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Assessment of digital maturity, the transformation of business models in the context of digital transformation

Evaluación de la madurez digital, la transformación de los modelos de negocio en el contexto de la transformación digital

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Resumen

En el contexto de la transformación digital y la integración dinámica de tecnologías, los modelos de negocio de las organizaciones se optimizan y mejoran. Este proceso requiere la evaluación de la madurez digital de una organización para medir el alcance de su transformación empresarial digital, así como la etapa y el nivel de implementación de la tecnología dentro de la empresa. El objetivo de este artículo es construir un modelo de madurez digital que facilite la evaluación del estado de implementación de las tecnologías de la Industria 4.0 en el sector logístico internacional. Esta evaluación se realizará a través de una evaluación cuantitativa de la incorporación de diversos elementos de Industria 4.0 en las operaciones logísticas. Metodología. El presente estudio ha ideado un modelo pragmático para evaluar la madurez digital del sector logístico, basándose en dos criterios principales: 1) las etapas (grados, niveles) de madurez (es decir, ignorar, definir, adoptar, gestionar, integrar) como se propone por Facchini et al. (2020); y 2) los diversos tipos de tecnologías implementadas dentro del sector logístico. Resultados. Se ha realizado una estimación del modelo de madurez digital dentro del sector logístico para delinear el nivel de implementación de diversas tecnologías de la Industria 4.0. Los resultados del modelo de madurez ilustran que el sector de la logística internacional se encuentra actualmente en las primeras etapas de integración de las tecnologías de la Industria 4.0, con una utilización limitada de soluciones digitales, salvo excepciones notables como el análisis de big data. Entre los componentes que componen el modelo de madurez, el análisis de big data emerge como el elemento más integrado, facilitando la recopilación, el procesamiento y la evaluación de datos por parte de las empresas. La transición de la etapa inicial a la posterior de la madurez del negocio digital se demuestra con la incorporación de las tecnologías Enterprise Resource Planning (ERP), Networking Management Solutions y Big data, específicamente en lo que respecta a la digitalización de la cartera de productos de la compañía, marcando la segunda etapa de madurez digital. La importancia práctica de esta investigación radica en la evaluación del modelo de madurez digital dentro del sector logístico internacional, que delinea el estado de implementación de varias tecnologías de la Industria 4.0.

Palabras clave: digitalización, transformación del negocio digital, procesos de negocio, madurez digital, modelo de madurez digital, niveles de madurez.

Abstract

In the context of digital transformation and the dynamic integration of technologies, organizations' business models undergo optimization and improvement. This process necessitates the evaluation of an organization's digital maturity to gauge the extent of its digital business transformation, as well as the stage and level of technology implementation within the company. The objective of this article is to construct a digital maturity model that facilitates the assessment of the implementation status of Industry 4.0 technologies in the international logistics sector. This assessment will be conducted through a quantitative evaluation of the incorporation of diverse elements of Industry 4.0 into logistics operations. Methodology. The present study has devised a pragmatic model for assessing the digital maturity of the logistics sector, relying on two primary criteria: 1) the stages (degrees, levels) of maturity (i.e., Ignoring, Defining, Adopting, Managing, Integrated) as proposed by Facchini et al. (2020); and 2) the various types of technologies implemented within the logistics sector. Results. An estimation of the digital maturity model within the logistics sector has been conducted to delineate the level of implementation of diverse Industry 4.0 technologies. The results of the maturity model illustrate that the international logistics sector is currently in the early stages of integrating Industry 4.0 technologies, with limited utilization of digital solutions, barring notable exceptions such as big data analytics. Among the components comprising the maturity model, big data analytics emerges as the most extensively integrated element, facilitating the collection, processing, and evaluation of data by companies. The transition from the initial to the subsequent stage of digital business maturity is demonstrated by the incorporation of Enterprise Resource Planning (ERP), Networking Management Solutions, and Big data technologies, specifically concerning the digitization of the company's product portfolio, marking the second stage of digital maturity. The practical significance of this research lies in the assessment of the digital maturity model within the

international logistics sector, which delineates the state of implementation of various Industry 4.0 technologies.

Keywords: digitalization, digital business transformation, business processes, digital maturity, digital maturity model, maturity levels.

Introduction

Within the framework of digital transformation and the dynamic integration of technologies, organizations endeavor to optimize and enhance their business models. The assessment of digital maturity encompasses the evaluation of an organization's digital transformation, encompassing the stage and level at which the company stands in terms of technology implementation. Digital maturity assessment involves the construction of models that gauge the preparedness of businesses and the extent to which technology has been integrated into various subsystems. Such assessments are conducted to ascertain organizations' potential and their capacity to leverage technology in process management. The logistics industry stands out as a prominent sector for the implementation of technologies aimed at overseeing material and information flows, as well as streamlining the management of goods and services supply chains.

The objective of this article is to construct a digital maturity model to evaluate the level of implementation of Industry 4.0 technologies within the international logistics sector. This assessment will be based on a quantitative analysis of the integration of diverse elements of Industry 4.0 into logistics operations.

Literature review

Maturity, as per the definition provided by Simpson and Weiner (1989), refers to a state of completeness, perfection, or readiness. It entails a process of growth, improvement, and enhancement, as highlighted by Maier et al. (2012). Within the scientific literature, the concept of maturity level is described as a measure of certainty and controllability of an object or system. This measurement encompasses several parameters, including predictability, certainty, stability, controllability, accuracy, and productivity. As an organization attains a higher level of maturity as a system, its potential increases, leading to a reduction in discrepancies and deviations between intended and actual performance outcomes. This progress is accompanied by improvements in business processes, such as cost reduction, revenue increase, enhanced productivity, and improved quality (Barreto, Amaral & Pereira, 2017).

Despite the prevalence and utilization of maturity models, a precise definition of the term is found only in the work of Pigosso et al. (2013), which builds upon Klimko's (2001) research. They define maturity models as "a conceptual framework consisting of components that depict the evolution of a specific area of interest over time." Another definition, put forth by Okongwu et al. (2013), characterizes maturity models as "structured collections of elements that describe the attributes of effective processes at different stages of development." Maturity models serve as valuable tools for assessing the current state, establishing and prioritizing improvement measures, as well as monitoring progress (Sternad, Lerher, & Gajšek 2018).

According to Banyani & Then (2010), maturity models find widespread application across industries such as Project Management (PM), Information Systems (IS), Knowledge Management, and Supply Chain Management (SCM). In the literature, maturity models exhibit diverse characteristics, including varying levels of complexity and the definition of maturity levels based on the extent of technology adoption. Fraser et al. (2002) introduced the first comprehensive classification of maturity models, which includes the following categories: 1) maturity grids, 2) Likert-scale questionnaires, and 3) CMM-like models.

Within the literature, the concept of process maturity is extensively discussed, originally introduced to enhance the controllability and mitigate risks associated with software development and implementation processes (as seen in the Capability Maturity Model Integration - a comprehensive model encompassing productivity and maturity). Subsequently, this concept has been adopted and implemented in various other business subsystems. In practice, both research and consulting organizations actively engage in the development and application of process maturity models within supply chains across several domains, including logistics and supply, functional areas of activity, processes, and projects, as well as universal and industry-specific models (Abdirad & Krishnan, 2020; Barreto, Amaral & Pereira, 2017).

Universal supply chain models serve as a prevalent example of assessing the digital maturity of an organization's business model and can be applied to any company for the evaluation of digital transformation. These models offer a comprehensive assessment of the organization's strategies and processes and find utility in industry research.

Noteworthy examples include the IBM and Booz Allen Hamilton Supply Chain Maturity Models, Tokyo Institute of Technology Supply Chain Maturity, Supply Chain Performance Maturity Model, Supply Chain Maturity Model, and Express Supply Chain Maturity Assessment (Fatorachian & Kazemi, 2020; Hahn, 2020).

Furthermore, the literature also presents findings from studies examining maturity models of specific functional areas within logistics or logistics technologies. These studies explore topics such as inventory management, interaction with third-party logistics providers (3PL), warehousing, supply, sales, and operations planning, as well as risk management (Hofmann & Rüsch, 2017).

The application of maturity models is limited by the proliferation of numerous models developed and the increasing number of "model applications." Table 1 provides a summary of maturity models developed by consulting firms and academic experts, along with their primary objectives and dimensions.

Table 1. Overview of Industry 4.0 Maturity Models (MM) of Consulting Firms

Company	Maturity model	The main aim	The dimension of the company that MM measure
Accenture	Digital Capability Assessment (DCA)	DCA analyzes the digital capabilities of the company to compete in markets.	Strategy and leadership; people and culture; product and service; customer experience; enterprise enablement.
BCG	Digital Acceleration Index (DAI)	DAI measure opportunities to accelerate the company's digital transformation	DAI describes four stages of digital passive; digital literate; digital performer; digital leader. The 4 building blocks are business strategy driven by digital; digitize the core; new digital growth; enablers) with 37 sub-building blocks (e.g., priorities & alignment, digital supply chain, shared services) covering the entire value chain from strategy to capabilities.
Deloitte	Digital Maturity Model (DMM)	DMM represents the first cross-organizational digital MM.	Five core business dimensions (customer; strategy; technology; operations; organization and culture) and 28 subdimensions (e.g., customer experience, security) are used to assess digital capability. Model stages are not publicly available.
EY	Digital Readiness Assessment	The model verifies the organization's strategy and provides an improvement plan for a fully digital organization.	The evaluation is based on seven focus areas (strategy, innovation, and growth; customer experience; supply chain and operations; technology; risk and cybersecurity; finance, legal, and tax; people and organization). The model contains three stages (developing; establishing; leading).
KPMG	Digital Readiness Assessment (DRA)	DRA assesses the organization's relevant sections	The two different perspectives are analyses: transformation intensity and operational effectiveness. The four dimensions are development and purchasing; production; marketing; sales. The process is based on four stages (reactive participant; digital operator; ambitious transformer; smart digitalism).

Source: Felch, Asdecker, & Sucky (2019).

The structure of organizational maturity models proposed by researchers varies depending on the components and business domains, leading to challenges in comparing and applying them. For instance, Facchini et al. (2020) devised a maturity model focused on various logistics subsystems, including company management, material flows, and information flows (see Table 2). The primary advantage of this conceptual maturity model lies in its flexibility to accommodate different maturity levels or elements, depending on the specific digital technologies employed in the process of digital business transformation.

Table 2. A maturity model for Logistics 4.0

Element / Maturity level	Ignoring	Defining	Adopting	Managing	Integrated
Management	Not aware of the need for integration	See the need for integration but do not know how to manage it	Integration is initiated	Integration at most level	Full integration resulting in synergy
Material flows	Do not know about advanced solutions improving material flows	Know about advanced solutions improving material flows but do not use it	Some advanced solutions improving material flows are implemented	Many advanced solutions improving material flows are implemented	All possible advanced solutions for improving material flows are implemented
Information flows	Do not know about advanced solutions improving information flows	Know about advanced solutions improving information flows but do not use it	Some advanced solutions for improving information flows are implemented	Many advanced solutions for improving information flows are implemented	All possible advanced solutions for improving information flows are implemented

Source: developed according to Facchini, F. et al. (2020).

Nagy et al. (2018) formulated a maturity model for Industry 4.0 in logistics, which centers on the business model and digitalization of the company's product portfolio (see Table 3). The primary advantage of the Industry 4.0 maturity model is its capability to discern the progression of a logistics company's digital business model, although it may not specifically identify the types of implemented Industry 4.0 technologies. Additionally, this model provides an advantageous means to evaluate the extent of digitalization within the company's product portfolio.

Table 3. Industry 4.0 maturity model.

	Digital Novice	Horizontal (Internal Processes) Integrator	Cooperating Vertically (with External Partners)	Digital Champion
1. Digital business model and customer access	First digital solutions, island-like applications	Digital product service with portfolio software, networks (M2M, machine-to-machine), and data as distinctive features	Integrated customer solutions across the supply chain, cooperation with external actors	Development of new, disruptive business models, innovative product and service portfolio, including one-time series
2. Digitalization of product portfolio	Online and offline channels are distinct, products focus instead of a customer focus	Multi-channel sales, online and offline channels are integrated, and data analysis is used for customization	Unique customer approach, integrated with value chain partners. Shared and integrated interfaces	Integrated Customer Life Path Management in all marketing and sales channels, customer empathy, CRM

Source: Nagy et al. (2018).

Wendler et al. (2012) introduced the "maturity model for data-driven manufacturing" (M2DDM), which specifically targets IT systems. M2DDM serves as an analytical tool to assess the IT architecture of manufacturing companies, employing a five-stage framework: "non-existent IT integration; data and systems integration; data integration at different stages of the life cycle; service orientation; digital twin to self-optimizing factory". Notably, this model is exclusively centered around IT systems, thereby exhibiting a single-dimensional focus.

Westermann et al. (2016) present a model featuring maturity levels for "cyber-physical systems" (CPS) designed for organizations involved in the development of "CPS capabilities". The first level of the model comprises five stages: "monitoring; communication and analysis; interpretation and services; adaptation and optimization; collaboration". Subsequently, the second level delves into a more detailed examination of

4-5 maturity stages for individual CPS components, encompassing readiness measurements such as executive; sensory (signal characteristics, signal source); information processing; communication system (vertical communication, horizontal communication, connectivity, network connection); human-machine interface (functionality, adaptability, location); data (data storage, storage location, utilization of external data); and services.

The investigation conducted by Gökalp, Şener & Eren (2017) concluded that none of the seven examined maturity models met the analysis criteria, including factors such as "volume, purpose, completeness and clarity, and objectivity." This suggests that maturity models entail a subjective evaluation of the preparedness of an object or system, considering their evolution in alignment with the objectives and requirements of companies, their industry domain, the specific technologies being implemented, and the business challenges these technologies to aim to address.

Thus, maturity models serve as tools for assessing the extent of technology implementation and readiness for adoption in various types of organizations and business domains, thereby gauging the level of digital transformation. However, it is important to note that maturity models primarily take into account the scale and specific characteristics of a company's operations, which inherently possess subjectivity.

Consequently, many of these models do not find widespread application in the practical activities of other companies. Typically, maturity models are developed through experimental research and remain conceptual.

Materials and Methods

The author employs the maturity model proposed by Facchini, F. et al. (2020) to evaluate the level of preparedness for adopting digital technologies within logistics subsystems. The study focuses on developing a practical model of digital maturity specifically tailored to the logistics sector, which is based on two primary criteria: 1) stages (degrees, levels) of maturity (Ignoring, Defining, Adopting, Managing, Integrated) as proposed by Facchini, F. et al. (2020); and 2) the types of technologies implemented within the logistics sector. The maturity model utilized in this study is derived from the Industry 4.0 model developed by Facchini et al. (2020), which assesses the levels of preparedness and the extent of technology adoption. Additionally, Rogers' (1983) typology is employed to determine the types of users based on their integration of innovations, represented as percentages within various user groups: innovators (2.5% of users), early adopters (13.5%), early majority (34%), late majority (34%), and laggards (16%). This typology forms the foundation for assessing the degree of maturity and the state of technology utilization within the logistics domain.

The constructed maturity model assesses the implementation status of Industry 4.0 technologies in the international logistics sector by quantitatively evaluating the integration of various elements of Industry 4.0 into logistics. Specifically, the author identifies several applied technologies of Industry 4.0 in logistics at a macro level, including blockchain applications, the utilization of the Internet of Things, the adoption of cyber-physical systems (CPS), and the implementation of big data solutions. To quantify the extent of technology adoption in the logistics industry, the study estimates the market volumes associated with these technologies used within the logistics sector.

To develop a model of digital maturity for the logistics sector, the following stages of maturity have been identified:

1. Initial Integration/Implementation: At this stage, the global market share of the relevant Industry 4.0 technology in international logistics is less than 2.5%. This indicates a low

level of automation in global logistics, with only a small portion of logistics operations being transparent and efficient due to technology implementation by large companies with sufficient financial resources. As a result, the opportunities for applying Industry 4.0 in the international logistics sector are limited.

2. Defined Integration/Implementation: This stage is characterized by a global market share of the relevant Industry 4.0 technologies in international logistics ranging from 2.5% to 13.5%. Companies at this stage understand the potential of utilizing Industry 4.0 technologies but may not fully grasp the possibilities of digitalization for management and further integration into their business processes.
3. Adopted Integration/Implementation: In this stage, the global market share of the relevant Industry 4.0 element in international logistics ranges from 13.5% to 34.0%. Companies have begun to adapt Industry 4.0 technologies on a global, national, and local scale, indicating a growing level of adoption.
4. Managed Integration/Implementation: Companies at this stage have achieved a global market share of the relevant Industry 4.0 element in international logistics ranging from 34.0% to 68.0%. They are integrating Industry 4.0 technologies at all levels and fully utilizing their capabilities in logistics operations.
5. Integrated Implementation: At this final stage, the global market share of the relevant Industry 4.0 technology in international logistics exceeds 68.0%. Companies have achieved a synergistic integration of all types of Industry 4.0 technologies, resulting in the full automation of business processes within the global logistics sector.

Result and discussion

The developed model of digital maturity and the state of use of Industry 4.0 technologies in the international logistics sector provides valuable insights into the integration of technologies in logistics. The analysis reveals a clear upward trend in the digital transformation of business processes within the sector, indicating a progressive adoption of Industry 4.0 technologies (see Table 4).

Table 4. Digital maturity model: the state of implementation of Industry 4.0 technologies in the international logistics sector

Specific applications technologies Industry 4.0	Quantitative Assessment of Industry 4.0 Elements in International Logistics	Level of implementation	Core application possibilities Industry 4.0 in International Logistic Sector	A Barrier to development applications in Logistics
Blockchain applications	The Global Blockchain Technology Market in Transportation and Logistics Industry Market is expected to grow by $ 811.51 million during 2020-2024 progressing at a CAGR of 54% during the forecast period. The assessment in logistics is less than 0.02%.	Initial integration / implementation	Drive efficiency (reducing bureaucracy and paperwork). Enable new digital business models	The need for security is the main barrier. Data connection from all applications with blockchain. Problems of blockchain adoption
Application of the Internet of Things	The global IoT market size in logistics was $34,504.8 million in 2019. As the global logistics market size is 4,963 Billion in 2019, the share of IoT in international logistics is 0.70%.	Initial integration/implementation	Keeping track of the product's current location. Connecting capabilities. Transparency, maintenance, efficiency, automation, cost optimization	Covid-19 slowdown logistic performance. Capacity limitations in global supply chains, regional hubs. The decline in logistic demand led to a decline in IoT logistics
Cyber-physical systems (CPSs)	In 2019, the global Cyber-Physical System market size was USD 6410.5 million, and it is expected to reach USD 12720 million by the end of 2026, with a CAGR of 10.2% during 2021-2026. The assessment in logistics is less than 0.01%.	Initial integration/implementation	The exchange of information, monitoring, and control are handled automatically	The more individual reaction of distribution centers to customer requirements is the main challenge.
Big data	The Supply Chain Big Data Analytics Market was valued at USD 3.03 billion in 2019 and is expected to reach USD 7.91 billion by 2025, at a CAGR of 17.31% over the forecast period 2020 - 2025. The share of Big Data in international logistics is 61.05%	Managed integration	Analyze data sets and identify key insights to apply to logistic operations. Access, store, and process a massive amount of data.	The need for security is the main barrier.

Source: built by the author based on MarketWatch (2020), ReportLinker (2020), Research and Markets (2020).

The model further includes a visual representation, depicted in Figure 1, that illustrates the capabilities of various technologies and their significance in the context of international logistics. The maturity model demonstrates that the integration of Industry 4.0 technologies in the international logistics sector is primarily in its early stages, with limited utilization of digital technologies. Among the different components of Industry 4.0, big data analytics emerges as the most integrated technology, owing to its crucial role in the collection, processing, and analysis of large datasets.

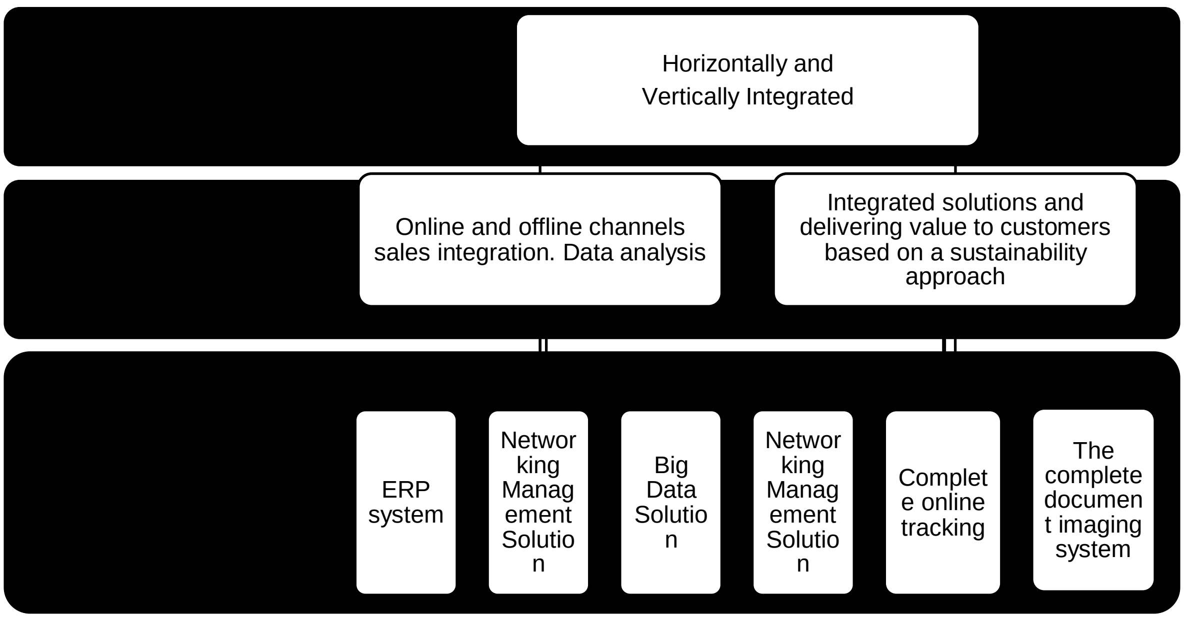

Figure 1. Digital maturity model of the logistics sector.
Source: developed by the author.

The process of digital transformation in business involves the integration of various Industry 4.0 technologies, such as Enterprise Resource Planning (ERP), Network Management Solutions, and Big Data, among others. This initial stage of digital maturity paves the way for the digitalization of the company's product portfolio, which represents the second stage of digital maturity. This entails the digitalization of logistics services and products offered by the company. To illustrate this, consider the example of tracking goods. Previously, customers would need to contact a logistics company's manager by phone to obtain information about the status of their goods. However, with the digitalization of logistics services, customers can now conveniently track the location of their goods through the company's website or application using the provided order number. The third stage of digital maturity involves the establishment of a comprehensive digital business model. At this stage, the company has fully integrated technology into all aspects of its business processes, achieving automation of logistics operations and services in both vertical and horizontal dimensions. This signifies a high level of technological integration and optimization throughout the company's operations.

The stage of digital business model and customer access addresses various important aspects:

1. One key aspect is the establishment of a dynamic and flexible supply chain that spans across all logistics channels. This enables companies to optimize product availability and enhance profitability. In this context, manufacturers, traders, transportation companies, warehouse organizations, and logistics service providers, functioning as supply chain links, employ different algorithms tailored to their respective functions and processes. These algorithms encompass the entire product lifecycle, including activities such as product design, capacity and resource provisioning, manufacturing, sales, after-sales services, and disposal. To achieve seamless coordination and synchronization among the units within the supply chain, modern management methods are essential. The Internet of Things (IoT), along with sensors embedded in various production control systems and infrastructure components, as well as mobile phones and GPS devices, generate a vast amount of information necessary for effective supply chain management. However, this information is often fragmented and scattered. Therefore, a crucial task in supply chain management is to devise mechanisms for tracking, storing, analyzing, and leveraging this data effectively. The ultimate objective of supply chain transformation is to evolve it into a dynamic Smart Supply Network (SSN), capable of adapting and responding intelligently to changing market dynamics and customer demands. The SSN is designed to operate as an adaptive system, capable of automatically adjusting its algorithmic data and structure to maintain or achieve an optimal state in response to changes in external conditions.

It is configured to dynamically consider individual customer requirements, and fluctuations in supply volumes, and promptly make operational adjustments during the execution of ongoing orders when necessary. By integrating information from diverse sources, the SSN facilitates customized delivery and direct production management. The key benefits of an SSN include enhanced flexibility, the ability to reconfigure operations to accommodate individual customer demands, expedited time-to-market for new products, and resilient performance in the face of technological or informational disruptions. Furthermore, the SSN is capable of mitigating the adverse effects of demand fluctuations, ensuring smoother business operations, and minimizing negative consequences.

2. Integrated inventory management at the level of each participant in the supply chain is crucial for achieving end-to-end visibility of trade flows in real-time, dynamic order execution, and efficient return management, ensuring uninterrupted business operations. A key component of the contemporary digital supply chain concept is the utilization of web-based enterprise logistics applications, which facilitate collaboration and optimization through a centralized logistics information backbone. This backbone enables enterprise-wide visibility and extends the reach of the supply chain. By tightly integrating enterprise and supply chain logistics with core inventory, warehouse, transport, and personnel management systems, organizations can create new process models and achieve swift order fulfillment. The adoption of software solutions empowers organizations to leverage data for optimizing supply chain logistics. Integrated inventory management offers significant advantages by streamlining activities across the entire supply chain, encompassing equipment manufacturing, fuel, and lubricant supply, product manufacturing, infrastructure construction, processing, transportation, and distribution. These advancements form the foundation for the establishment of an integrated supply chain within a modern digital environment.
3. The optimization of critical processes and the efficient handling of vast amounts of relevant information are essential in the digital transformation of logistics operations. Leveraging artificial intelligence and predictive analytics enables informed decision-making for planning and managing logistics operations while ensuring reliable control and monitoring of supply chain participants' actions. The formation of SSNs is

contingent upon the digital transformation of business processes across all system components. Depending on the specific problem at hand, the optimization of business processes can encompass various strategies, including streamlining process stages, eliminating unnecessary steps, reducing points of agreement, modifying the sequence of execution stages, eliminating approval cycles, aligning parallel process execution, enhancing the performance of process steps, mitigating bottlenecks, and reducing unnecessary complexity.

4. The primary objectives of digital logistics include cost reduction, the implementation of efficient solutions in logistics and supply chains, and the enhancement of customer service quality. A significant economic aspect of digital logistics is the recognition that a substantial portion of transportation costs (around 10 to 15%) is attributed to the preparation of paper documents and the resulting delays in delivery. These costs and delivery time inefficiencies can be reduced by 20-40% through the adoption of legally recognized electronic document management systems. The integration of Industry 4.0 technologies offers effective solutions to address and mitigate such cost-related challenges in logistics operations.

Conceptually, supply chain management involves two main approaches: vertical integration and horizontal integration. Digitalization encompasses more than just advanced automation; it also encompasses the need to address three production dimensions: vertical integration, which focuses on flexible and reconfigurable production systems within individual enterprises ("smart factories"); horizontal integration, which involves the integration of value chains within an organization group ("smart supply chains"); and integration of product lifecycles and digital engineering activities throughout the product value chain and associated manufacturing system. Integration plays a crucial role in configuring and coordinating the functioning of the supply chain. Vertical integration occurs when a single organization controls all the links in the supply chain, enabling decisions on supply chain configuration and coordination to be made from a central control center. On the other hand, horizontal integration involves different parts of the supply chain being owned by different entities, requiring agreements among organizations to ensure coordination and seamless operation. In some cases, horizontal integration between enterprises leads to the formation of partnerships that evolve into strategic alliances. Vertical integration impacts all systems within the traditional automation pyramid, spanning from the field level and control level to the production level, operations level, and enterprise planning level. Horizontal integration, on the other hand, pertains to the non-hierarchical representation of multiple systems, encompassing suppliers, processes, information flows, and information systems throughout the stages of product development, production, logistics, distribution, and ultimately, reaching the end customer.

Stage Digitalization of product portfolio solves such questions:

1. The reliability of the entire supply chain and the quality of the services provided, are closely related to the efficiency of logistics and currently play a key role in the choice of a carrier. Reliability and predictability often take precedence over speed and cost of delivery. ERP system is used to digitize the supply chain. ERP systems are usually implemented in large corporations and enterprises with complex production processes, a large range of products, and a large volume of inventory. One of the main advantages of ERP systems is their ability to combine multiple tasks. These systems can simultaneously take into account and plan their expenses and track the flow of money. All processes become transparent, thereby ERP provides: 1) consolidation of all processes according to general rules in a single system; 2) timely reporting on all processes within the company; 3) planning and monitoring of the organization's activities. Along with these benefits, ERP implementation increases the productivity of the company. Thanks to its modularity, ERP software can be implemented incrementally, for example, an enterprise can start by automating the workflow and then move on to human resource management. ERP applications today can include functions for customer relationship management (CRM), finance, accounting, supply chain, and human resource management, among many other activities. Each employee, in turn, uses only those functions and options that meet their needs.

2. Ability to quickly respond to emergencies and force majeure. Maintenance and Inspection – Robotic systems are already being used to service and inspect road and rail vehicles and their respective infrastructures, and can be expanded to automate even more tasks using artificial intelligence. For example, robots on railway tracks can be deployed to automatically clean or monitor the condition of the rails at set intervals (for example, at night when the lines are less busy) or when unexpected objects / failures are detected (via sensor networks); wheeled robots can be used to maintain clean roads (e.g. automatic snow plows, salt distribution, etc.); robots can be used to control vegetation; scanning and penetrating robots can be used to test carrying cables or ventilation pipes; flying robots (such as helicopters, unmanned aerial vehicles, etc.) can be used for aerial photography or to transport equipment or maintenance parts in remote areas, thus reducing transportation costs and lead times; Swarm robots and robot networks can be used in conjunction with 3D printing for a variety of interior and repair work and infrastructure inspections, improving service times, costs and efficiency; or robotic suits (exoskeleton) can be used by maintenance personnel to allow them to carry heavier objects and reduce the workload of a person and increase his or her ability to work. In addition, robots can be used to carry out maintenance and inspection work in hazardous environments that would otherwise have to be performed by humans (e.g. work on active lines, in elevated or toxic areas during storms, tunneling, etc.) reducing the risk of accidents
3. Transition to higher margin and high-value goods (transportation of high-tech products, luxury goods, perishable goods, unique products, and much more). Digital transformation is beneficial for most key financial metrics. For example, concerning the cost of production, the effect arises due to the optimization of operational processes: repair and maintenance work, the launch of production lines, quality control, and internal warehouse operations.

The integration of online and offline sales channels aims to achieve a high level of channel integration, where the boundaries between channels become indistinguishable for both customers and logistics companies, resulting in the formation of an omnichannel sales technology. The defining characteristic of an "omnichannel" approach is that customers perceive no distinction between channels when purchasing goods, as they have the flexibility to choose the most convenient channel at any given moment for making purchases, receiving items, and returning them if necessary. The omnichannel technology ensures a unified assortment across all channels, including the company's website and other devices through which orders can be placed. It also encompasses consistent pricing, synchronized data storage systems that capture customer information, purchase history, and preferences across all utilized sales channels, as well as flexible payment and delivery options tailored to the buyer's convenience. In an omnichannel setup, when a customer registers an account within one channel, all their data and purchase information should be saved and synchronized across all other channels.

Integrated solutions aim to deliver value to customers by adopting a sustainability approach, which entails considering the environmental aspect of logistics operations. The application of new technologies plays a crucial role in reducing the environmental impact. One prominent technology is the Big Data Solution, which utilizes sensors to collect and transmit data through the Internet of Things (IoT) to a cognitive computing platform. This platform processes and interprets the vast amount of data, providing business leaders with valuable insights necessary for effective decision-making and conducting their operations efficiently.

The Networking Management Solution offers an automated approach to managing a company's transport logistics, requiring minimal initial costs and a short implementation time. This comprehensive solution encompasses the entire cargo delivery process, starting from receiving delivery requests to the final receipt of the cargo at the customer's warehouse. It includes various functionalities such as routing request management, documentation handling, route optimization, and delivery time agreement between departments. Key features of this solution include route planning, cost estimation, GPS tracking, integration with map services, mobile application support, and email and SMS notifications.

Furthermore, the implementation of complete online tracking enhances the ability to track orders and parcels using unique track numbers, providing real-time updates on their exact location. This digital transformation contributes to an intelligent and optimized supply chain by offering transparency and timely information. By utilizing telematics data, this smart solution eliminates labor-intensive processes, optimizes the use of transport systems, and enables proactive transport management. The benefits of complete online tracking are manifold, including improved delivery timeliness, enhanced customer satisfaction, elimination of inefficiencies and unfulfilled time slots, and increased flexibility and adaptability within the supply chain.

The Complete document imaging system offers a comprehensive solution to optimize the work of various specialists involved in transport logistics management, including dispatchers, logisticians, forwarders, sales and purchasing managers, and department heads. These professionals face multiple challenges simultaneously, such as processing incoming requests, planning transport loading, creating routes, and monitoring their execution. Additionally, they need to ensure the timely completion of documents, oversee repairs, maintain accurate records of fuel and lubricant costs, and manage the vehicle fleet to ensure delivery profitability. While managing logistics within a city with 20-30 delivery points may pose manageable difficulties, the task becomes significantly more complex for distributors or online stores with 100-200 delivery points. In such cases, a smart logistics program is essential to efficiently address these challenges. The Complete document imaging system serves as a robust solution, particularly on a global scale, to address these complexities.

The spectrum of digital technologies that shape the extent of digital transformation in supply chains is vast and has been partially discussed earlier. The specific combination of digital technologies employed relies on numerous factors, primarily within the business domain of the focal company within the supply chain. Prominent consulting firms, along with leading system integrators and logistics providers like Accenture, SAP, and DHL, consider three technologies as the foundational pillars of digital supply chain transformation: the Internet of Things (IoT), blockchain, and cognitive computing.

Conclusion

A digital maturity model is employed to assess the implementation status of various Industry 4.0 technologies within the logistics sector. This model provides insights into the current state of integrating Industry 4.0 technologies in the international logistics sector, highlighting the limited utilization of digital solutions except for big data analytics. Among all the components of the maturity model, big data analytics emerges as the most extensively integrated element, facilitating data collection, processing, and analysis. The initial stage of digital maturity involves the digital transformation of businesses through the adoption of Industry 4.0 technologies such as ERP, Networking Management Solutions, and Big data. Subsequently, the second stage of digital maturity entails the digitalization of a company's product portfolio, including the digitalization of logistics services and products. Further research endeavors should focus on assessing the effectiveness of digital business processes within the logistics enterprise management system. Such investigations will provide valuable insights into enhancing operational efficiencies and optimizing the management of logistics enterprises in the digital era.

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