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Improving performance measurement through quality management in logistics 4.0: case of a smart port

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Abstract: This research project focuses on improving logistics performance in the context of Logistics 4.0, by implementing the use of quality management principles. In addition, the study looks at international companies operating in the port of Tangier Med. The objective is to measure the impact of improving overall performance on overall business results, taking into account quality standards, management tools and the effectiveness of decisions made. The research will take a quantitative approach by examining logistics performance improvement variables in a 4.0 context. It focuses on how the integration of quality management methods can influence business performance. This study contributed to the development of scientific research in the field by providing tangible information and quantitative data on the impact of improving logistics performance in an international environment. The results of this research aim to provide innovative solutions for international companies operating in the port of Tangier Med. By combining the concepts of Logistics 4.0 with quality management practices, companies could benefit from a significant improvement in their operational efficiency and overall results. Ultimately, this research project has contributed to the promotion of best practices and the adoption of innovative approaches in the field of Logistics 4.0, thus providing competitive advantages to companies operating in this sector. A quantitative methodology was adopted. Surveys of 300 employees at the port provided quantitative data.

1 Introduction

The advent of Logistics 4.0 has revolutionized the way companies manage their operations, highlighting the integration of technology and automation to optimize workflows and improve efficiency. In this constantly changing environment, the focus on improving performance becomes paramount to maintaining competitiveness on the global stage. It is with this in mind that this research project aims to examine in depth the improvement of performance in the field of logistics 4.0, highlighting the importance of quality management methods. More specifically, this study focuses on a relevant case: that of international companies established in the port of Tangier Med. This port, as a major hub for international trade, provides an ideal setting to explore how quality management principles can be applied to strengthen logistics performance in the era of Logistics 4.0. The methodological approach adopted for this research is based on an in-depth quantitative study. The use of surveys of 300 employees working in the port made it possible to collect rich and varied quantitative data. By measuring the key variables related to improving overall performance, this study aims to assess the impact of quality management methods on the results of companies operating in the port of Tangier Med. By contributing to the development of scientific research, this study aspires to open new perspectives in the field of logistics 4.0. By taking a close look at how global companies can benefit from integrating quality management principles, this research aims to provide innovative solutions to optimize operational performance and overall results. This study offers an informed vision of the opportunities and challenges in the quest for a more efficient and competitive 4.0 logistics in the dynamic context of the port of Tangier Med.

2 Literature review

Logistics 4.0, as an integral component of the fourth industrial revolution, represents a paradigm shift in global logistics and supply chain management. It integrates emerging technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, cloud computing, and cyber-physical systems to create intelligent, responsive, and highly interconnected supply chains [2-6]. In the port environment, these technologies enable real-time monitoring and optimization of cargo flows, significantly reducing delays and operational bottlenecks while improving the coordination between multiple stakeholders including shipping lines, terminal operators, customs authorities, and logistics service providers [3-7]. The deployment of smart sensors and automated handling equipment enhances the precision and speed of cargo operations, while AI-driven predictive models facilitate better resource planning and decision-making, particularly in large and complex port infrastructures like Tangier Med [8,9]. Moreover, the integration of blockchain technology within Logistics 4.0 ecosystems ensures greater transparency, traceability, and security of transactions, thus reducing the risks of fraud and administrative errors that often hamper international trade operations [10]. These technological advancements not

only streamline operations but also contribute to the environmental sustainability of ports by optimizing energy consumption and reducing carbon emissions through intelligent route planning and automated systems [11,12]. However, despite these promising opportunities, the adoption of Logistics 4.0 faces several challenges such as resistance to change, a lack of standardized protocols, and the need for upskilling human capital to manage and operate these advanced systems effectively [13,14]. Consequently, ports embracing Logistics 4.0, such as Tangier Med, position themselves as strategic nodes in global supply chains, enhancing their competitiveness and resilience in the face of ever-evolving market demands and technological disruptions [13,15,18].

2.1 Logistics 4.0 and its impact on ports

Logistics 4.0 is based on a complete digitalization of logistics activities, facilitating real-time operations and dynamic decision-making across the entire supply chain. By leveraging advanced technologies such as big data analytics, artificial intelligence (AI), and the Internet of Things (IoT), it promises a significant improvement in port performance in terms of speed, reliability, and traceability [1,2]. In the specific context of ports, the integration of smart IoT sensors enables continuous data collection on cargo status, equipment usage, and environmental conditions, allowing operators to anticipate congestion, optimize resource allocation, and prevent delays. Collaborative digital platforms enhance communication and coordination between shipping companies, terminal operators, and customs services, thereby streamlining administrative procedures and reducing vessel turnaround times [16]. Intelligent management systems further support predictive maintenance, automate container handling operations, and improve inventory management, ensuring better space utilization and reducing human error. These technological advancements collectively contribute to maximizing quay capacity, enhancing operational efficiency, and strengthening the port's competitiveness on an international scale. However, the successful adoption of Logistics 4.0 in ports is not without challenges. Resistance to change often stems from the reluctance of traditional actors to modify established workflows and adopt new digital tools. Moreover, the absence of global standards for data exchange and technology interoperability complicates the seamless integration of these systems. Ports in developing regions, in particular, face additional barriers due to limited technical skills and insufficient investment in infrastructure and training, which hinders the full realization of Logistics 4.0 potential [17-23]. Addressing these challenges is crucial for ports aspiring to become smart, resilient, and competitive hubs in the global logistics network.

2.2 The role of quality management in logistics performance

Quality management (QM) focuses on the implementation of standards, processes, and approaches to continuously improve the performance of organizations [18-24]. In a port environment, QM can enhance the reliability of operations, minimize human and technical errors, and improve customer satisfaction [11-19]. The adoption of international standards such as ISO 9001 in ports helps structure and standardize logistics processes, thereby promoting proactive management and increased responsiveness.

These principles are equally applicable in complex operational settings, such as ports, where the efficiency of logistics and operations significantly impacts the broader supply chain. In a port environment, quality management is crucial for maintaining smooth and efficient operations, which directly influence the reliability of services provided to customers. By focusing on quality, ports can reduce both human and technical errors, which are common sources of delays and inefficiencies. This can range from minimizing mistakes in cargo handling and documentation to ensuring the timely maintenance of machinery and equipment. Through the systematic application of QM principles, ports can significantly enhance operational reliability, reduce operational costs, and improve the safety and security of both workers and cargo. Furthermore, adopting internationally recognized quality standards such as ISO 9001 is an effective way for ports to standardize their processes. ISO 9001, with its rigorous focus on process control, customer satisfaction, and continual improvement, provides a structured framework for ports to assess and optimize their operations. This global standard promotes a consistent approach to managing quality, fostering transparency, accountability, and collaboration between different departments and stakeholders within the port ecosystem. Additionally, it strengthens a port's competitive advantage by ensuring that it meets international expectations, thereby attracting global business partners and customers.

The adoption of ISO 9001 and other quality management practices can also lead to increased responsiveness in port operations. With a structured system in place, ports can more easily adapt to changes in demand, emerging challenges, and unexpected disruptions, such as weather events, labor strikes, or supply chain shifts. This proactive approach ensures that ports remain agile and can quickly implement corrective actions or improvements where necessary. Ultimately, the integration of quality management practices not only elevates the operational standards within ports but also enhances customer satisfaction by ensuring the timely, efficient, and reliable delivery of services.

2.3 Interaction between Logistics 4.0 and quality management

Quality management acts as a key lever to maximize the benefits of Logistics 4.0. Advanced technologies such as AI and data analytics improve quality control systems by enabling early detection of anomalies and process optimization [4-23]. Ports that adopt a strategy combining Logistics 4.0 and QM see improvements in their key performance indicators, including reduced operating costs, increased productivity, and increased stakeholder satisfaction.

Several case studies show how modern ports, such as Rotterdam and Hamburg, have integrated Logistics 4.0 solutions while relying on quality frameworks to optimize their performance. These ports have notably invested in digital platforms to coordinate logistics actors and ensure full traceability of goods [16]. In North Africa, ports such as Tanger Med are also beginning to adopt this combination to position themselves as competitive logistics hubs [18].

3 The specific impact of Logistics 4.0 on global supply chains

The emergence of Logistics 4.0 has profoundly transformed global supply chains by integrating cyber-physical systems, the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and advanced automation [5-21]. These technological advancements are no longer limited to operational support but have become strategic assets that redefine global trade and supply chain management.

One of the most significant impacts of Logistics 4.0 is the enhancement of supply chain visibility. Real-time tracking systems and connected devices enable continuous monitoring of goods flows from production to final destination. This capability improves demand forecasting, supports proactive decision-making, and strengthens the resilience of global supply chains, particularly during disruptions such as port congestion or health crises [21-26].

Furthermore, Logistics 4.0 fosters process optimization and resource efficiency. The use of smart sensors, autonomous vehicles, and predictive maintenance reduces operational costs and downtime while improving asset utilization. This optimization contributes to faster transit times, lower inventory costs, and increased flexibility in supply chain operations [20-25].

Another essential aspect is the integration of blockchain technologies, which enhances transparency and trust among global supply chain stakeholders. Blockchain secures transactions and documentation, reduces fraud risks, and accelerates customs clearance processes — a crucial advantage for large transshipment hubs like the Port of Tangier Med [18-27].

Logistics 4.0 contributes to supply chain sustainability by enabling data-driven environmental optimization. Advanced analytics help reduce fuel consumption and emissions through route optimization, thus meeting growing environmental and corporate social responsibility demands [28]. However, these benefits come with challenges. Data standardization, interoperability, and digital skills gaps remain major obstacles to the full deployment of Logistics 4.0 within global supply chains [29,30]. Diverse technological capabilities across international actors can hinder seamless integration and limit the expected efficiency gains.

The impact of Logistics 4.0 on global supply chains is transformative. By enhancing visibility, operational efficiency, transparency, and sustainability, while also demanding significant organizational adaptation, Logistics 4.0 provides a competitive edge to major logistics hubs like Tangier Med Port, reinforcing their position as pivotal players in international trade [18].

4 Materials and methods

The literature highlights that major shipping companies operating at the Tanger Med container terminals include Maersk Line, CMA-CGM/Delmas, Hamburg Süd, Hapag Lloyd, ARKAS, and Tanger Alliance [1]. Tanger Med Port has four container terminals with a total capacity of 9 million TEUs, making it the leading container port in Africa and the Mediterranean by volume. In 2022, it handled 7.6 million TEUs, ranking as the fourth most efficient port globally according to the Global Container Port Performance Index (CPPI). The port is connected to 174 ports in 74 countries [18] and serves as a strategic hub for transshipment and trade, particularly for Morocco's import/export activities. Tanger Med I connect the port to inland areas via rail and highways, enhancing its role in the region’s logistics network.

Maersk Line, founded in 1928 and headquartered in Copenhagen, Denmark, began operations at Tanger Med in 2005. As the largest container shipping company globally, Maersk operates a fleet of 639 ships and handles approximately 12 million containers annually. In 2016, Maersk reported a net income of $20.7 billion and invested $822 million to improve Tanger Med’s infrastructure. APM Terminals, also part of the Maersk Group, has operated at Tanger Med since 2005 and handles 43% of transshipments and 48% of container movements at the port.

The CMA-CGM Group, founded in 1978 and based in Marseille, France, started operating at Tanger Med in 2008. With 449 ships and 29,000 employees, the company handles 15.6 million TEUs globally. CMA-CGM/Delmas operates at the second terminal of Tanger Med in partnership with EUROGATE, Contship Italia, and MSC. In 2016, CMA-CGM/Delmas managed 16% of container movements at Tanger Med, a significant increase from 13.4% in 2014.

Hamburg Süd, established in 1871 and headquartered in Hamburg, Germany, has operated at Tanger Med since 2008. With 177 ships and a capacity of 4.3 million TEUs, Hamburg Süd handles around 7% of the port's container

movements. The Maersk Group acquired Hamburg Süd in 2016.

ARKAS, founded in 1996 and based in Istanbul, Turkey, began operating at Tanger Med in 2008. The company's fleet of 39 vessels handles containers from Europe, Africa, the Middle East, and recently South and Central Asia. Arkas contributes 3-4% of container movements at the port.

Hapag-Lloyd, headquartered in Hamburg, Germany, is the fifth-largest container shipping company globally. Operating at Tanger Med since 2006, Hapag-Lloyd contributes 9-10% of the port's container movements and transshipments.

X-Press Feeders, founded in Singapore in 1972, began operating at Tanger Med in 2008. With a fleet of 110 vessels, X-Press Feeders handles about 2% of the port's transshipments and 5% of container movements.

The aim of this study is to explore how quality management can improve logistics performance, particularly for international companies operating at Tanger Med Port. By measuring performance improvements and applying quality management tools, the study will assess the effectiveness of management decisions, contributing to scientific research and the development of innovative solutions for Logistics 4.0.

For data processing, we chose to use SPSS software for this study due to its ease of use and accessibility, although it has some limitations compared to more advanced software. SPSS is known for its user-friendly interface, making it particularly suitable for researchers and practitioners who are not necessarily experts in statistics or programming. This simplicity allowed us to focus more on data analysis without wasting time mastering complex software, which was essential for our study. In addition, SPSS performs well for standard statistical analyses such as correlation tests, regressions, t-tests, and analyses of variance, which were sufficient to meet the needs of our research. The software is also widely validated in academia, making it a reliable choice for basic to intermediate quantitative analyses. However, we are aware that SPSS has limitations compared to software like R or Python, which are better suited for processing large amounts of data or for more advanced statistical analyses, such as machine learning or complex models. In terms of flexibility, SPSS offers fewer possibilities than these other tools, as it is less customizable and less powerful for certain nonparametric analyses or advanced models. In addition, the cost of using SPSS can be a disadvantage, especially in comparison to R or Python, which are free and open source. Nevertheless, due to its effectiveness for simple to moderate analyses, its availability in many academic institutions, and its robustness, SPSS was a pragmatic choice for our study. For future analyses requiring more sophisticated tools, we may consider using more advanced software like R or Python.

5 Results and discussion

In the software industry, the developers will never state that the product is free of imperfections, dissimilar to other modern item makers generally do. This distinction is because of the accompanying reasons.

5.1 Technical performance and quality management within port terminals

A Pearson correlation is used when it is necessary to find a relationship between two or more variables and check if there is significance (p-value <0.05). There can be a positive or negative correlation between two or more variables. So, if the value exceeds the significance level of 0.05, a null hypothesis should be accepted, and if the value does not exceed the significance level, the alternative hypothesis can be accepted. To use a Pearson correlation; the variables should be both quantitative and the research hypothesis should be about linear relationships. Thus, for each increase in the independent variable, the dependent variable will also increase. In this part of the chapter, the correlation analysis was assessed between technical, organizational and governance factors (independent variables) and the level of (dependent) significance.

Table 1 shows the correlation coefficient between the technical services provided at the Tanger Med port, the level of services and the challenges that guide port operations. Correlation analysis is basically done to assess the interrelation between two quantitative variables and to analyze the statistical association between them. From the table, it can be assumed that the technical support variables have a high Pearson correlation. However, the p-values of 'Transport vehicles' (0.040), 'Equipment and facilities are automated' (0.021) and 'Beachside cranes' (0.025) indicate that these variables are significant at the 0.05 level. . Thus, it is shown that these variables have a confidence interval of 95% and that since they do not exceed the level of 0.05, they reject the null hypothesis and are consistent with the alternative theory. In addition, the p-values of "the water depth of the port" (0.001), "the length of the quay is suitable" (0.000), "the volume of cargo handled by the port" (0.000), "The quality and the quantity of transport and transfer equipment used in the port are sufficient and efficient for good port performance" (0.001), "Port containerization" (0.000) and "stacking equipment" (0.000) indicate that these variables are significant at the 0.01 level. Thus, the variables are consistent with the alternative theory and reject the null hypothesis.

Table 1 Correlation analysis statistics for technical services at Tanger Med Port

		Niveau du service
Terminal water depth	Pearson correlation	0.463**
	sig. (2-tailed)	0.001
	N	50
Mooring length is suitable for vessels of all sizes	Pearson correlation	0.592**
	sig. (2-tailed)	0.000
	N	50
The quality management of the cranes used are optimal for handling incoming containers	Pearson correlation	0.473**
	sig. (2-tailed)	0.001
	N	50
Containerization at the Terminal	Pearson correlation	0.542**
	sig. (2-tailed)	0.000
	N	50
stacking equipment	Pearson correlation	0.514**
	sig. (2-tailed)	0.000
	N	50
Management processes	Pearson correlation	0.291*
	sig. (2-tailed)	0.040
	N	50
Equipment and facilities are automated	Pearson correlation	0.327*
	sig. (2-tailed)	0.021
	N	50
The volume of goods handled by the terminal	Pearson correlation	0.697**
	sig. (2-tailed)	0.000
	N	50
Available seaside cranes are effective	Pearson correlation	0.317*
	sig. (2-tailed)	0.025
	N	50

Regression analysis of post-correlation studies was also conducted to test effective variables that influence overall port operations. With studies of regression models, ANOVA and regression coefficient, was done to predict that the dependent variable, Level of services, influences port operations at Tanger Med port. An analysis of the regression coefficients was performed to check the importance of the predicted variable and how the predicted variable is influenced by the independent variables.

5.2 ANOVA model and statistics between technical services and port operations

Statistical correlation analysis of organizational services provided by Tanger Med port authorities has been shown in Table 4.20. From the statistical analysis, it was found that all the factors have very high Pearson correlation values and variables like; “Online customs service is available” (0.754), “Transactions are available online” (0.749), “The quality and quantity of transport and transfer equipment used in the port are sufficient and efficient for good performance port” (0.723) and “Loss settlement” (0.711) were proven as they were able to achieve the highest Pearson correlation values. Furthermore, the p-values for these variables were also found to be 0.000, which means that the variables are significant at a level of 0.01 and a confidence level of 99%. Other Pearson low correlation variables such as, "Customs service" (0.581), "Availability of port accessibility information online" (0.543), "Vessel movement can be tracked online" (0.521) and rest of the variables also showed significance at a level of 0.01 and a confidence level of 99%. Thus, one can interpret that, since the variables have p-values less than 0.05 and do not cross the threshold, the variables can accept.

Table 2 shows the regression coefficient evaluated between the factors and the level of services at the Tanger Med port. Thus, from the table, it was found that "Mooring length is suitable" (0.000), "Port containerization" (0.015), "Stack equipment" (0.011) and "Volume of goods handled by the port” (0.001) have a positive and significant value (<0.05), which implies that an increase of one unit would respectively increase the overall operations of the Tanger Med port. Thus, these variables can be considered as the most significant variable of the technical services which influence the whole port operations. Moreover, with a high beta value, “Mooring length is adequate” (0.326), “Containerization at the port” (0.217), “Stack equipment” (0.213) and “Volume of goods handled by the port” (0.343) indicate that the more the effective improvement of these factors will have a positive impact on the whole of the

operations of the port. This is interpreted as with each one standard deviation increase in "mooring length is adequate", "port containerization", "stacking equipment" and "volume of cargo handled by port", port operations in Tangier Med will also increase.

Table 2 ANOVA model and statistics between technical services and port operations

Factors		Standardized coefficients Beta	T	Sig.
1	(Constant)		-4.079	0.000
	Terminal water depth	0.131	1.661	0.105
	La longueur de l'amarrage convient aux navires de toutes tailles T2	0.326	4.170	0.000
	La quantité et la qualité des grues utilisées sont optimales pour traiter les conteneurs entrants T3	0.047	0.572	0.571
	Mooring length is suitable for vessels of all sizes	0.217	2.542	0.015
	L'équipement d'empilement T5	0.213	2.674	0.011
	Les véhicules de transport T6	0.067	.876	0.386
	The quality management of the cranes used are optimal for handling incoming containers	0.116	1.523	0.136
	The volume of goods handled by the Terminal	0.343	3.579	0.001
	Available seaside cranes are effective	0.031	0.374	0.711

5.3 Quantitative data, normality and reliability test

The methodology employed to conduct and assess the research on port performance indicators and the challenges affecting port operations was outlined. In this section of the study, the results and interpretations of the primary data collected and analyzed are presented. Various intervariable tests, including reliability, correlation, regression, and ANOVA, were performed using primary data gathered from employees of different shipping companies at the Tangier Med port. The findings from the quantitative analysis contributed to addressing the research questions and testing the hypotheses. Reliability tests were conducted to assess the internal consistency between the study variables, while correlation, regression, and ANOVA tests were used to analyze the hypotheses. Descriptive analysis provided insights into the frequency distribution of responses, while inferential analysis demonstrated the relevance of the primary data and helped answer the research questions.

On the other side, we will present the main results and interpretations of the analysis of secondary data collected and processed.

Quantitative data from 100 employees of logistics companies in the Tangier Med Port then analyzed the data using SPSS (v21.0) and Microsoft Excel statistical tools.
The "Cronbach's Alpha" reliability test is crucial for assessing the internal consistency between the study variables. It is used to examine the interrelationship and proximity of the variables to one another. However, a high reliability score does not indicate a unidimensional nature of the variable; it is merely a test to evaluate the stability of a theoretical measure. Additionally, another hypothesis test was conducted to validate the collected data and its expected values. The normality test for the hypothesis was performed to determine if the dataset followed a normal distribution. When conducting this test, it is essential to check whether the variables show a "Shapiro-Wilk (W)" statistic less than "1," which indicates that the observed distribution deviates from a normal distribution. Furthermore, when the "W" value is sufficiently small, the p-value must also be below 0.05 (at the 5% significance level).

Table 3 Shapiro-Wilk normality test for the collected data set

	Shapiro-Wilk		
	Statistics (w)	Ddl	Signification (p)
Overall performance	0.864	50	0.000
Technical	0.941	50	0.015
Organizational	0.924	50	0.003
Quality management	0.922	50	0.003

Table 3 presents the results of the Shapiro-Wilk normality test for the respondents working at the port of Tangier Med. The normality test was conducted on several operational factors affecting port performance, and the

results indicate that the data for most of these factors do not follow a normal distribution. Specifically, the p-values for the variables related to Technique (0.015), Organization (0.003), and State Benefits (0.003) are all below the critical threshold of 0.05. This suggests that the data for these variables significantly deviate from a normal distribution, as the Shapiro-Wilk test indicates non-normality when the p-value is less than 0.05. Therefore, based on the outcomes of the normality test, it can be concluded that the dataset collected from the port of Tangier Med does not exhibit a normal distribution across these key operational factors. This non-normality has implications for the choice of statistical methods to be used in subsequent analysis, as non-parametric tests may be more appropriate for interpreting these results.

Table 4 Co-effectiveness of Cronbach's Alpha reliability

Cronbach reliability test		
Factors	Cronbach's alpha	Number of items
Technical performance	0.887	10
Organizational Performance	0.890	12
Quality management	0.847	5

The reliability test was conducted to assess the stability and consistency among the key factors—Technical, Organizational, and the Benefits granted by the State—that influence port operations. The primary objective of this test was to evaluate the internal consistency of the data collected through the survey, ensuring that the variables measured are reliable and produce stable results. As indicated in Table 4. The Cronbach's alpha coefficients for each factor were found to be well above the commonly accepted threshold of 0.6, with values of 0.887 for Technical, 0.890 for Organizational, and 0.847 for benefits granted by the State. These high Cronbach's alpha values suggest a strong internal consistency between the items within each factor, demonstrating that the data collected is both stable and reliable. This high level of consistency reinforces the validity of the factors in accurately reflecting the operational aspects of port management, and it supports the robustness of the study's findings. Consequently, the results can be interpreted as indicating that the factors under consideration are stable and consistent in their influence on port operations, providing a solid foundation for further analysis.

Table 5 Model of regression analysis between logistics performance and quality management

Model	R	R-R	R- R adjusted
1	0.855	0.923	0.920

Table 4 presents an in-depth regression analysis that explores the links between the different organizational services offered by the companies defined in the port of Tangier Med. The results revealed by this statistical analysis present significant indicators. Indeed, the coefficient of determination, also called R-squared, displays a value of 0.923, equivalent to 85.5%. Moreover, the adjusted R-squared, which reached 0.920, or 92.0%, highlights the strong correlation between logistics services and overall business operations. In other words, each logistics service plays a crucial role in influencing the overall operations of companies operating from the port of Tangier Med.

A crucial observation follows from these results. Indeed, they show that the rise in organizational performance variables exerts a direct influence on the increase in overall operations within companies in this logistics area. In other words, an improvement in organizational performance factors will inevitably lead to a concomitant increase in operational activities on a global scale thanks to an optimal quality management system. This finding highlights the crucial importance of logistics services in the overall operations of companies, thus conferring an in-depth understanding of the mechanisms underlying the optimization of organizational and operational performance in the specific context of the port of Tangier Med.

5.4 Discussion

Our study centered on enhancing performance within the framework of Logistics 4.0 by utilizing quality management practices, with a particular focus on international companies operating within the port of Tangier Med. This research aimed to explore how the integration of quality management methodologies could contribute to optimizing performance in the evolving landscape of Logistics 4.0, specifically in the context of global players in the port's logistics ecosystem. The objective was to gain a deep understanding of how these practices could be applied to enhance the operational efficiency of companies and improve overall logistics performance. To achieve this, we adopted a comprehensive approach to data collection, drawing from both qualitative and quantitative sources. On one hand, we utilized official Port Authority publications, such as press releases, newsletters, and other resources available through the port's website, to gather secondary data. These sources provided valuable insights into the operations and strategies in place at the port of Tangier Med, particularly in relation to Logistics 4.0 and the practices being implemented by international companies. Additionally, the resources from the Tanger Med Special Agency (TMSA) were integral to our research, offering detailed information about port policies, infrastructural developments, and strategic objectives that align with the broader logistics goals of the region. On the other hand, to complement and deepen our findings, we incorporated a quantitative research approach, engaging port employees through a structured survey. A questionnaire was specifically designed and distributed to gather primary data on their perspectives regarding the impact of quality management

on performance in the context of Logistics 4.0. To ensure the reliability and validity of the collected data, we employed the "SPSS" software for statistical analysis, which allowed us to manage, analyze, and interpret the responses effectively. The core of our methodology involved testing hypotheses related to the influence of quality management practices on performance enhancement within the Logistics 4.0 framework. This rigorous empirical approach enabled us to probe and assess the correlation between quality management strategies and improvements in logistics performance, providing a quantitative dimension to our study and strengthening the credibility of our findings. Through this combined approach, we were able to draw valuable conclusions about the significant role of quality management in driving performance improvement in the dynamic environment of Logistics 4.0, with particular attention to international companies at Tangier Med. The integration of both qualitative and quantitative data not only enriched our understanding of the subject but also contributed to a more comprehensive exploration of the ways in which logistics performance can be optimized in global port environments. This research ultimately provided a robust empirical foundation for understanding and applying the principles of Logistics 4.0 in the context of international ports, offering new insights into the pivotal role of quality management in enhancing performance across complex logistics networks. The combination of diverse data collection techniques and advanced analytical methods has provided substantial value to our results and opened up important perspectives for future research and practical applications within the domain of Logistics 4.0.

6 Conclusion

In conclusion, this research project has shed new light on performance improvement within the dynamic context of Logistics 4.0, based on the integration of quality management practices. Particularly focused on international companies established at the port of Tangier Med, this study has provided significant insights into the optimization of logistics operations in a constantly changing environment. The objective of this research was to quantify the impact of quality management methods on improving the overall performance of companies. Performance improvement variables have been thoroughly analyzed to understand their influence on overall business results. Quality management requirements and tools served as a common thread to guide this exploration, while examining the effectiveness of decisions made in the logistics 4.0 context. The methodology adopted, based on a quantitative approach, made it possible to gather tangible and substantial data. Surveys of 300 port employees provided crucial information to support our analyses. The results highlighted the significant correlation between improved logistics performance and quality management practices in international companies. The importance of this research lies in its contribution to the development of scientific research in the field of Logistics 4.0. By highlighting the links between quality management practices and performance improvement, this study paves the way for innovative solutions for optimizing logistics operations. The conclusions drawn from this research offer practical and strategic perspectives for companies operating in a constantly changing environment, such as the port of Tangier Med. This research lays the groundwork for a more informed and efficient approach to Logistics 4.0 by highlighting the crucial role of quality management methods. The results obtained offer concrete opportunities to improve business performance, thus propelling operational efficiency and competitiveness on the international scene.

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