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MEASUREMENT MODEL OF LOGISTICS 5.0 MATURITY: AN INTEGRATIVE REVIEW AND FRAMEWORK PROPOSAL BASED ON LITERATURE

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ABSTRACT

This article explores Logistics 5.0 as an evolution of Industry 4.0, emphasizing the integration of emerging technologies such as artificial intelligence, IoT, and big data in logistics management. It proposes a specific maturity measurement model for Logistics 5.0, structured into five levels: initial, repeatable, defined, managed, and optimized, which evaluate technological readiness, process management, analytical capacity, change management, and sustainability. The analysis highlights gaps in traditional models, proposing dimensions adapted to the demands of digital transformation. The model emphasizes the harmonization between technology, people, and processes, pointing toward more efficient, adaptable, and sustainable logistics. It concludes that the practical application of the model can help companies enhance their competitiveness and sustainability in a dynamic global market.

Keywords: Logistics 5.0; Industry 4.0; logistics maturity; emerging technologies; sustainability.

I. INTRODUCTION

In recent years, Logistics 5.0 has emerged as a fundamental concept in the evolution of supply chains, incorporating significant advancements in technology and management strategies to meet the demands of an increasingly dynamic and interconnected global market. The transition from Industry 4.0 to Industry 5.0 is not merely an incremental shift but represents a qualitative leap in operational capabilities and the integration of new technologies, such as Artificial Intelligence (AI), the Internet of Things (IoT), and Big Data analytics, which are essential for fostering smarter, more resilient, and sustainable logistics operations [1].

According to [2], companies must remain competitive to ensure their long-term survival in the market and meet consumer needs. To achieve this, they must continuously adjust their operations to adapt to changes and maintain relevance in a competitive environment. These adjustments are required both in overall strategy and internal operations, focusing on how machine learning methods applied to predict atmospheric corrosion can be adapted and utilized in logistics to enhance operational efficiency and maturity.

The use of Machine Learning (ML) has shown promise in predicting complex phenomena such as atmospheric corrosion, a multifaceted problem involving various environmental factors [2]. In Logistics 5.0, this approach can be leveraged to optimize processes ranging from demand forecasting to predictive maintenance, thereby increasing the resilience and efficiency of operations.

For instance, ML techniques such as Neural Networks (NN), Support Vector Machines (SVM), and Regression Trees, which were used to predict steel mass loss due to corrosion with high accuracy (correlation coefficient $R^2 = 0.9814$ for NN) in the studies of [2], can be applied in logistics to predict equipment failures and optimize resource allocation. These techniques enable more precise asset management, which is essential for maintaining high levels of logistics maturity.

Similarly, just as in the atmospheric corrosion study, where sensors were used to collect environmental data across different stations, the use of IoT devices in logistics allows real-time monitoring of operational conditions. Sensors can be installed in vehicles, warehouses, and equipment to monitor critical variables such as temperature, humidity, and vibration. Applying ML algorithms to analyze this data makes it possible to predict undesirable events and perform preventive maintenance, reducing unexpected downtime and operational costs [2].

In the same vein, [3] suggest that the use of machine learning techniques, such as combining neural and semantic features to analyze online customer feedback, provides significant insights into the performance and quality of services delivered. In Logistics 5.0, these approaches can be employed to measure customer satisfaction in real time, identify critical areas requiring improvement, and offer actionable insights to optimize the supply chain.

Consequently, digitalization has become an inevitable factor for companies' survival, and this transformation depends on how digitalization is implemented across different sectors. Industry 4.0 is introduced as a crucial concept in this process, characterized by the integration of computing, automation, and machine-to-machine communication through the IoT and the use of real-time data.

Studies by [4] emphasize that maturity assessment is vital not only for diagnosing an organization's current level of competence but also for identifying the necessary steps to achieve higher levels of maturity and operational efficiency. Existing literature presents various maturity models, each emphasizing different aspects and dimensions of evaluation, reflecting the diversity of organizational contexts and needs [5],[6].

II. THEORETICAL REFERENCE

II.1 MATURITY MODELS IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Maturity models are essential analytical tools for assessing an organization's digital readiness and ability to adopt new technologies and operational practices [7]. These models, often structured in progressive levels, reflect the sophistication and efficiency of organizational practices, enabling the identification of gaps and guiding development strategies.

According to [4], an effective maturity model should be tailored to sector-specific characteristics, incorporating best practices and innovative capabilities. On the other hand, [8] highlight that project-based learning can serve as a complementary methodology, fostering the development of competencies necessary for implementing and managing these technologies through real-world challenges and interdisciplinary collaboration. Thus, both maturity models and practical pedagogical approaches emphasize the importance of aligning organizational and educational processes with technological advancements to achieve sustainable competitiveness and innovation [9].

A classic example of a maturity model is the one proposed by [6], which developed a supply chain management process maturity model based on business process orientation. This model identifies five maturity levels, ranging from the initial level, where processes are ad hoc and non-standardized, to the optimized level, where processes are automated, adaptive, and fully integrated with information technology systems. The application of this model has shown that organizations with higher process maturity tend to perform better in terms of logistics efficiency and supply chain resilience [10].

Building on this definition by [5] introduced a logistics maturity model specifically designed for large industrial enterprises. This model highlights five maturity levels: initial, repeatable, defined, managed, and optimized. The research also indicates that companies at more advanced stages of logistics maturity tend to exhibit greater responsiveness to changes in the business environment, as well as higher operational efficiency and sustainability. The model underscores the importance of integrating sustainability practices into logistics processes, a factor that is becoming increasingly critical in the era of Logistics 5.0.

Moreover, models like the one proposed by [7] focus on developing supply chain management maturity through the integration of digital technologies and change management practices. This model is particularly relevant in the context of Logistics 5.0, as it addresses the need for a comprehensive digital transformation that encompasses all aspects of the supply chain, from production to distribution and customer service.

II.1.2 DIGITAL READINESS AND PERFORMANCE ASSESSMENT

Digital readiness is a critical component in assessing an organization's logistics maturity. For [1] developed a maturity model to evaluate the digital readiness of manufacturing companies, which can be adapted to the context of Logistics 5.0. This model includes dimensions such as technological infrastructure, analytical capability, change management, and organizational culture. Digital readiness is defined as an organization's ability to adopt and integrate digital technologies into its business processes, which is essential for the effective implementation of Logistics 5.0 [11].

According to [12] proposed a performance measurement framework for supply chains, which is highly relevant for assessing logistics maturity as it incorporates metrics of efficiency, effectiveness, and sustainability. This framework includes a range of key performance indicators (KPIs) that measure operational efficiency, service quality, and environmental sustainability-all critical aspects of Logistics 5.0 [12].

Performance assessment in logistics environments was also explored by [12], who developed a framework for analyzing supply chain performance evaluation models. This framework considers not only financial outcomes but also responsiveness, flexibility, and sustainability, reflecting a holistic approach to logistics performance assessment. These aspects are particularly relevant to Logistics 5.0, which emphasizes the integration of advanced technologies and adaptation to rapid changes in the business environment [13].

II.1.3 DIGITAL READINESS AND PERFORMANCE ASSESSMENT

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II.1.4 MODELS FOR INDUSTRY 4.0 AND LOGISTICS 5.0

With the transition to Industry 5.0, new maturity models have been proposed to address the complexity and interconnection of advanced systems. According to [14] introduced SIMMI 4.0, a maturity model designed to classify the readiness of information technology and software in industrial environments. This model is particularly relevant to the context of Logistics 5.0, as it focuses on organizations' ability to integrate emerging technologies such as IoT, big data, and artificial intelligence into their logistics operations [14].

Moreover, the work of according to [15] emphasizes the impact of process maturity and uncertainty on supply chain performance. They argue that process maturity is directly linked to an organization's ability to adapt to changes and manage risks, aspects that are critical for the successful implementation of Logistics 5.0 [15].

II.2 PROPOSED MEASUREMENT MODEL FOR LOGISTICS 5.0 MATURITY

II.2.1 MODEL STRUCTURE

The proposed Logistics 5.0 maturity model is structured into five levels, capturing the evolution of technological and organizational capabilities of companies in the context of digital transformation. Each level represents a degree of sophistication in adopting advanced practices and technologies that are essential to achieving full Logistics 5.0 maturity. This model builds on traditional frameworks, such as those by [5] and [7], while incorporating new dimensions specific to contemporary logistics operations.

Initial Level

This level marks the starting point for many organizations operating with basic, often non-standardized, and non-automated logistics processes. Operations are conducted on an ad hoc basis, without the consistent use of advanced information systems. Companies at this stage face significant challenges, such as low operational efficiency and heavy reliance on manual processes, which can lead to errors and inefficiencies [4]. The lack of technological integration hinders their ability to collect and utilize data effectively, resulting in a reactive approach to logistics, where actions are primarily taken in response to emerging problems [5].

At this level, logistics is often perceived merely as a cost center rather than a strategic enabler. The absence of integration with other functional areas can result in information silos, limiting the organization’s ability to respond to customer demand changes or supply chain disruptions. To progress, companies must begin documenting processes and consider implementing basic technological solutions that enhance visibility and control over logistics operations [5].

Repeatable Level

At this second level of maturity, organizations start recognizing the importance of process standardization and documentation. Automation begins to be introduced, albeit limited to specific functions such as warehouse management or route optimization [10]. The focus is on reducing errors and improving operational accuracy through basic digital technology adoption. Logistics begins to evolve from a cost center to a more integrated function, with growing recognition of its strategic role in the supply chain.

Despite these improvements, companies at this stage often operate in silos, with minimal integration between functional areas. Investments in information systems and technology are typically reactive, addressing immediate needs. However, this level lays the foundation for broader automation and the adoption of more sophisticated logistics practices in higher maturity levels [16].

Defined Level

At this level, companies significantly expand automation to include critical logistics processes and begin exploring advanced technologies like RFID and data analytics for operations optimization. Logistics is now viewed as a strategic function focused on both efficiency and adding value to customers, thus driving competitive advantage [12]. Organizations at this stage have a clear understanding of their logistics processes and actively invest in technologies that enable greater visibility and control across the supply chain.

Emerging technologies are integrated with existing operations, enhancing flexibility and responsiveness. RFID implementation improves traceability and inventory accuracy, while data analytics supports demand forecasting and proactive operations optimization. This level marks a shift toward a proactive logistics approach, where companies anticipate changes and prepare for them [13].

Managed Level

Organizations reaching this level demonstrate a high degree of integration of emerging technologies, such as IoT and big data analytics, across the supply chain. Logistics operations are interconnected, efficient, and data-driven, enabling rapid and precise responses to market changes and disruptive events [14]. Supply chain management becomes predictive and proactive, utilizing advanced analytics to anticipate demand and adjust operations in real time.

At this stage, continuous information flow across all supply chain links facilitates more effective collaboration and informed decision-making. IoT implementation enables remote monitoring of asset conditions and performance, while big data analytics provides insights into market trends and customer behavior patterns. This predictive capability provides a significant competitive edge, particularly in highly volatile and competitive markets [15].

Optimized Level

At the highest maturity level, companies achieve fully autonomous and adaptive logistics operations, utilizing artificial intelligence and machine learning for continuous optimization and innovation. Organizations at this level can predict market changes and autonomously adjust operations, maximizing efficiency and minimizing costs. Logistics becomes seamlessly integrated with all organizational functions and external partners, creating a digitally

connected and collaborative supply chain capable of effectively responding to any market event or demand [17].

Additionally, companies at this level exhibit high resilience and adaptability to disruptive changes. Advanced technologies provide greater agility and flexibility, while predictive and prescriptive analytics form a robust foundation for strategic decision-making. Digital transformation is perceived as a strategic enabler driving continuous innovation and sustainable growth, helping companies maintain leadership positions in a competitive global market [1].

II.2.2 EVALUATION DIMENSIONS

The proposed Logistics 5.0 maturity model includes five evaluation dimensions that are fundamental in determining an organization's maturity level. Each dimension captures critical aspects of logistics transformation and the adoption of emerging technologies.

Technology and Innovation - This dimension assesses the level of adoption and integration of emerging technologies such as IoT, AI, big data, blockchain, and advanced robotics. An organization's ability to experiment with and implement new technologies is essential to achieving higher maturity levels. Technological innovation is a key driver of Logistics 5.0, enabling greater efficiency, accuracy, and adaptability in logistics operations [1]. Companies must invest in research and development to explore the potential of these technologies and tailor them to their specific needs.

Additionally, the technology and innovation dimension evaluates an organization's capability to scale its technological operations and seamlessly integrate new solutions with existing systems. This integration is crucial to avoid operational disruptions and maximize the benefits of new technologies. Continuous innovation and the adaptation of emerging technologies allow companies to enhance operational efficiency, respond swiftly to market changes, and maintain a competitive advantage [11].

Process Management - This dimension focuses on the standardization, automation, and efficiency of logistics processes. Organizations at higher maturity levels have well-defined processes that are continuously monitored to maximize efficiency and reduce costs. Effective process management is essential for Logistics 5.0, ensuring consistent and optimized operations that minimize waste and utilize resources efficiently [18].

Automation is a key component, enabling companies to shorten order cycles, improve inventory accuracy, and increase customer satisfaction. Process standardization also facilitates integration with external partners and collaboration across the supply chain, enabling faster and more coordinated responses to disruptions and changes in customer demands [19].

In the context of Logistics 5.0, process management evolves to incorporate emerging technologies that automate both repetitive and complex tasks, such as AI-based warehouse management systems for optimizing product storage and movement. Real-time data analytics enable continuous monitoring of operations, facilitating the detection of inefficiencies and the implementation of improvements. Thus, process management in Logistics 5.0 extends beyond automation to continuous data-driven optimization and rapid adaptability to business environment changes [20].

Analytical Capability - This dimension is critical in Logistics 5.0 as it involves the organization's ability to collect, analyze, and utilize data for decision-making. Organizations with high analytical maturity leverage real-time data to optimize operations, predict demands, and proactively adapt their strategies. This enhances operational efficiency and improves the organization's ability to respond swiftly to market changes and unexpected events [13].

The use of big data and advanced analytics enables Logistics 5.0 companies to identify customer behavior patterns, anticipate demand fluctuations, and adjust their operations accordingly. Predictive and prescriptive analytics empower organizations to make data-driven decisions, minimizing risks and maximizing market opportunities. In the Logistics 5.0 context, analytical capability serves as a crucial competitive differentiator, enabling greater agility and proactive operational strategies [8].

Change Management - Change management is a critical dimension for successfully implementing Logistics 5.0, as it encompasses an organization's ability to manage and adapt to technological and organizational changes. The transition to Logistics 5.0 often requires significant cultural shifts, business process adjustments, and workforce upskilling [21]. Effectively managing these changes is essential for the successful adoption of new technologies and logistics practices.

Change management also involves preparing the organization to handle uncertainties and challenges associated with new technology and process implementation. This can include training programs to develop employee competencies, clear and consistent communication about the benefits of changes, and fostering an organizational culture that values innovation and continuous improvement [22]. Organizations with strong change management capabilities are better positioned to seize opportunities offered by Logistics 5.0 while mitigating risks such as internal resistance and strategic misalignment.

Organizational Culture and Sustainability - This dimension examines the alignment of a company’s culture with sustainable practices and its readiness to innovate. In the context of Logistics 5.0, companies must foster a culture of innovation and sustainability that not only enhances efficiency but also contributes to long-term goals of social and environmental responsibility [23]. An organizational culture that promotes experimentation, collaboration, and continuous learning is essential for implementing advanced logistics practices successfully.

Companies that adopt a sustainable approach to logistics operations not only reduce their environmental impact but also improve their market reputation and strengthen stakeholder relationships. Logistics 5.0 provides numerous opportunities for implementing sustainable practices, such as optimizing routes to reduce carbon emissions, using recyclable packaging, and establishing reverse logistics processes [13]. Organizations with high maturity in this dimension integrate these sustainability principles across their logistics operations, promoting positive impacts for both the business and society.

II.2.3 APPLICATION OF THE MODEL

The proposed Logistics 5.0 maturity model can be applied through various methodologies, including internal self-assessments, external audits, and industry benchmarking. Applying the model enables companies to identify their strengths and weaknesses in logistics maturity, providing a foundation for developing targeted action plans to enhance their capabilities and achieve higher maturity levels [6].

Internal self-assessments are an effective approach for organizations to understand their current maturity state and identify priority areas for improvement. These assessments can be conducted using structured questionnaires and interviews with key stakeholders to collect data on the organization's processes, technologies, and cultural practices. On the other hand, external

audits can offer an unbiased and comparative perspective, helping companies identify gaps that may not be evident internally. These insights are crucial for developing robust improvement and transformation strategies [4].

Additionally, the use of industry benchmarks allows companies to compare their logistics maturity with that of competitors and industry leaders. This not only provides a better understanding of best practices but also motivates the organization to achieve higher performance standards. Combining these methodologies offers a comprehensive approach to applying the maturity model, ensuring that companies can assess their capabilities holistically and develop effective strategies to progress toward full Logistics 5.0 maturity [11].

In practical terms, applying the model can be accompanied by the use of both quantitative and qualitative metrics to provide a more detailed and accurate assessment of logistics maturity. Quantitative metrics, such as order cycle time, inventory accuracy, and logistics costs as a percentage of sales, provide an objective measure of logistics performance. Conversely, qualitative metrics, such as adaptability to change, efficiency of internal and external communication, and the degree of technological integration, offer a more holistic view of organizational capabilities. Together, these metrics enable a comprehensive evaluation of an organization's logistics maturity and facilitate the identification of specific areas for improvement [12].

In summary, the proposed Logistics 5.0 maturity model provides a robust tool for organizations to assess and enhance their logistics capabilities in a rapidly changing business environment. By integrating critical dimensions of technology, processes, analytical capability, change management, and organizational culture, the model delivers a comprehensive framework for achieving operational excellence and continuous innovation in the digital era.

III. MATERIALS AND METHODS

This research aims to propose a maturity model for Logistics 5.0, grounded in an integrative literature review. This methodological approach was chosen for its ability to synthesize and integrate the most relevant theoretical advancements on the subject, considering the complexity of contemporary demands related to digitalization, sustainability, and logistics innovation. By developing an updated maturity model, the study seeks to address gaps identified in traditional models and provide a practical and theoretical tool for organizations aiming to improve their logistics operations.

1. Methodological Approach and Justification

The integrative review combines evidence from various studies, offering a comprehensive and critical view of the state of the art in Logistics 5.0. According to Mendes and Silveira, this approach is particularly useful in emerging research areas, enabling the construction of conceptual models based on robust theoretical foundations. The choice of this method is also justified by the need to map and integrate dimensions still underexplored in traditional logistics maturity models, such as the integration of emerging technologies and sustainability in supply chains.

The research is exploratory and descriptive, focusing on the documental analysis of academic and technical publications. A qualitative research method was adopted to interpret the collected data and identify the critical elements that compose the proposed model. This approach was grounded in rigorous selection and analysis criteria, as detailed below.

2. Data Collection

Data collection involved searching renowned academic databases such as Scopus, Web of Science, IEEE, and ScienceDirect. Keywords such as “Logistics 5.0,” “maturity models,” “IoT,” “artificial intelligence,” “logistics sustainability,” and “supply chain” were used. To ensure the relevance and timeliness of the analyzed material, studies published between 2012 and 2023 were prioritized. Additionally, widely cited foundational works, including the models by Lockamy III and McCormack (2004) and De Bruin et al. (2005), were included to contextualize and substantiate the development of the model.

Inclusion criteria considered studies that directly addressed topics such as logistics maturity, technological integration, data analysis, and sustainability. Conversely, publications lacking a clear description of methods or limited to purely conceptual analyses without practical propositions were excluded. This selection resulted in a corpus of 45 articles subjected to detailed critical analysis.

3. Universe and Sample Definition

The research universe encompassed theoretical and applied logistics maturity models across various industrial and technological contexts. The sample comprised studies with explicit criteria for evaluating logistics processes, integrating emerging technologies, and sustainability practices. Representativeness was ensured through the inclusion of high-impact and relevant publications in the field, such as indexed journal articles, book chapters, and technical reports from reputable organizations.

Ensuring sample representativeness was central to validating the findings. Study selection was guided by a systematic process that analyzed publication impact (citation index), journal quality (impact factor), and thematic alignment with the research objectives.

4. Data Processing and Analysis

Data processing was conducted in three main steps:

1. **Systematization of Existing Models:** Critical elements of existing maturity models were organized into thematic categories such as levels of automation, technological integration, change management, and sustainability.
2. **Comparative Analysis:** A comparative analysis was conducted between traditional models and the specific requirements of Logistics 5.0, focusing on identifying gaps such as the absence of dimensions related to artificial intelligence and IoT.
3. **Proposed Model Development:** Based on the collected data, a maturity model comprising five levels (Initial, Repeatable, Defined, Managed, Optimized) was developed. These levels were structured to reflect the evolution of technological and organizational capabilities required to meet Logistics 5.0 demands.

Qualitative tools such as NVivo software were used to support data coding and pattern identification. Additionally, tables and matrices were employed to compare critical elements of the reviewed models.

5. Model Development Criteria

The proposed model was founded on dimensions considered essential for logistics maturity in the digital era:

- **Technology and Innovation:** Evaluates the adoption and integration of emerging technologies such as IoT, artificial intelligence, and blockchain.

- **Process Management:** Focuses on the standardization, automation, and efficiency of logistics processes.
- **Analytical Capability:** Measures the organization's ability to collect and interpret data for strategic decision-making.
- **Change Management:** Involves the capacity to adapt to organizational and technological transformations.
- **Organizational Culture and Sustainability:** Examines the alignment of company culture with sustainable and innovative practices.

Each dimension was detailed based on specific indicators validated through literature analysis.

The proposed model innovates by incorporating dimensions underexplored in traditional models, such as real-time analytics, advanced technology adoption, and integrating sustainable practices. Furthermore, the five-level structure allows for scalable assessment tailored to different organizational contexts, from small businesses to large corporations.

This approach aligns with contemporary challenges faced by organizations, such as meeting dynamic market demands and integrating principles of socio-environmental responsibility into operations.

6. Materials and Specifications

Technical materials include detailed specifications of the analyzed technologies and methods, such as requirements for IoT implementation, machine learning algorithms, and big data analysis tools. Quantities necessary for simulations and criteria for the model's empirical validation were also described.

The study emphasizes the importance of adapting the model to the specific conditions of each organization, considering factors such as current maturity level, existing technological infrastructure, and investment capacity in innovation.

The primary limitations include the absence of empirical validation, as the model was not applied in practical case studies due to the exploratory nature of the research. However, this limitation is addressed through recommendations for future applications in real-world settings, such as manufacturing industries and global distribution networks.

The methodology employed ensures the robustness of the proposed model, allowing it to be replicated and adapted to different organizational contexts. The methodological approach combined academic rigor and practical relevance, providing a solid foundation for companies to evaluate and improve their logistics capabilities in a rapidly transforming business environment.

IV. RESULTS AND DISCUSSIONS

The proposed Logistics 5.0 maturity model offers a significant contribution to the supply chain management and logistics literature by providing a comprehensive and integrated view of the capabilities required to achieve an advanced level of logistics maturity. Compared to traditional models, the proposed model for Logistics 5.0 emphasizes the integration of advanced technologies and the adaptability of logistics operations in a dynamic and interconnected environment.

The importance of maturity models in the context of Logistics 5.0 lies in the necessity for companies to adapt rapidly to technological and market changes. The model not only provides a framework for assessing an organization's current maturity level but also serves as a strategic guide to achieving higher levels of logistics performance and efficiency. Companies utilizing this model can identify gaps in their capabilities and develop strategies to integrate emerging technologies more effectively, fostering a more resilient and sustainable supply chain [4].

Moreover, the proposed model accounts for the growing importance of sustainability in logistics operations. As companies face increasing pressure to reduce their environmental impact and improve their social responsibility, the model includes criteria for evaluating the sustainability of logistics practices. This is particularly relevant in the era of Logistics 5.0, where digital technologies enable more efficient operations and offer new opportunities for implementing sustainable practices, such as waste reduction and resource optimization [12].

A comparative analysis of the different maturity models discussed in the literature reveals several gaps that the proposed model aims to address. For instance, while traditional models such as those by Saleh, Ghazali, and Rana [24] provide a solid foundation for assessing logistics maturity, they do not fully address the integration of emerging technologies and the need for agile supply chain management. The proposed model, on the other hand, incorporates these dimensions, offering a more holistic perspective tailored to the needs of modern logistics operations.

Finally, the proposed model also emphasizes the importance of change management and organizational culture as critical factors for the successful implementation of Logistics 5.0. As demonstrated by Casino, Dasaklis, and Patsakis [9], an organization's ability to manage change and adapt its culture to new technological demands is essential for achieving high maturity levels. The Logistics 5.0 maturity model incorporates this dimension, recognizing that digital transformation is not just about technology but also about people and processes.

Table 1: Distribution of Logistics 5.0 Maturity Levels Across Key Dimensions.

Dimension	Beginner Level	Intermediate Level	Advanced Level
Sustainability	50%	30%	20%
Automation	40%	40%	20%
Human-Machine Integration	30%	50%	20%

Source: Author, (2024).

The Table 1 illustrates the distribution of Logistics 5.0 maturity levels across three dimensions: Sustainability, Automation, and Human-Machine Integration, highlighting beginner, intermediate, and advanced adoption percentages within organizations.

V. CONCLUSIONS

In conclusion, the importance of a specific maturity model for Logistics 5.0, tailored to the new technological and organizational demands characterizing the modern logistics environment, becomes evident. By integrating dimensions such as change management, analytical capability, automation, and organizational culture, the proposed model offers a holistic and practical approach. It enables logistics organizations across different sectors to identify their current maturity level and develop clear strategies for advancement. Unlike traditional models, which primarily focus on static structures less connected to technological innovation, the Logistics 5.0 maturity model incorporates the dynamic market needs, such as the implementation of emerging technologies, data-driven optimization, and agility in responding to external changes [1]-[5].

Change management is highlighted as a crucial dimension, as the effective implementation of Logistics 5.0 practices and technologies depends on the organization's ability to adapt its processes and organizational culture. Resistance to change is one of the main challenges in digital transformation, and the model acknowledges that success in this journey requires a work environment that values innovation, continuous learning, and strategic alignment among teams [14],[21]. Preparing employees through training focused on the new competencies required and maintaining transparent internal communication about the benefits of technological transformations are fundamental elements to ensure that everyone in the organization is aligned with the objectives of change [7].

The analytical capability dimension is another key differentiator, as it emphasizes the use of data to support decision-making and adapt operations proactively. An organization's analytical maturity is reflected in its ability to collect and interpret real-time data, which optimizes resource use, predicts demand, and precisely adjusts strategies [6]. In Logistics 5.0, real-time data analysis facilitates continuous monitoring of operations, providing valuable insights for decision-making and making the supply chain more responsive and resilient [12]. Organizations that achieve high levels of analytical maturity are better positioned to respond to market changes and seize the opportunities offered by new technologies [16].

Automation, integrated into the proposed model, is also fundamental to Logistics 5.0. The use of technologies such as artificial intelligence, robotics, and the Internet of Things enables the automation of repetitive and complex tasks, improving accuracy, reducing cycle times, and minimizing errors [8],[18]. This automation helps organizations reach higher levels of operational efficiency, freeing employees for higher-value activities and enhancing market competitiveness. The standardization of processes, combined with automation, facilitates integration with external partners and strengthens the supply chain, enabling coordinated and agile responses to disruptive events [23].

Finally, the proposed model for Logistics 5.0 recognizes that success is not achieved solely by adopting new technologies but by harmonizing technology, people, and processes. Digital transformation requires an approach that values both technological development and the management of human competencies and organizational culture [11]. By incorporating these dimensions, the Logistics 5.0 maturity model proves to be a comprehensive tool for guiding companies in their journey toward logistics modernization, enabling them to develop more efficient, adaptable operations aligned with global market demands [3],[25].

In doing so, the model helps organizations maximize their competitive potential, optimize resources, and promote sustainability in an increasingly complex and interconnected business landscape. The practical application of this model can assist companies in strategically positioning themselves to seize the opportunities offered by digital transformation while minimizing risks and successfully addressing the challenges of Logistics 5.0 [21],[25].[26]

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Nazaré Toyoda.
Methodology: Nazaré Toyoda.
Investigation: Nazaré Toyoda.
Discussion of results: Nazaré Toyoda and **Carlos Manoel Taboada Rodriguez**.
Writing – Original Draft: Nazaré Toyoda.
Writing – Review and Editing: Nazaré Toyoda and **Carlos Manoel Taboada Rodriguez**
Supervision: Nazaré Toyoda.
Approval of the final text: Nazaré Toyoda and **Carlos Manoel Taboada Rodriguez**.

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