Improving Supply Chain and Logistics Through Automation

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Abstract – The field of logistics is undergoing a transformative shift, marking the advent of a new age. The progression of digitalization and technologization facilitates the emergence of novel business models, enhanced operational efficiency, innovative planning strategies, and several other benefits. However, it is important to acknowledge the potential drawback of being overwhelmed amongst the rapid pace of advancements. The logistic operations automation and the subsequent creation of autonomous logistics systems are significant phenomena that have profound implications for the future execution and planning of logistics processes. This article seeks to add to the ongoing discourse and delve into the inquiry of how the development of automated and autonomous logistics systems should be strategically planned and executed. The current editorial establishes a framework by elucidating the practical domains in which automation is used and deliberating on the conceptual trajectory leading to the development of autonomous logistics systems. The following papers provide valuable insights into the latest research findings on the autonomization and automation of physical and informational logistics operations, with a strong emphasis on practical applications.

Keywords – Supply Chain Management, Logistics, Automation in Supply Chain and Logistics, Digital Transformation, Antecedents of Automation.

I. INTRODUCTION

According to Mishra, Kumar, and Garg [1], the supply chain refers to a complex network of manufacturers and distributors who are responsible for the provision of raw materials, their conversion into intermediate goods and final products, as well as the subsequent distribution of these end products to consumers. Supply chain management (SCM) refers to the comprehensive integration of all activities that occur between the supplier and the end consumer. Supply chain management (SCM) is a conceptual framework that facilitates the systematic control and coordination of various inter-organizational operations. Digitalization and digital transformation are distinct ideas that are sometimes used interchangeably but have different meanings. Numerous meanings have been articulated since the inception of the word "digitalization." The word "digitalization" was first used by the North American Review in 1971, specifically referring to the process of transforming society via digital technologies [2]. The aforementioned notion was associated with the contextual framework and possibilities of "computer-aided humanities research" during the period mentioned. Digitalization encompasses technology that are accessible to all individuals, and it is a term that is intertwined with substantial transformations in several domains, including cultural, behavioral, demographic, and life cycle characteristics.

The concept of digital transformation, as articulated by Pasinitsky [3], has emerged as a subject of extensive scholarly discussion and practical application; however, it lacks a definitive and universally accepted definition. Industry 4.0 is situated within the context of digital transformation in supply chains, as it persists in being used interchangeably with the terms digital transformation and Industry 4.0. The notion of digital transformation is rooted in the historical context of industrial revolutions, with particular emphasis on the omission of digital transformation in previous discussions. The proliferation of automation started in the 1970s, driven by advancements in technology. The technologies that emerged during the Second World War, in response to the demands of the time, played a pivotal role in the inception of Industry 3.0. The advent of World War II facilitated the development of automation in manufacturing via advancements in communication and technology. During this era, along with the development of the software industry, there have been notable transformations in machinery as well. Moreover, the industrial process has transitioned to an entirely another dimension. The phenomenon of globalization has seen a progressive expansion as a result of the improved accessibility and efficiency of communication and transportation systems. As seen by historical instances of industrial revolutions, there has been a consistent endeavor to affect a transition in energy resources within this context.

Over the course of many years, the logistics and supply chain sector has seen a significant trend known as the digital transformation. This development has posed notable obstacles for practitioners, while also providing them with substantial potential to gain competitive benefits at several levels. The physical and informational processes automation is a very significant advancement that has the potential to profoundly influence the management and planning of logistics systems across operational, tactical, and strategic levels. The motives for the automation of processes are diverse and include a variety of factors. These factors include the objective of cost reduction and the pursuit of increased productivity. Additionally, there is a desire for greater autonomy in decision-making for workers within the logistics network.

According to Denk, Kaufmann, and Carter [4], the increasing prevalence of automated SCM and logistics procedures is a major development of the present and future. Yet, when it comes to creating automated solutions, many businesses still show resistance and run across roadblocks. When compared to the automation of informational processes, the amount of automation in the domain of automating physical operations, like those found in industrial or warehousing logistics, is more sophisticated. The significant cost and complexity of integrating these automated technologies into existing infrastructure remain, though. Intricate global networks are already difficult to manage, and the automation of informational operations in logistics networks adds another degree of complexity.

Regardless of how accurate these predictions are, it is clear that the autonomous and automation integration of logistics systems is a major and growing trend. This article seeks to provide a contribution to the ongoing issues around automation and autonomization in certain domains. In this discourse, we elucidate the theoretical trajectory towards the development of autonomous logistics systems. In order to achieve this objective, the outcomes of a recent comprehensive analysis on the many domains of application and factors leading to the initiation of automation initiatives in the field of logistics are first condensed. Following that, the evolutionary progression towards autonomous systems is succinctly elucidated, and a clear differentiation is made between the ideas of automation and autonomy.

The rest of the article has been organized as follows: Section II presents a review of the key concepts such as logistics and supply chain management, identifying their objectives and functions. Section III presents a detailed analysis of autonomous supply chains and logistics: discussing the antecedents and application areas of automation in supply chain management and logistics; as well as a transition from automated to autonomous processes. Lastly, Section IV presents a conclusion to the article.

II. OVERVIEW OF KEY CONCEPTS

Logistics

According to the definition provided by Habibullah and Pudjianto [5], logistics can be defined as the systematic procedure involving the strategic planning, execution, and supervision of the streamlined and economical movement and storage of raw goods, in-process inventory, finished products, and associated data, commencing from the initial source and concluding at the final destination, with the primary objective of meeting customers' specific demands and specifications.

The goals of logistics include the following (see **Table 1**):

Table 1. Goals of logistics

Lowering of inventory	Inventory levels are one of the most crucial factors that may have a big impact on a business's bottom line. In the previous arrangement, companies had to have a large inventory of goods on hand in order to fulfill demand and provide clients' top-notch service. Money, however, cannot be used more effectively elsewhere while it is constrained by stock.
Freight efficiency	In logistics, freight is a significant source of expense. This may be decreased by using strategies including route planning, long-distance shipments, freight consolidation, and mode of transportation selection.
Dependability and consistency in delivery performance	The consumer must get the material they have requested on time, neither early nor late. This will be ensured through careful planning of the transportation modalities and the availability of merchandise.
Minimal product harm	Products may sometimes get harmed as a result of poor packaging, frequent handling of shipments, and other factors. This damage raises the cost of logistics. This damage may be minimized by using effective logistical packing, automated material handling equipment, etc.
Fast and quick response	A company must be able to provide service to the consumer in the least amount of time. Utilizing the most up-to-date information processing and communication technology will enhance decision-making and allow the organization to be flexible enough to meet client needs in the shortest amount of time.

The following are some of the several logistical functions (see **Table 2**):

Table 2. Functions of Logistics

Order Processing	Order processing is a crucial step in fulfilling customers' requests, but it also requires a significant time commitment and mountain of paperwork. Acknowledging the owner and identifying any discrepancies between the order and the agreed-upon conditions, price, payment, and delivery requires assessing stock levels, planning production, and preparing delivery schedules.
Inventory management and planning	Organizations may improve customer satisfaction and inventory management by carefully planning the inventory. This entails a wide range of operations, including but not limited to: inventory forecasting, engineering the order amount, optimization of the level of service, correct deployment of inventory, etc.
Warehousing	This is where the completed products are kept until they are sent out to the clients. This is a significant expense area, and mismanaging the warehouse will lead to many issues.
Transporting	Facilitates the actual transport of products to the location of the end user. This is accomplished using several transportation channels (e.g., sea, road, rail).
Packaging	A vital part of the good`s physical distribution that has an effect on the logistics system's effectiveness.

Supply Chain Management

The term "supply chain management " was introduced by Keith Oliver, a consultant at Booz Allen Hamilton, in 1982 [6]. Initially, it was primarily associated with logistics. However, over time, it has developed into a multifaceted corporate endeavor encompassing various functions such as distribution, procurement, after-sales service, and demand forecasting. A supply chain refers to the collection of companies engaged in the process of designing new services and products, acquiring raw materials, converting them into partially or fully processed goods, and ultimately distributing them to the final consumers. Supply chain management refers to the effective management of the whole process, spanning from the initial design of a service or product through its ultimate disposal and consumption by the end user. The comprehensive process encompasses many stages, including after-sales service, product design, fulfillment, sourcing, distribution, planning and forecasting, and manufacturing. The primary goals of supply chain management encompass (see **Table 3**):

Table 3. Goals of Supply Chain Management

Minimize Costs	Reducing overall costs is the fundamental focus of supply chain management. Both indirect and direct expenses are included here. Companies may boost their earnings and level of competition by cutting expenses.
Enhance customer value	Improving customer value is another main objective of supply chain management, which in turn increases the value of the brand. Customers' satisfaction with the goods or service they purchase and the overall quality of the transaction may boost its worth.
Enhancing Quality	Every supply chain should prioritize delivering high-quality products and services to consumers. Effective quality control and assurance methods, supplier management, and listening to and responding to customer input are just a few ways to attain superior quality.
Enhance Logistics	Streamlining the logistics is crucial for lowering costs and guaranteeing a steady supply of products. Logistics management encompasses all aspects of moving and storing merchandise. Managers of the supply chain may maximize efficiency and save costs by focusing on logistics. Improving logistics has far-reaching effects since it is the backbone of the supply chain.
Boost Distribution	Improving the distribution system so that completed products and services are accessible to clients when they need them is a fundamental goal of supply chain management. This goal is met by having a sufficient amount of completed items on hand in the appropriate location at the right time. Sales and profitability may be increased and customer satisfaction boosted through improved distribution.

The five main responsibilities of global supply chain management are as follows (see **Table 4)**:

Table 4. Functions of Supply Chain Management

Purchasing	The process of managing the supply chain begins with purchasing. It involves acquiring the components and inputs needed to produce the final product.
Operation	Supply chain management's first step is purchasing goods and services. This entails collecting all the stuff that will be used to make the stuff.
Logistics	This activity falls within the purview of supply chain management and requires extensive coordination. Production has begun in earnest. There must be somewhere to put it until it can be delivered by ship.
Management of resources	Human labor, water, and energy are essential to the operation of every company. However, it is crucial that everything operates efficiently and successfully. The team in charge of the resource management function handles this step.
Data Workflow	The smooth operation of the other parts of supply chain management depends on the timely and accurate dissemination of information. The whole process might fall apart and be mismanaged if there was a breakdown in the information flow and communication.

III. AUTONOMOUS SUPPLY CHAINS AND LOGISTICS

Antecedents and application areas of automation in supply chain management and in logistics

Jan. Vollering and Waarts [7] conducted a meta-analysis to offer a comprehensive examination of the potential application domains of automation and the factors that contribute to the success of automation projects. Supply chain management and logistics professionals were surveyed and participated in a structured group exercise for this research. Consequently, a total of ten application regions, including various sub-areas, were consolidated, while a comprehensive framework consisting of four dimensions of antecedents, encompassing a total of 10 antecedents, was established. **Fig 1** illustrates the conceptual framework that has emerged from this research.

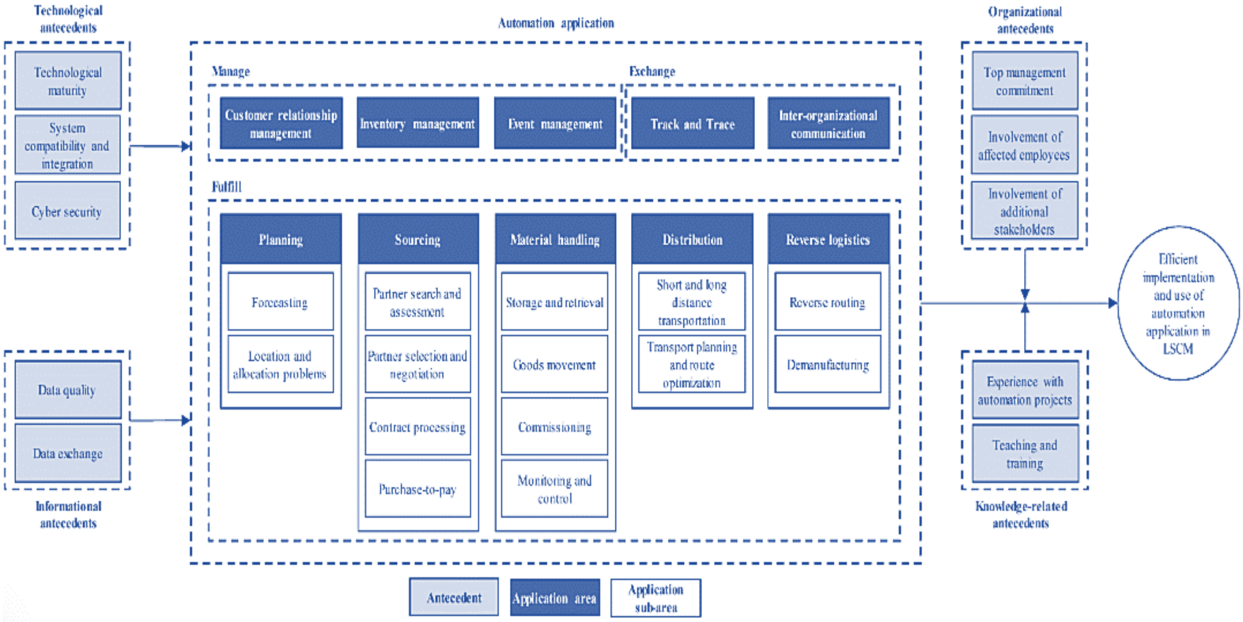

Fig 1. Automation Concepts and Framework for Supply Chain and Logistics Management

Application Areas of Automation

Fig 1 shows that the areas of automation may be broken down into three distinct classes: manage, exchange, and fulfill. The "fulfill" dimension of automation describes those elements of automation that are mainly designed to ease the execution of the core client order process. Reverse logistics, planning, material handling, sourcing, and distribution are all subfields of supply chain management. In [8], it was discovered that the majority of articles focused on sourcing and material handling automation. Automated robots and autonomous vehicles are commonly used in material handling applications, while sourcing applications tend to automate the more cerebral aspects of the purchasing department like payments, partner searches, and negotiations. In addition, the field of planning focuses primarily on perfecting automated forecasting methods.

Applications that are associated with the "exchange" dimension primarily aim to streamline the automated gathering and sharing of data throughout the supply chain. In order for an industry to effectively run, it is essential that each stage within the industry has an adequate number of well-functioning actors, meaning that enterprises within the sector should be able to generate profits. Moreover, it is crucial to note that the central aspect of our research revolves on the willingness and capability of participants to transmit the necessary information at the interface between stages. In situations where there is a potential for mutual benefit among individuals operating at the intersection of distinct phases, it is postulated that the exchange of information will take place. The present analysis focuses on the scenario whereby enterprises have difficulties in exchanging necessary information due to its unavailability in a format compatible with the requirements of other firms. The probability of information being unavailable or inaccessible in a manner that is comprehensible and applicable to others is heightened during the emergence or disruption of an industry and its associated supply chain.

Fig 2 is a simplified representation of a supply chain, illustrating potential challenges that may develop while transferring the necessary information for the effective functioning of the supply chain. The data shown in the figure indicates that the level of information sharing throughout a supply chain may fall below the desired or anticipated level due to various structural factors that are independent of the intent of enterprises to engage in such communication. Based on the information shown in **Fig 3**, we propose many structural criteria.

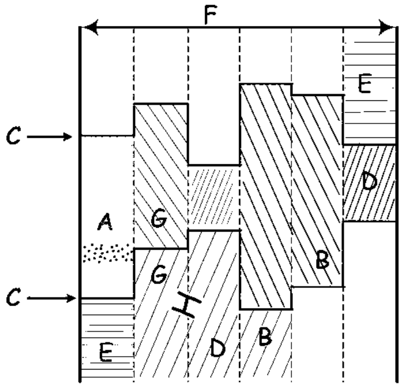

Fig 2. Information Exchange in a Supply Chain

Task Layers \ Logistic System	New demands on Logistics Processes
Decision System / Organisation and Management	**Organisational demands** • Definition of autonomous logistics processes • Definition of limits of conventional and autonomous control • Availability of adequate information at the correct place in time • Ability to measure and evaluate autonomous logistics processes • Design and structuring of dynamic distributed targets • Management strategies to consider external and internal risks • Methods to establish efficient distributed Quality Management Systems
Information System / Informatics Methods and I&C Technologies	**Technological demands** • System items' ability to communicate and cooperate • Distributed data management and date handling • Mobile data communication technologies • Data security guidelines regarding establishing mobile data communication • Localisation's ability • Mobile hardware components (transponder etc.) • Software requirements (new PPC-/ERP-functions)
Execution System / Material Flow and Logistics	**Process-related demands** • Development of autonomous decision algorithms • Development of strategies to use the process immanent intelligence • Ability to model autonomous logistics processes • Adaptation/development of PCS- and logistics-functions • Robustness (resource, object, part) • Divisibility of orders / mergence of intelligent items (e.g. assembly stage) • Logical and physical reactivity

Fig 3. System Layers and their Demands

The diagram illustrates the many steps in a supply chain, with each stage represented by independent lines denoted as C. The fill pattern and line style used in the diagram reflect the quantity of economic activities undertaken by enterprises. Additionally, the number of columns within each stage represents the number of competing firms involved. Furthermore, letters are used to highlight possible concerns related to information transmission. The high number of participants in a given stage, especially in scenario F, might provide challenges to the sharing of information between stages, particularly when a focus business must engage with numerous enterprises in the neighboring stage. Furthermore, it should be noted that some businesses in the aforementioned stage have a tendency to outsource a greater number of operations compared to others (referred to as Situation C).

Consequently, it is plausible that enterprises may exhibit varying levels of involvement within their respective stages of a supply chain. This might provide challenges in terms of information flow, particularly inside the main company. The probability of information sharing between a focal business and a participant at an adjacent level of the supply chain is significantly elevated when there exists a formal agreement between the two firms (referred to as Situation D). The focal business may afterwards use this knowledge to its advantage when engaging with different entities in a neighboring phase of the supply chain. The continued sharing of information can also have advantages for the firm initially engaged with by the focal firm, while potentially posing a disadvantage to the focal firm itself. This is because the competitors of the focal firm may be empowered as a result of indirectly obtaining information about the focal firm through a shared business partner.

In the scenario where a single corporation has significant market power (referred to as Situation H), said firm possesses the ability to establish norms governing the sharing of information across different stages. Moreover, in the case when economic activities within a stage are fragmented (referred to as Situation A), there is a significant rise in the total need for information transmission, which might potentially hinder the smooth flow of information exchange. According to Kembro and Selviaridis [9], if the need for information sharing between actors at neighboring stages of the supply chain is such that it completely satisfies the needs of either party in terms of scope, then the level of information exchange is expected to be sufficient (referred to as Situation G). at the event that the focal business necessitates the engagement of many firms at an adjacent stage of the supply chain, it is probable that there will be deficiencies in the sharing of information (referred to as Situation B).

Ultimately, it is necessary for several entities to engage in the exchange of information, resulting in the potential for incomplete information transmission. Additionally, a focus business is likely to interact with rival companies in the adjacent stage. In accordance with academic conventions, it is necessary to include a citation for the source referenced as Moreover, it is worth noting that a focal business may need access to information from a non-adjacent firm, as shown by case E. Acquiring such information is expected to provide more challenges compared to obtaining information from players on a neighboring level. In accordance with academic conventions, it is necessary to include a citation for the information provided in in response to the need for information sharing along a supply chain, several companies have established comprehensive forms of partnerships with enterprises operating in subsequent phases. This approach has the potential to enhance the advantages of Situation G, but the realization of situation D may not have been achieved at this point.

The "manage" programs mostly deal with management tasks that are tangentially connected to the fulfillment procedure. This includes a wide range of uses in areas like CRM (customer relationship management) and event planning. In addition to autonomous multi-agent techniques for risk assessment and subsequent modifications in logistics planning, these applications also include automated replenishment methods and automated customer service applications.

Based on the aforementioned broad categorization of automation's application areas in SCM (supply chain management) and logistics, it becomes evident that this discipline encompasses a wide range of subdomains within research and literature. Moreover, the categorization further splits automation applications into many domains, however it is possible that a certain automation application in reality encompasses multiple application domains simultaneously. The domain of autonomous logistics systems, which involves the autonomous communication and decision-making of several players, encompasses various application areas.

Antecedents of Automation

While the precise antecedents of an automation application in every given field may vary, examining them at a higher level offers valuable insights into effectively implementing automation solutions in real-world scenarios. Based on the findings of Ragavan, Ganapathy, and Kusnanto [10], it has been shown that there exist four distinct dimensions of antecedents that have an impact on the effective deployment and use of automation systems.

The efficiency of implementing and utilizing an automation solution is directly influenced by technological antecedents, like cyber security, technological maturity, integration and system compatibility. Additionally, informational antecedents, like data exchange and data quality, also play a significant role in this regard. This implies that the technology and data-related aspects of the solution are crucial, albeit not the only determining factors. This observation, while not unexpected, highlights the intricate nature of acquiring or creating a solution that satisfies these various criteria. Specifically, the solution must possess technological maturity, compatibility with current systems, and adequate consideration of security aspects. Additionally, it must also have access to the requisite data for the automation solution and enable seamless data exchange. Nevertheless, there exist additional variables that have an effect on the efficacious execution.

In particular, the moderating effects of technical and informational antecedents are shaped by organizational antecedents such as top management commitment, engagement of impacted workers, involvement of extra stakeholders, and knowledge-related antecedents. This discovery underlines how crucial it is to keep people in mind when developing and implementing automated systems. This phenomenon has also been seen in several other technological implementations, highlighting the potential of automation to enhance productivity and decrease reliance on staff. However, it is crucial to acknowledge that people remain essential in the planning, management, development, and use of projects, solutions, and applications. With that being said, the role of human involvement in automation is a prominent subject matter within this article, among other equally significant considerations.

From Automated to Autonomous Processes

Technological Impact

Impact of Innovation on Efficiency via Coordination

The primary objective of the organization's strategy is to effectively align decisions and corresponding behaviors in order to achieve desired outcomes. To maintain enduring strategic advantages, this method seeks to effectively respond to the continuous and rapid changes. By implementing innovative strategies in commercial, organizational, technical, and operational aspects, corporations may gain new advantages. The pervasive presence of emerging enterprises and the phenomenon of globalization in commerce had a significant impact on the advancement of business. It is essential for a corporation to maintain current and relevant information system technology. The invention has a multitude of characteristics that enable every organization to choose the appropriate industry. This facilitates effective collaboration between the firm and its producers and consumers.

The "Application-Push" perspective involves the use of a step-by-step approach throughout the innovation phase, particularly when novel technology is promptly introduced to the market. The creative approach known as "Market Pull" is characterized by its focus on client demand and preference, therefore providing customers with a strong foundation. Hence, it is imperative to acknowledge the profound impact of the company's innovation on the overall success of the organization. Consequently, any organization should consider various technologies and prioritize the appreciation of current technology by fostering innovation and endorsing the technological and knowledge systems. The integration of both elements would optimize the impact and efficacy of creativity, hence enhancing the advantages for the company.

E-business technology advancements for better supply chain management

To facilitate a more comprehensive comprehension, the supply chain may be dissected into three primary components. The determination of the quantity of items and services that a company has to produce in order to address certain criteria and fulfill customer demands is a crucial aspect of marketing. The market provides information in the form of indicators that might aid in making informed judgements. The information generated encompasses research conducted inside the sector as well as insights derived from customers, including their preferences, expectations, and stylistic inclinations, among other factors. In order to optimize efficiency and enhance performance, the implementation of effective product and logistics procedures might be advantageous. The optimal determination of inventory levels and the efficient transportation of products may be achieved via the use of developed technology and the application of relevant materials. The transfer mechanism is the primary method through which cash is exchanged for products and services that are delivered.

When considering the inquiry about the terms and circumstances of payment that are to be discussed and agreed upon with the supplier, it is important to thoroughly analyze and evaluate the many factors involved. In order to establish a payment method that is both efficient and dependable, it is essential to comprehend the intricacies of the supply chain process inside the organization. One of the advantages for businesses in sharing information is the introduction of Enterprise Resource Planning (ERP) systems. The three networks of electronic business have been upgraded with state-of-the-art technology, enabling enterprises to effectively manage real-time demand and efficiently gather and analyze critical information throughout the supply chain. The organization has the ability to manage the dissemination of information throughout its many departments, as well as with its suppliers and customers, via the implementation of e-business systems. These systems are the result of strategic choices made within the supply chain networks. The integration of E-business has facilitated the incorporation of networks, enhancing access to valuable information for making informed decisions on sales, output, marketing, and related areas.

Novel Demands

The establishment of autonomous logistic processes necessitates the fulfillment of a certain set of general requirements inside the logistics system. Figure 3 provides a comprehensive representation of the many needs associated with logistics from a holistic standpoint. The figure depicted above illustrates the allocation of the new demands on logistic processes to various system layers, including the execution system, information system, and decision system. Additionally, these demands can be further categorized into task layers, namely organization and management, logistics and material flow, I&C technologies, and informatics methods. Consequently, the various needs may be classified into three distinct categories: organizational expectations, technology demands, and process-related demands.

Organisational demands

The establishment of autonomous logistic processes necessitates the development of new organizational general conditions. To provide a comprehensive knowledge of the paradigm, it is necessary to begin by providing a definition of autonomous logistic processes and clarifying their differentiation from conventional logistic processes. In order to find potential applications, it is important to conduct an investigation into the boundaries of both conventional and autonomous control, as outlined by the provided definition. One defining feature of autonomous logistic operations is a heightened need for dispersed information. The provision of sufficient and timely information is a primary need for the effective functioning of autonomous logistic operations inside an organization. The primary objective in implementing autonomous logistic processes is to enhance the logistics system efficiency.

Hence, it is essential to establish an assessment framework that takes into account the alterations in the order processing as a result of autonomy. This feature will allow the user to assess autonomous processes in comparison to traditionally controlled operations. Moreover, it is important to establish clear boundaries for management and autonomy, and to include various perspectives on autonomy (such as resource, object, and component) into the overall system framework. Dynamical targets may be established, allowing for the exploration of novel attributes pertaining to autonomy. The autonomous management of logistic operations encompasses the capacity to respond to exceptional and unforeseen occurrences. In regards to the organization of suitable operations, it is important to use effective management methods in order to mitigate or reduce potential risks. Another essential necessity for organizations is the establishment of a localized quality management system, whereby several departments oversee their own quality management processes or those of other components.

Technological demands

In relation to the layer of information systems, it is necessary to take into account some novel technical requirements in light of the paradigm shift. Relocation of planning and control functions to different resources or parts leads to new or modified technological requirements, particularly in the areas of data management (ensuring data consistency, accommodating large amounts of memory, etc.), information handling (managing data overload, implementing standardized interfaces, etc.), and the system's ability to facilitate communication and cooperation among its components. The mobility of the pieces necessitates additional requirements for data communication and localization. Technologies such as Bluetooth or WLAN have been deemed appropriate for facilitating mobile data transfer, while radio communication-based or satellite-based positioning systems have been used for localizing components. The adherence to data security requirements is crucial due to the use of mobile data transmission technologies. The hardware requirements will also undergo modifications. The significance of technology of transponder is expected to grow, particularly in relation to the specified memory capacity. The implementation of autonomous control and planning in systems of production at a lower level, such as subsystem or component level, necessitates the incorporation of new functionalities into the existing or newly developed software systems.

Process-related demands

In order to facilitate autonomous logistical operations, it is important to meet certain process-related demands on the logistics system and material flow system, in addition to the organizational and technical requirements. The implementation of effective strategies is necessary in order to harness the inherent intelligence of subsystems and system elements, enabling them to make independent choices that align with their own objectives or specified goals. Hence, the intelligent components of the system possess the capability to autonomously execute algorithms of drawback-solving. Through the development of essential software tools and the evaluation of the system in simulations, it is feasible to construct a model of the chosen system together with its associated processes. The present planning and control systems must be modified to accommodate the additional requirements.

There is a need to establish new techniques for planning and control, together with their respective duties. In order to ensure uninterrupted production, it is essential to guarantee the resilience of the logistics system via the incorporation of autonomous logistical operations. An additional requirement pertaining to the logistics system is the capacity to divide orders. Enabling independent control of individual activities in a broad context is deemed vital. It is possible that the independent entities must exert mutual effect upon one another. One essential need for the usage of processes of autonomous assurance of both physical and logical responsiveness of the systems involved. These factors include several aspects such as materials handling, application method, and all other production units.

Stages of Development

The continued advancement of automation in supply chain and logistics networks extends beyond the current state of information and physical process integration. The concept of automating processes and eventually endowing them with decision-making capabilities, so allowing autonomous operation, is a driving force for scientists and practitioners. This vision has already been realized in certain application cases. Hence, the progression towards automation might be comprehended as the subsequent rational progression towards self-governing logistical systems. Makarova, Shubenkova, and Pashkevich [11] have put forward a framework consisting of five distinct developmental phases for technological systems that aim to achieve autonomy. These stages are shown in **Table 5.** The aforementioned classification pertains to the autonomization and automation of technical systems, specifically software, machines, vehicles, and robots. However, it may require additional refinement to accommodate the technical processes commonly observed in logistics systems. Nevertheless, this classification effectively demonstrates the imperative evolution of these systems and provides a clear differentiation between autonomous and automated systems. The five steps are operationally characterized as follows (see **Table 5**).

Table 5. Progression Phases of Technical Systems in the Advancement Towards Autonomous Systems

Remote-control devices	In these technological setups, people are in charge of most decisions and decisions are made without any kind of automation or autonomy.
Assistive technology works	These programs employ predetermined procedures to help the user. Although such systems have some of the hallmarks of automation applications, they lack the flexibility afforded by intelligent reconfiguration in the face of change.
Semi-automatic models	These programs may carry out predetermined automatic procedures and respond to certain conditions based on if-then connections. While this is a significant step toward fully autonomous systems capable of self-directed learning, current systems can only identify and process events using prior information.
Semi-autonomous models	These systems are extremely efficient and automated; nevertheless, they are also capable of self-learning, with their knowledge base growing in real time as they continue to function. Some of these systems can already self-regulate and make judgments autonomously using the data they've collected, while human oversight is still required for the most complicated issues.
Autonomous models	Here, systems are completely capable of self-learning and making decisions without human involvement in most cases, even when specific details about such cases are unknown. The system not only responds to, but also anticipates, changes in its environment. They operate independently over extended periods of time, with little oversight from humans.

While it may not always be feasible to definitively designate an existing system to a certain level, it is evident that some essential properties of the system become apparent as the levels increase in particular circumstances. While automated systems typically execute predetermined, familiar tasks, autonomous systems are characterized by their possession of decision-making skills and competences, enabling them to effectively adapt to various situations. This implies that as the amount of complexity increases, the ability to solve issues becomes increasingly feasible with decreasing need on human involvement. The capacity to make choices is essential for autonomous systems. In the realm of logistics, the complexity arises from the interdisciplinary nature and the significant involvement of numerous stakeholders [12]. Consequently, the creation of autonomous systems capable of executing intricate logistics operations without human intervention is a highly intricate task. Presently, the advancement of such systems has not attained the same level as autonomous technical systems like autonomous vehicles. The categorization of the developmental phases of self-directed technological operations in the field of logistics is undeniably vital within the framework of future scholarly investigations. However, it is also reasonable to explore the timing of when these evolutionary phases are expected to be attained or when they will become prevalent practices throughout the business, as well as the necessary conditions that must be established in the field of logistics.

IV. CONCLUSION

This article has made a valuable contribution to scholarly discourse around the topics of automation and autonomization within the field of logistics. In their meta-analysis, Nitsche et al. have identified ten distinct application areas and four dimensions of antecedents that contribute to the success of automation initiatives in the field of SCM (supply chain management and logistics). The aforementioned domains include the tasks of fulfilling, exchanging, and managing. Applications that provide assistance for client order procedures are known as fulfillment applications, while exchange apps are designed to ease the gathering and sharing of data inside the supply chain. The management of applications primarily centers on the execution of managerial activities pertaining to the process of fulfillment. The effectiveness of automation deployment is influenced by several elements, including technological, informational, and organizational aspects. The role of human involvement in automation is of utmost importance, since it has the potential to enhance productivity and reduce reliance on individuals. This research emphasizes the need of comprehending these variables in order to guarantee the achievement of automation initiatives. The progression towards autonomous logistics systems involves more than just the automation of supply chain and logistics activities; it necessitates the integration of decision-making capabilities into these systems. Dumitrescu et al. (year) established a framework consisting of five distinct developmental phases for technological systems that progress towards achieving autonomy. These stages are categorized as follows: autonomous system, remotely controlled systems, semi-automated systems, systems with assistance functions, and semi-autonomous systems. Autonomous systems possess decision-making skills and exhibit adaptive adaptation to various contexts, hence facilitating the resolution of intricate issues with less reliance on human involvement. Nevertheless, the intricacy of implementing autonomous systems in logistics arises from the need for interdisciplinary collaboration and extensive stakeholder engagement.

Data Availability
No data was used to support this study.

Conflicts of Interests
The author(s) declare(s) that they have no conflicts of interest.

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There are no competing interests.

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