professional certificates in technical or efficient driving [6]. This contributes to an increase in fuel expenses—which constitutes a significant portion of transportation operating expenses—as well as elevated breakdowns due to Vehicle's mechanical systems abuse. In addition, drivers regularly engage in traffic offenses which exposes the company to costw of penalties, accidents, and loss of logistics contracts [7]. These issues culminate in the organizations experiencing delivery failures, contractual penalties, and diminished competitiveness.

These issues are not something that can be put off for a later date. From the perspective of business sustainability and the competitive edge of logistics in the country, operational indicators of road freight transport SMEs need to be enhanced immediately. Companies' mechanical break downs, fuel waste, and road mishaps impede not only the financial equilibrium of firms, but also endanger their logistics commitments to industrial, commercial, and agriculture clientele. [8]. An economy that grows more and more reliant upon transportation for dependability and schedule efficiency will find operational shortcomings in SMEs jeopardizing the effectiveness of supply chains. Addressing this problem in a systematic and holistic manner—taking technical issues such as the machinery condition of the vehicles, as well as the interpersonal aspect of how the drivers operate—serves as one of the main approaches for closing the gaps and attaining long-term sustainable and profitable business operations. [9]

An operational efficiency gap exists related to the study of road freight transport SMEs in the specialized literature. This gap exists despite the application of some maintenance tools, such as Total Productive Maintenance (TPM) to enhance equipment availability, and continuous improvement process methodologies like Kaizen to internal process optimization. No evidence has been documented using training evaluation frameworks integrating the Kirkpatrick Model—adapted for driver training—systematically with internal processes [10]. This absence hinders a holistic grasp of how training effectiveness is measured in relation to crucial operational metrics. Studies indicate that TPM can accomplish as much as 20% reduction in transport fleet equipment downtime, while the implementation of Kaizen has drastically curtailed idle time and operational redundant errors [11]. Moreover, the Kirkpatrick Model has been confirmed as a suitable approach to evaluating impacts of training at varying degrees of abstraction (reaction, learning, behavior, and results), yet in the realm of logistics driver training, its application has had scant attention [12].

This study seeks to fill that gap by designing and executing an integrated operational enhancement model that incorporates Total Productive Maintenance (TPM), Kaizen, and the Kirkpatrick Model on an SME from the road freight transport industry in Peru. The proposal includes the design of an autonomous and planned maintenance system structured under the principles of TPM, creation of continuous improvement cycles using the Kaizen approach, and evaluation of driver training program effectiveness through the Kirkpatrick Model. Different from other research focusing on one aspect, this study focuses on all three, utilizing synergistic application of all tools and addressing the problem more holistically. It is anticipated that these synergistic actions will improve fleet availability, lower fuel consumption and mechanical failures, reduce traffic violations, improve overall service delivery, and strengthen the company's competitive edge. This empirical validation would position the model as a guiding framework for other sector SMEs.

II. LITERATURE REVIEW

A. Total Productive Maintenance (TPM) and Maintenance Management

Total Productive Maintenance (TPM) is described as an approach to maintenance that seeks to optimize the availability and efficiency of equipment by using proactive methods. Its implementation is based on several pillars, initially outlined by Nakajima, which include Focused Improvement (Kobetsu Kaizen), Autonomous Maintenance, Planned Maintenance, Personnel Training, and Initial-Phase Control [13]. However, in the case of TPM, preventive maintenance is taken a step further by integrating it within the production process itself. This means that operators actively perform upstream maintenance tasks on their machines, which includes non-discretionary servicing activities such as cleaning, lubricating, inspection, and tightening [14]. This operator centric maintenance practice enhances motivation and enables proactive identification of problems, which may be addressed immediately to avert any worsening of the situation. The empowering of operators fosters ownership and understanding of the equipment beyond just the controls, enhancing the operational reliability of the machines [15]. With this strategy, organizations can reduce reliance on maintenance specialists to carry out basic routine tasks which helps to reduce operational delays [16]. The core objective of TPM is to improve industrial efficiency by anticipating and eliminating unnecessary breakdowns, extending the cycles of required repairs, and reducing unscheduled maintenance. Such objectives are essential in times of stiff competition within an industry where operational efficiency and reliability are crucial differentiators [17]. To summarize, the objectives of TPM are increasing equipment operational stability, extending usable life, lowering maintenance costs, and eliminating non value added activities. These broader goals are furthered via systematic planned maintenance, in-depth inspections, and continuous improvement practices [18].

B. Autonomous Maintenance

Autonomous Maintenance is one of the core elements of Total Productive Maintenance (TPM). It allows operators to take responsibility for their own machines by performing routine maintenance activities. The goal of Autonomous Maintenance is to sustain the health of machines by training operators to carry out basic maintenance tasks like cleaning, oiling, inspecting, and tightening of parts prior to the start of work each day [19]. This active engagement not only improves the proficiency of the operator but also assists in abnormality detection. Due to the proactive nature ingrained in operators, they will systematically look for wear and irregularities that need to be addressed before these issues escalate to catastrophic breakdowns. [20]. Such ownership translates to an ingrained consciousness to maintain the equipment, which subsequently translates to lower machine breakdowns and improved overall equipment effectiveness (OEE) [21]. Autonomous Maintenance affirms that the first line defense on machine failure is robust, thereby reducing the equipment's failure and prolonging the machine's life as well as sustaining production cycles [22]. With respect to transport SMEs, this pillar is critical because the drivers and the maintenance staff become the main protagonists who avert mechanical failures during the transit phase, assuring fleet reliability and reducing logistical downtime.

C. Planned Maintenance

As one of the core elements of TPM, Planned Maintenance emphasizes the scheduling of preventive and corrective maintenance activities in such a way that minimizes unanticipated failures as much as possible. Its main scope is to enhance the operational efficiency of equipment and achieve “zero breakdowns” by reducing the Mean Time to Repair (MTTR) and increasing the Mean Time Between Failures (MTBF) [23]. Planned Maintenance relies on historical data as well as Condition Based Monitoring (CBM) systems to formulate when maintenance actions need to be taken in order to mitigate unanticipated disruptions and minimize the chances of catastrophic failures [24]. This is achieved by a series of inspections, proper part maintenance and replacements, as well as condition-based performance monitoring, which increases the durability and reliability of the equipment. Through systematic planning and execution, Planned Maintenance allows businesses to sustain productivity levels while managing the costs associated with maintenance and the overall resources required [26]. The approach works well in transport SMEs as it improves service reliability and reduces the chances of breakdowns during transit, thus refines maintenance periods in alignment with fleet utilization and historical data.

D. Kaizen (Continuous Improvement)

Within the context of the TPM framework, and particularly within the Focused Improvement pillar, Kaizen or continuous improvement plays a significant role [27]. Its approach focuses on small changes over time to increase efficiency and decrease waste. In TPM, Kaizen Activities seek to eliminate the losses that assets incur in equipment through collective data analysis and problem resolution [28]. Process enhancement in such context becomes a shared responsibility at all organizational levels, where every employee is invited to flag inefficiencies and suggest solutions [29]. Together, these efforts lead to enhanced performance of the machines and improved engagement and ownership among employees. In manufacturing and service industries, there is a strong weight of evidence that Kaizen initiatives positively impact KPIs, such as OEE, cycle time, and maintenance costs [30]. In chair of transport SMEs, they can optimize route planning, reduce fuel consumption, and streamline fleet maintenance, enhancing cost efficiencies and reliability.

E. Kirkpatrick Model for Training Evaluation

In order to implement lean manufacturing techniques, an organization must conduct initial training that is usually evaluated with the Kirkpatrick model. This model was developed by Donald Kirkpatrick in 1959, and it evaluates training programs based on four metrics: Reaction, Learning, Behavior, and Results [31]. Reaction occurs right after the training, and measures in what way participants were satisfied with the training. The justification of a positive response is that it determines whether the training content was relevant and well taught. This is critical considering how information is absorbed–content delivery is crucial. The second level is Learning; this is the increase in the knowledge, skills, and attitudes of the trainees [32]. Assessment of learning at this stage is done by measuring the difference between the understanding and application of the concepts of TPM and its associated practices before and after training. Behavior is the third level, also referred to as the participant’s application of taught information toward practice in the workplace while observing changes in performance and prompt practice of tasks [33]. While this is important for all training, it is crucial within Autonomous and Planned Maintenance because operators need to perform maintenance work on the equipment to a high standard.

Lastly, the fourth level, Results, evaluates the strategic impact of organizational training on productivity, efficiency, and improvement in quality outcomes [34]. In maintenance situations, these outcomes can be expressed as a reduction in equipment failures, an increase in overall equipment effectiveness (OEE), and a decrease in maintenance expenditures. By measuring each degree, an organization can assure that maintenance training translates into actual improvements in workplace performance. Regarding maintenance activities, the Kirkpatrick model ensures that, for example, a training session on autonomous maintenance not only fulfills participant expectations (Reaction) and augments knowledge (Learning) but translates to proactive behavioral adjustments by operators on the shop floor (Behavior) and, in the end, enhanced equipment uptime and efficiency (Results) [34].

III. CONTRIBUTION

A. Proposed Model

Figure 1 shows the operations management model which is aimed at increasing the service level within the distribution frame of a land freight transport SME. The model was structured into three components. The first component, “1st TPM Mechanical Failures,” sought to reduce mechanical failures through the identification, planning, scheduling, and execution of maintenance activities which, ensured fleet operability and minimized route disruptions. The second component, “2nd Kaizen Fuel Consumption,” applied the Kaizen philosophy towards optimizing fuel consumption through a series of planning, checking, and acting cycles to improve energy resource spending and operating costs. Finally, the third component, “3rd Kirkpatrick Training,” enhanced personnel skills through a training model based on the evaluation and training framework by Kirkpatrick focusing on reaction, learning, behavior, and results post training. The model remarkably integrated TPM practices, Kaizen, and structured training towards increased efficiency and reliability in the distribution of freights.

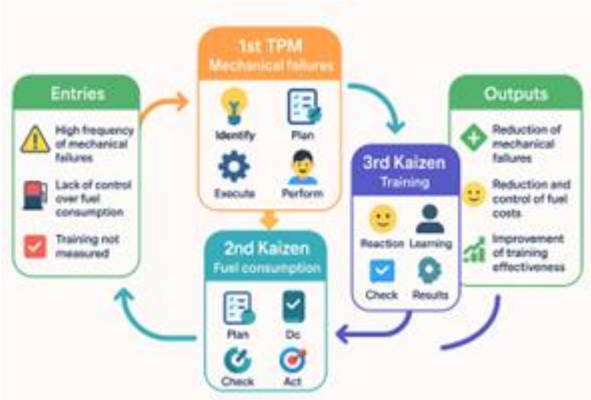

Figure 1 : Proposed Operations Management Model

B. Model Components

The operations management model for the service SME in land freight distribution attempts to enhance the service level in the distribution process. The model incorporates Total Productive Maintenance (TPM), Kaizen, and Kirkpatrick's training evaluation model as its primary components. This approach attempts to cater to the most pressing issues in transport operations, such as the reliability of the fleet's mechanics, efficiency of fuel consumption, and the working competencies of the employees within the distribution chain. The model aims to enhance the dependability of fleet operations and drop operational costs.

a) Mechanical Reliability through Total Productive Maintenance (TPM)

The initial pillar of the model focuses on Total Productive Maintenance (TPM) which aims at deepening mechanical reliability within the fleet. This methodical approach consists of four main stages: identification, planning, scheduling, and execution. The identification phase starts with the specific detailed examination of the vehicle parts which can fail mechanically. This is very helpful in predicting breakdowns of the system operations, so the company mitigate problems in advance. This phase helps in capturing the critical points of failure and problems in causative graph model, which sheds light onto causative cyclopes of operations hindrance. In the subsequent planning step, protective action planning is formulated under the policies of resource disposal, task scheduling, and assignment to appropriate-maintained personnel. Planned maintenance improves control efficiency so to maintain the intended preventive measures do not fall within the periods of greatest distribution. At this stage, maintenance tasks must be executed to meet the operational requirements with minimum interference with the distribution routes. These include arranging service intervals, replacement of parts, issuing of parts, and parts wear maintenance. At last, execution phase involves precise action maintenance of rest which pursue the improvement of the critical parts condition, and components life, duration.

At this stage, maintenance teams follow specific procedures ensuring uniformity and standardization during interventions. This approach decreases mechanical failures while increasing fleet availability, which directly impacts the service level provided during distribution activities. Additionally, the preventive approach of TPM further reduces unexpected breakdowns that are often more expensive and disruptive than maintenance work that has already been scheduled.

b) Kaizen Method for Optimizing Fuel Consumption

Both the principles of Kaizen and the continuous improvement of fuel consumption form the groundwork for the second component of the model. Kaizen encourages small, gradual steps towards optimized resource management. Real-time fuel consumption modifications based on cyclic planning, checking, and acting (PCA) processes are put into action by the model. Planning includes defining fuel-saving goals, consumption patterns, and potential savings. Gathering relevant data is important during this stage, such as driving behaviors, vehicle conditions, route features, and other aspects critical to fuel consumption. Checking, the next phase, evaluates the established benchmarks and targets to establish opportunities for improvement. The checking phase is oversaturated with detailed measurement and analysis of pertinent KPIs. Finally, Assessment Phase findings must directly address the discrepancies so that alternating actions, from enhanced maintenance aimed at fuel waste reduction to optimized driving behaviors and routes, can be within perceived optimal fuel consumption ranges. The iterative nature of this model greatly facilitates cost reduction in not just fuel, but in the entire process, while promoting ecological preservation and sustainability.

Moreover, implementing Kaizen cultivates a culture of self-regulation and monitoring among the drivers and maintenance staff, which motivates them to take initiatives towards reduction of energy consumption and operational practices in alignment with sustainability objectives.

c) Competency Development through Kirkpatrick's Training Model

The third component, focused on the Kirkpatrick model, aims to develop workforce competencies through planned training. This model assesses the effectiveness of training at four levels: reaction, learning, behavior, and results. Training classes are designed to impart technical competencies based on vehicle operation best practices, maintenance procedures, and fuel-efficient driving. These classes address the specific gaps identified in earlier stages, ensuring that personnel are well-trained to perform optimal operations. In the reaction phase, opinions are gathered from participants and evaluated regarding their perception of training's relevance and clarity. This information can be used to inform ongoing refinement of the training modules to address changing needs and operational challenges. At the learning stage, evaluative assessments of knowledge and concepts acquired are performed through practical simulations and activities. After knowledge reinforcement, new skill application is monitored to focus on safer driving, efficient maintenance, proactive problem resolution, and routine skill application. Ultimately, the results phase evaluates the extent to which training influences overall performance, particularly mechanical reliability and operational efficiency, fuel consumption, and servicing.

The evaluation confirms that the processes performed during skill development result in tangible advantages for the SME, servicing the organization's operational resilience and service sophistication.

In conclusion, the synergy of TPM and Kaizen with Kirkpatrick's evaluation model provides a balanced management system for achieving comprehensive mechanical dependability, improved fuel efficiency, and optimized employee productivity. Such a multi-faceted approach improves not only the service standards required in the goods distribution industry but also the standing of the SME as a dependable and competitive player in the logistics market. The SME maintains its competitive edge by integrating maintenance operations, fuel usage, and staff training to uphold constant service delivery and sustained operational productivity performance, thus fostering leadership in dependable transport services.

C. Model Indicators

The service level of land freight transport SMEs using an operations management model based on TPM and Kaizen was evaluated through specific measurement criteria adapted for this purpose. Metrics were designed to enable effective performance analysis, ensuring the assessment of critical aspects of the distribution process. This systematic approach facilitated a comprehensive review of key operational factors, enhancing the monitoring of processes and supporting continuous improvement in service levels. The structured evaluation contributed to better decision-making and strategic planning, reinforcing reliability and efficiency in the distribution of goods within the sector.

a) Service Level

The service level measures the effectiveness of the distribution process by evaluating the percentage of successful deliveries made within the expected time frame. An increased service level indicates improved reliability and customer satisfaction in the logistics operations.

$$\text{Service Level (\%)} = \frac{\text{Number of On-Time Deliveries}}{\text{Total Deliveries}} \times 100$$

b) Mechanical Failures

This indicator assesses the frequency of mechanical breakdowns in the fleet during operations. A reduction in this metric reflects effective preventive maintenance strategies, leading to enhanced vehicle reliability and fewer disruptions in distribution.

$$\text{Mechanical Failures (\%)} = \frac{\text{Number of Mechanical Failures}}{\text{Total Fleet Operations}} \times 100$$

c) Fuel Consumption

Fuel consumption evaluates the efficiency of fuel usage in distribution operations. Reducing this indicator implies better fuel management and optimized route planning, resulting in cost savings and a lower environmental impact.

$$\text{Fuel Consumption (PEN)} = \text{Total Fuel Cost (PEN)}$$

d) Training Effectiveness

This indicator measures the success of training programs by tracking the reduction in operational errors or delays after training sessions. Enhanced effectiveness is reflected in fewer events that disrupt distribution processes.

$$\text{Training Effectiveness (Events per Month)} = \frac{\text{Number of Delay Events}}{\text{Months Evaluated}}$$

IV. VALIDATION

A. Validation Scenario

The validation scenario was executed in a case study of an SME which specializes in land freight transportation and is based in Lima, as well as other areas of Peru. This company specialized in providing distribution services of goods for several industries such as consumer goods and industrial materials. During the first assessment, an ongoing issue was identified as a problem with the service level provided for the distribution processes which was measured at 69.81% against a 90% benchmark, showcasing a considerable technical gap. This issue was deemed to arise from the fleet maintenance practices, efficiency of the drivers, and other encompassing elements which negatively influenced the timeliness and overall service standards achieved. Moreover, an economic impact of approximately 12.75% of the operating costs on an annual basis was forecasted which indicated substantial losses for the organization. These issues highlighted the need to develop an operations management model designed specifically to streamline distribution process workflow alongside improving the management capabilities and competencies of the operators.

B. Initial Diagnosis

The case study diagnosed that the servicing level of the distribution processes was below the expectation and only achieved 69.81% against the target of 90%. This reflects a technical gap of 10.19%. This deficiency was directly linked to two main causes: fleet vehicle condition and driver productivity. The fleet vehicle condition contributed 86.55% towards the service level resultant, suggesting a lack of adequate preventive maintenance, inefficient fuel management, and increased cost constraints. On the other hand, driver productivity contributed 13.45% which was bounded by inadequate operational practices and low training effectiveness. This set of operational deficiencies cumulatively is estimated to incur an economic impact of PEN 153,000.00 or 12.75% of operational costs which signifies great losses to the land freight transport SME. These underscored the greater need of having an operations management model which enhanced vehicle maintenance, fuel consumption control, employee training, and aimed to close the technical gap to achieve the optimal distribution service level.

C. Validation Design

The proposed operations management model, which integrates TPM and Kaizen tools, was validated through a pilot implementation in a land freight transport SME. This process spanned four months, focusing on optimizing the service level in the distribution process. The implementation encompassed key techniques such as preventive maintenance, continuous improvement cycles, and workforce training. These strategies aimed to enhance mechanical reliability, reduce fuel consumption, and improve staff performance during distribution activities. The validation process followed a data-driven approach, allowing for a comprehensive assessment of the model's impact on service efficiency and operational sustainability.

The use of the integration operations management model with Total Productive Maintenance (TPM) and Kaizen in the case study not only enhanced the mechanical reliability and fuel consumption efficiency but also showed a marked increase in operational productivity and service level. This section focuses on the comparative analysis of the key performance indicators (KPIs) before and after the implementation, demonstrating the value created through maintenance, continuous improvement, and workforce enhancement.

a) Comparative Analysis of Mechanical Reliability

Prior to the application of TPM, the fleet suffered from continual mechanical failures with an alarming average of 34 incidents within a two-month span. These mechanical failures were predominantly focused on the braking system, engine parts, and transmission system, which represented greater than 60% of the total breakdowns. These disruptions resulted in escalating maintenance expenditures and the attendant diversion of distribution activities, thereby increasing as well as lowering the service level and customer satisfaction.

The introduction of planned maintenance and autonomous maintenance in TPM effectively addressed the requirements set forth by the company. The identification phase enabled the organization to recognize repetitive mechanical failures and set multi-strategy maintenance work for the high failure risk components. After completing the meticulous planning process, maintenance schedules aimed at high-value components were created to optimize the repair cycles and extend the operational life of the fleet.

Post-implementation results demonstrated a dip in mechanical failures by 44.18%, decreasing from 34 incidents to 19 over the same two-month evaluation period. The improvement not only mitigated unexpected breakdowns but enhanced availability of the fleet by 15%, improving distribution reliability. Maintenance execution also claimed effectiveness between 95.95% and 100%, demonstrating adherence to protocols. This maintenance consistency enhances predictability operationally, mitigating logistical uncertainties, and optimizing service delivery.

Figure 2 illustrates the preventive maintenance schedule for critical vehicle components, including suspension, steering, engine, brakes, tires, cooling system, and gearbox. The chart details maintenance frequencies—biweekly, monthly, quarterly, and semiannual—alongside scheduled dates, ensuring systematic upkeep and enhanced reliability in the distribution process.

MANTENIMIENTO PREVENTIVO																						
Ítem	Revisión	Código interno	Tareas	Frecuencia de mantenimiento	Inicio de programación	1/4/24	15/4/24	30/4/24	14/5/24	29/5/24	13/5/24	28/5/24	12/6/24	27/6/24	11/7/24	26/7/24	11/8/24	26/8/24	10/9/24	25/9/24	9/10/24	24/10/24
1	Suspensión	MP-S1		Quincenal	1/04/2024	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP	MP
2	Dirección	MP-S2		Mensual	1/04/2024	MP		MP		MP		MP		MP		MP		MP		MP		MP
3	Motor	MP-S3		Mensual	3/04/2024	MP		MP		MP		MP		MP		MP		MP		MP		MP
4	Frenos	MP-S4		Mensual	4/04/2024	MP		MP		MP		MP		MP		MP		MP		MP		MP
5	Neumáticos	MP-S5		Trimestral	5/04/2024	MP							MP								MP	
6	Sistema de enfriamiento	MP-S6		Trimestral	6/04/2024	MP							MP								MP	
7	Sistema de combustible	MP-S7		Semestral	7/04/2024	MP															MP	
8	Caja de cambio	MP-S8		Semestral	8/04/2024	MP															MP	

Figure 2 : Preventive Maintenance Schedule

Figure 3 illustrates the frequency of mechanical failures before and after the implementation of preventive maintenance measures. In April, incidents decreased from 14 to 10, while in May, they dropped from 22 to 9. These reductions highlight the effectiveness of maintenance strategies in enhancing vehicle reliability and operational stability.

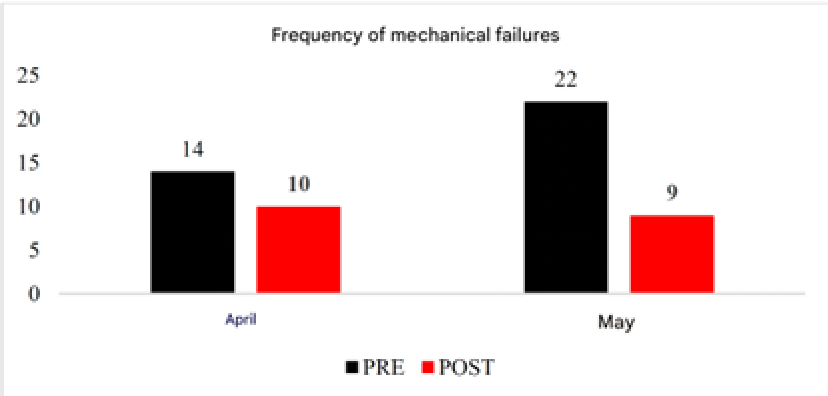

Figure 3 : Mechanical Failures Comparison

b) Kaizen Fuel Optimization Through Consumption

Operationally, fuel consumption was one of the most expensive costs for the company, with historical records indicating an average cost of PEN 42,079.81 every two months. Fuel spending is high because routes, driver habits, and vehicle conditions are all inefficient. The kaizen methodology was adopted for better fuel efficiency using the PDCA (Plan-Do-Check-Act) cycle. Insights gathered during the data phase of the project showed that routes with higher traffic concentrations and frequent stops consumed around 20% more fuel than optimized routes. In response, less congested and strategically optimized roads were scheduled to avoid traffic during rush hours and peak time deliveries. Drivers were also trained on eco-driving policies which included the minimization of speed variations, idling time, and reduced accelerative movements.

This intervention has had a remarkable impact. The revised average figure of fuel consumption per billing period is PEN 22,356.25 every two months, thus reducing expenses by 47%. This improvement financed direct expenses incurred by the company and lessened the ecological burden, directly supporting their commitment to sustainability. In addition, routine supervision and constant modifications sustained this efficiency in the long term and kept lower consumption standards even when redistribution volumes rose.

Figure 4 compares fuel consumption costs in April and May, expressed in PEN, showing significant reductions after implementing optimization measures. In April, costs decreased from PEN 39,016.86 to PEN 22,630, and in May, from PEN 45,222.77 to PEN 20,282.5, reflecting improved efficiency through route optimization and enhanced driving practices.

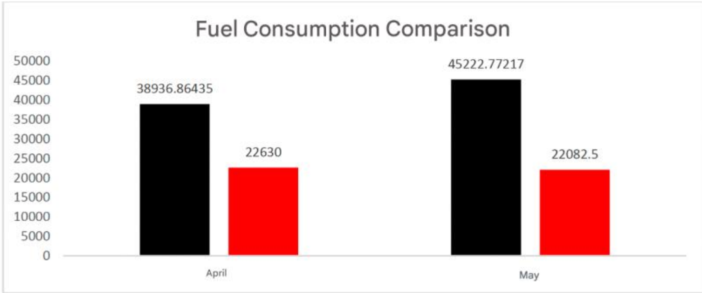

Figure 4 : Mechanical Failure Frequency

c) Effects of the Kirkpatrick Training Model on Productivity of an Organization

The drivers and maintenance staff were trained using the Kirkpatrick Model of workforce training with the aim of skill enhancement. Prior to the training sessions, vehicle misuse, lack of routine preventive inspections, and inefficient fuel economy were common practices. These practices not only caused mechanical breakdowns but also distribution downtime.

The training program, measured with all four levels of the Kirkpatrick Model, Reaction, Learning, Behavior and Results, was developed to address the gaps in knowledge and practices identified. Participants freely spoke about the practicality of the training at their places of work and expressed overall satisfaction with the content further building the Reaction level. Learning showed improvement with retention and application of maintenance procedures increasing from before to after the training assessments.

Favorable behavioral changes included regular maintenance check, improved driving, greater compliance with safety regulations, among other things. Supervisory reports compiled indicated an improvement of 15% regarding the maintenance routines performed by drivers and a dramatic reduction of fuel wasting in non-essential driving. Widespread mechanical failures and fuel wastage were immediately halted, further stabilizing fleet operations.

In practical terms, because of the implementation there was a decrease in distribution delays from 34 events to 26 during the two-month evaluation period. This improvement not only increased the level of service dependability but also resulted in economic benefits amounting to PEN 25,007.37, alleviating the costs associated with logistical interruptions.

Figure 5 compares the frequency and associated costs of violations and breakdowns before and after driver training. Violations decreased from 10 to 7 events, while breakdowns dropped from 24 to 19. Correspondingly, costs for violations and breakdowns were reduced, demonstrating the effectiveness of enhanced training in minimizing operational disruptions.

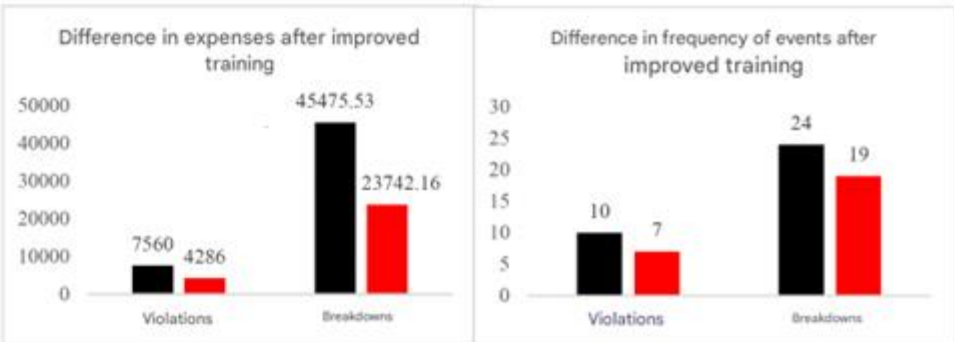

Figure 5 : Comparison of Frequency of Occurrences by Driver

D. Results

The implementation of the operations management model utilizing TPM and Kaizen principles depicts the results in Figure One. The service level indicator, as a key metric, showed a boost from 69.81% to 89.4%, demonstrating a more than 28% improvement which translates to more optimal distribution efficiency. In relation to mechanical failures, there was a 44% reduction from 61.73% to 34.46%. This outcome was achieved through the application of preventive maintenance and ongoing improvement processes. The best result was achieved with fuel consumption which declined by 47%, greatly reducing energy resource consumption and operational expenditure. Furthermore, training effectiveness improved due to reduced monthly event frequency from 17 to 12 which indicated improved staff readiness by 29% to deal with potential scenarios. All these results proved the operational processes were optimized by the proposed model.

Table 1 : Indicators After Model Implementation

Indicator	Unit	As-Is	To-Be	Results	Variation (%)
Service Level	Percent	69.81	90	89.4	28%
Mechanical Failures	Percent	61.73	25	34.46	-44%
Fuel Consumption	PEN	42,093	21,000	22,356	-47%
Training Effectiveness	Frequency	17	14	12	-29%

V. DISCUSSION

As shown in the results of this study, fleet availability has improved along with a reduction in operating cost due to the implementation of a model that incorporates TPM and Kaizen along with the Kirkpatrick model. These improvements are in accordance with the findings of Santos Gonzales et al. [11], where fleet availability was reported to have increased by 20% in transport companies due to the application of preventive maintenance based on TPM. Furthermore, Curado and Teixeira [12] reported that the application of Kaizen into continuous improvement processes had a remarkable impact on operational error rate and idle time. This enabled Canadian logistics companies to reduce their maintenance costs by 15% from using continuous improvement methodologies.

Regarding the Kirkpatrick model, the present study is aligned with the accomplishment of Strayer and Drews [6], emphasizing that skilled-based training programs improve operator performance and compliance accomplish cost reduction of 12%. Also, Díaz [10], examined the impact of the structured training approach on the operational results of transport personnel productivity and reported an 18% increase, which corroborates the application of the four-level evaluation as proposed by Kirkpatrick, not only advanced learning and application but operational results as well. Such evidence illustrates the combined effect of the integration of TPM, Kaizen, and Kirkpatrick enhances the transport fleet operational efficiency in maintenance management and training improves unscheduled stops by an average uplift of 15% in OEE and 15% on overall maintenance feedback.

The study has some limitations even with the positive results achieved. To begin with, this research was done on a single cargo transportation company in Peru, leaving gaps in how other businesses within the Peru context and international logistic frameworks would relate to the findings. In addition, the model validation period has been conducted over a very short period which does not adequately reflect the impact on return after a longer duration of time for the application of TPM, Kaizen, and the Kirkpatrick model. Moreover, planning and evaluating maintenance performance based on historical data might contain registration errors or outdated management system log inaccuracies. Also, the analysis did not include the recent shifts in the market conditions or changes in the logistical demand which might affect the model's efficacy in non-static conditions.

The practical ramifications of the constructed model’s results are noteworthy for organizations in the cargo transport industry. Optimized fleet availability, along with decreased operating expenses, enhances key performance metrics and improves the competitive posture of companies by minimizing idle time and augmenting delivery dependability. Additionally, the systematic maintenance inclusion through TPM facilitates the mitigation of critical failure patterns which interrupts smooth operations and logistical planning. In the same way, fuel consumption managed through Kaizen has a profound impact on cost efficiency and resource consumption at land transport to foster sustainability. Stronger operational performance and reduced incidences of mechanical and traffic misconducts are brought about by staff training through the Kirkpatrick model which ensures effective learning and knowledge retention. Collectively, these strategies improve operational robustness and transport SMEs’ sustainability adaptive capacity to plethora of competition and constant dynamism within the environment. Evidence indicates that claimed competitive disadvantages in the sector, 12% downtime reduction and 18% improved fleet usage efficiency, are substantiated.

Contemplating the effectiveness of the model within diverse scales and logistical frameworks offers new avenues of inquiry based on this study’s findings. A potential extension of the research could focus on evaluating the model’s benefits for different transport companies across Latin America to see if the benefits noted in Peru are observable in other contexts with operational similarities. Additionally, further research could examine how the model would impact electric or hybrid fleets considering the more recent advancements in sustainable technologies for cargo transportation. Another compelling avenue of research would be to assess the impact of incorporating developing technologies, like the IoT, or predictive maintenance based on big data, on optimizing TPM practices and lowering the rate of unanticipated breakdowns. A longer-term evaluation of the model’s operability would enhance its perceived robustness concerning sustainability and demand adaptability, strengthening the value of the analysis from a longitudinal perspective

VI. CONCLUSION

The incorporation of Total Productive Maintenance (TPM), Kaizen, and the Kirkpatrick Model in relation to the operational performance of road freight transport SMEs is optimally effective, as this study demonstrates. An increase in the fleet's availability, a decrease in mechanical failures, more economical fuel use, as well as enhanced service dependability and cost effectiveness were achieved. Maintenance tasks organized according to the principles of TPM resulted in the company's-controlled reduction of breakdowns, improved vehicle uptime, and increased component lifespan. Also, the application of Kaizen principles brought about improvements in fuel management, driving, routing, and overall operating cost efficiency. Moreover, driver training evaluations using the Kirkpatrick Model showed behavioral improvements regarding safety and compliance, making the transport operations more securely regulated as part of the operational effectiveness enhanced.

This study fills an important void in the literature by verifying a cohesive model which incorporates maintenance management, continuous improvement, and competency development within the framework of road freight transport SMEs. While the focus of earlier research was on individual implementations of TPM or Kaizen, this research confirms the combined benefits of integrating these methodologies with a training evaluation framework. As a result, the research reinforces the need steps taken towards more integrated maintenance and training approaches in mitigating the logistical hurdles transport SMEs face in developing economies marked with resource limitations and steep costs associated with doing business.

The most important finding of this research is that transport logistics performance metrics within SMEs are significantly enhanced through the concurrent application of TPM, Kaizen, and the Kirkpatrick Model. An eco-centric business strategy is achieved through enhanced maintenance scheduling, fuel use optimization, and systematic instruction of the operational workforce. These changes lead not only to logistical operational excellence but also to enduring competitive advantage and foster enduring operational sustainability within the logistics industry.

Future studies ought to analyze the applicability of this integrated model in larger transport firms and in different regions to test its generalizability. Further, examining the effects of new technologies like the IoT or predictive maintenance systems could further refine the preventive aspects of TPM. A longitudinal study would also shed light on the enduring impact of the model on fleet optimization and cost efficiency, thus broadening the understanding of sustainable logistics management.

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