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POSTPANDEMIC INNOVATIVE TRENDS IN LOGISTICS, DISTRIBUTION AND SUPPLY CHAIN

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Abstract: The paper describes the weaknesses of material flows and the lack of resilience of supply chains, which resulted in the outbreak of the COVID-19 pandemic. This unpleasant situation has presented the whole of logistics with new challenges and problems, which society and industry have tried with their approach to achieving non-stagnant logistics processes, which were therefore threatened mainly by the pandemic. The article describes both old and new trends and innovations in logistics, distribution and supply chain, which are the result of accelerated digital transformation.

Keywords: *postpandemic logistics, trends, distribution, supply chain*

1. INTRODUCTION

In 2020, supply chains experienced the biggest supply disruption since World War II. The COVID-19 pandemic and the coronary crisis have highlighted weaknesses in material flows and a lack of resilience in global supply chains. The crisis has presented the whole of logistics with new problems and challenges, which were largely preventable by timely access to accurate data and more flexible operating processes [1]. One of the most important findings since the outbreak of the pandemic has been that too much emphasis has recently been placed on streamlining logistics flows and accelerating "Just in Time" deliveries at the expense of their resilience to outages [2]. Therefore, the challenge for the near future in the logistics sector will be to ensure the performance of lean supply without compromising the flexibility and operability of its individual components.

Recent supply disruptions and disruptions in logistics flows foreshadow more extensive changes in the global supply chain model. Strategies to ensure the continuity and continuity of supply and delivery activities in the face of possible crises and outages mean that the transition to the characteristics and operating principles of the digital supply network is accelerated. In the following sections of this article, we will take a closer look and define the changes and new trends that have been caused by the impact of the pandemic on logistics, distribution and supply chain.

2. DATA ANALYTICS

One way to achieve supply flexibility is through more accurate sales planning and design. Businesses that want to better anticipate potential changes and be prepared for the rising

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volatility of customer and customer orders and for sudden market changes will focus on forecasting solutions [3]. Proper implementation of forecasting analytics requires the company to have access to relevant data. The right data ensures that sales planning and scheduling consider strategic and operational objectives. The output of the forecast analyzes also serve as timely alerts for employees about expected changes (or outages). Based on this information, the authorized staff can respond adequately and well in advance by changing priorities and operational interventions [4]. Digitalization of data and their subsequent effective use in intelligent production and logistics also brings new challenges for companies. The key question is how to process the data so that it can extract information that will bring real value to the company. According to the Market Research Future (MRFR) study, the global data analytics market is expected to grow by up to 30% between 2017 and 2023 [5]. The Internet of Things (IoT) market is experiencing a similar boom, which has radically multiplied the collection of a wide range and amount of data, along with the affordability of various sensors (Fig. 1) [6]. The speed of adoption of both new technologies only confirms their benefits for industrial enterprises.

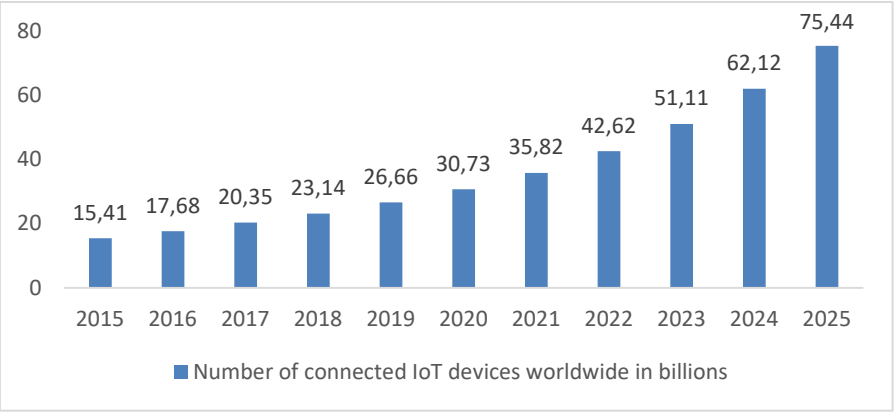

Figure 1. IoT connected devices installed base worldwide from 2015 to 2025 [6]

Among the most common reasons for implementing data analytics are companies reducing operating costs, increasing the level of services provided to end customers, or creating simulations and forecasts using historical data, which facilitate decision-making in complex processes [7]. Industrial Internet of Things (IIoT) and big data are an essential part of smart industry and smart industry solutions, as they enable the optimization of processes in production and material flows. At the same time, they speed up decision-making processes at all levels of management, as data and analyzes are available in real-time [7-8].

2.1. Data Logistics and Supply

Insufficient supply chain visibility during the pandemic was one of the relatively frequent findings of shortcomings in supply management. Businesses do not yet make sufficient use of data that would contribute to fast and informed decision-making. Incorrect or missing data is reflected in the low visibility of material flows and insufficient monitoring of material movements and orders, which significantly limits the flexibility of logistics

processes and their adaptation to changes in the markets. These shortcomings can be caused, for example, by manual demand design, insufficiently flexible ERP system, WMS system with significantly limited monitoring functionality, data analysis and generally lower performance [9]. The result is not only an inaccurate and out-of-date overview of the current state of stocks and what is happening in material flows, but also necessarily inefficient and slow supply processes. A larger volume of collected and analyzed data means:

- enhancing the visibility of supply operations,
- more detailed status information on material flows,
- more accurate capture of relevant material and component movements and movements in real-time,
- access to different demand patterns that can be used for efficient inventory, order and delivery planning [10].

In order for companies and operators to multiply the added value of data analytics in supply and logistics management, they should process data from a variety of sources, such as sales forecasts, POS terminals, and more. The interconnection of data sources should lead to the collaboration, integration and synchronization of data and processes, including the interconnection of data forces (data silo) between the production plant (shop floor), warehousing, in-house supply and subcontracting flows.

2.2. Advanced Data Analytics

Advanced data analytics is part of the innovative concept of "Demand-Driven Adaptive Enterprise", which was created in response to the growing volatility of global supply chains. The demand-driven adaptive enterprise represents management and operational model focused on the flow of relevant information and materials in the operational, tactical and strategic scope of the enterprise, especially in three key components:

- demand-driven operating model,
- demand-driven sales and operations planning,
- adaptive sales and operations planning.

The Demand Driven Adaptive Enterprise (DDAE) model is a management and operations model designed to enable businesses to adapt to complex and unstable environments (Fig. 2). This model aims to protect and support the flow of relevant information and materials within strategic, tactical and operational relevant ranges in order to achieve a lasting return on equity performance [11].

Figure 2 describes the function of the DDAE model in detail. In essence, it is neither right to the left nor left to right. It's both at the same time. It is a two-way system that seeks to control adaptation through a three-component configuration cycle, feedback, and matching [11]. In order for an enterprise to have adaptive operating models, it must begin the transformation to demand-driven supply, which includes:

- increasing data transparency, clarity and timeliness in the company's material flows and supply chains,
- demand-driven production planning and scheduling,
- long-term demand and capacity planning,
- coordinated management of resources and materials in logistics flows,

- automated replenishment of stocks,
- cross-departmental data integration across departments to maintain timeliness of material and inventory deliveries,
- real-time tracking of material transfers,
- data analysis with the intention of identifying deviations, downtimes and errors in material flows,
- predictive analytics to increase throughput in logistics flows,
- automation of sales planning and scheduling [12].

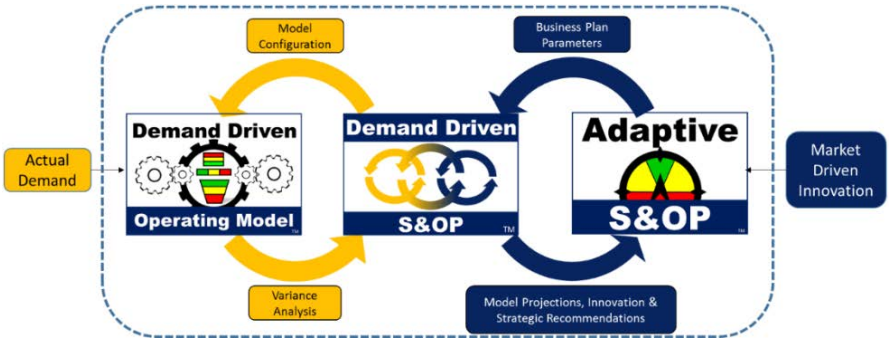

Figure 2. The framework of DDAE model [11]

3. CONTEMPORARY LOGISTICS

Digitalization has fundamentally affected trade and ways of shopping. According to the study, up to 74% of consumers rely on social media to make purchasing decisions, while up to 71% of consumers are more likely to make purchases as recommended on social media [13]. Another study found that up to 31% of consumers use social networks to find new goods they plan to buy [14]. Social networks have significantly influenced and changed consumers' shopping behavior, to which retailers have had to adapt and invent new business strategies. The speed, availability and convenience of online shopping have also been marked by a sharp increase in the e-Commerce sector, which has also begun to threaten established brick-and-mortar stores. Given the massive move to a new business model and the scale of the changes initiated by e-Commerce, this phenomenon has come to be referred to as e-revolution [15].

Speed and availability are also features to which logistics processes have had to be adapted. While social media connectivity has been most affected by consumer pre-purchase behavior and decision-making processes, the interconnectivity enabled by digital technologies has an equally significant impact on consignment delivery processes themselves: from order acceptance, supply management, through picking, packaging, shipping only after delivery to the customer [16]. In the following subchapters, we will describe several modern strategies that are the result of logistics development, either before or during the pandemic.

3.1. Omnichannel Logistics

An omnichannel strategy is a form of sales and customer care available on various

channels: online shopping on mobile devices, computers, telephone orders or in-store purchases. Integration and automation with modern technologies are a means of interconnection and coordination of individual components in all channels [17]. In practice, this means that the customer has access to advanced functionality that allows you to check the availability of goods in the relevant stores or distribution centers of the seller in real-time, buy online, but pick up the goods in a stone operation ("click & collect"). Or, conversely, shop directly at the store and have the goods brought by courier to the designated place. The sellers thus strive to ensure the best and most comfortable customer experience, including the personalization of consumer preferences regarding the selection, payment and delivery of goods. A functioning smooth customer experience necessarily means the integration and coordination of diverse purchasing processes. These processes take place at the micro-level of the warehouse and distribution center, but also at the macro-level of supply and demand flow management. These include order receipt and processing, inventory management, picking and packing technology management, human resources in the warehouse and shipping, as well as last-mile transport and delivery management [18].

The combination of diverse online and offline sales processes, ie the omnichannel strategy, is already becoming a necessary standard. Logistics procedures, supply chain management and the overall process of fulfilling customer orders must also be adequately adapted to omnichannel sales strategies. The interconnection of the physical and digital environment in omnichannel logistics provides a substantial part of the answer to the question of how to ensure sufficiently flexible, sustainable and operational logistics with the required performance. Timely and flawless operation of e-commerce logistics is no longer possible without:

- an immediate overview of available stocks,
- real-time monitoring of material flows,
- qualified design of expected sales,
- expanding customer-oriented services [19].

From the point of view of strengthening the strategy of sustainability of business continuity, even in cases of unexpected circumstances, such as a pandemic, it becomes necessary to serve several sales channels simultaneously. The transformation of the warehouse, the adaptation of inventory management and warehouse logistics to the multi-channel model already requires a comprehensive and integrated intelligent logistics solution. In addition, due to the efficient processing of larger volumes of diverse orders, shortening picking cycles and maximizing the efficiency of fulfillment processes, companies can no longer do without an advanced Warehouse Management System (WMS) [19].

With regard to ever-increasing demands on the efficiency and quality of inventory and warehouse management processes, the scaling of warehouse automation and the demand for extended customer-centric logistics functionality, a new generation of WMS systems is emerging, namely WES systems (Warehouse Execution System). This is also because omnichannel logistics is currently a long-term innovation. These systems bring a higher degree of process control dynamization to warehousing and supply processes and are also integrated into other systems in the production or material flow, such as MES (Manufacturing Execution System), or QMS [Quality Management System] [20]. WES systems view warehousing, supply and logistics processes as integrated processes, ie as work that needs to be planned, scheduled and managed. This opens up new possibilities for optimizing these processes as well as for their advanced integration with other processes in

the supply chain.

3.2. Lean Warehouses

The speed of information transfer at the digital level, as well as the ability to process and evaluate the amount of information in real-time, predetermine such solutions for intelligent, dynamic and autonomous process management in production, supply and logistics. That is why this concept is also used in the new generation of Smart Industry systems, which plan, manage and control business processes in production, supply, maintenance or quality control [21]. Process management thus becomes more agile and adaptable to changes in the external (eg market) or internal environment. The operational agility of the company and processes include, for example, flexible change of production equipment parameters, revision of work procedures and methods, as well as the incorporation of individual customer requirements in the area of mass production. In the area of warehousing and logistics, agility is manifested in the dynamic management of warehouse stocks and the use of warehouse capacity, as well as in the coordination and navigation of handling equipment.

Increasing customer order volumes, increasing turnover of goods, variability of sizes and types of offered goods, as well as the integration of other activities into picking processes, such as order completion, packaging and repacking of goods and express shipments, already require a smart warehouse with an automated control system. Following the trend of omnichannel logistics and the expansion of services aimed at individual customers, in addition to the operational intelligence of the warehouse, the concept of a lean warehouse is also becoming a key attribute. The concept of lean inventory management and warehousing processes primarily focuses on eliminating three side effects: waste, variability and inflexibility. Focusing on these side effects, leads to improvements in the areas of optimizing operating costs, increasing the quality of processes and expanding the level of customer service. The methodology of lean warehouse and supply management specifically includes:

- elimination of unnecessary walking around the warehouse,
- elimination of lengthy search for required goods,
- prevention of downtime, overtime and value-added activities,
- elimination of picking errors,
- preventing the keeping of erroneous items among available stocks [22].

E-commerce logistics and retail supply management must be adapted and tuned according to changing consumer behavior and market conditions. This is one of the reasons why warehouse and distribution center operators need to take more agile logistics management so that they can adapt smoothly and without delay to changing trends, market circumstances, variable customer requirements and individual customer expectations. For these reasons, too, increasing warehouse intelligence and streamlining inventory management processes (or orders in the case of retail and e-commerce logistics) go hand in hand. To achieve this, dynamic warehousing procedures, automated and demand-driven replenishment and hybrid picking strategies are used. A similar set of functionalities is used to increase the efficiency of the omnichannel warehouse (distribution center), while the basic premise in both situations is a powerful warehouse operating system and the right management infrastructure, which are already included in modern WES systems in most cases [23].

3.3. Mixed logistics strategies

Extending IoT in logistics, connecting additional devices and data sources allows companies to collect and analyze more data, and thus work with more advanced analytics. While this data is key in the transformation to demand-driven supply, to further scale digital logistics management solutions and integrate them with other components of the supply chain (eg production sites, assembly lines, etc.). Real-time data processing helps with more flexible planning, which allows you to minimize the reaction time to cope with market fluctuations. Scaling of logistics IoT and integration of other components of material flows (warehouses, cross-docks, in-house flows, external logistics, shopfloor inventory subsidies) towards suppliers as well as customers (production, distribution, retail) contributes to a greater expansion of agility and responsiveness by deploying dynamic strategies and procedures [24].

Cyber-physical management platforms and technologies, such as digital twins, make it possible to diversify ordering and inventory planning, management and picking procedures. The intelligent control system often uses artificial intelligence algorithms to evaluate the suitability of procedures in order to eliminate unproductive time and efficiently allocate available resources with respect to current job assignments, which also has an impact on the optimization of operating costs. This approach is part of a wider change in logistics and supply management. Modern management systems and smart industry solutions have decentralized management, thus achieving extended adaptability in identifying the most appropriate supply strategies and their implementation. In this way, the intelligent warehouse management system - WES - can combine different picking methods based on available key data and expected sales projections, as different strategies are more appropriate for different types of goods, volumes and orders. By combining them, operators can achieve better lead times in inventory handling, goods transfers and order picking. Current WES systems can simultaneously manage cluster picking of retail orders while deploying zone picking for wholesale orders due to the recurring type of goods. At the same time, dynamic slotting of incoming goods can take place, which the system evaluates as fast-moving according to current trends and sales, and therefore has it stocked as close as possible to the assembly and shipping workplace [25].

With the availability of accurate data and a combination of well-chosen strategies, the company will increase its performance, while processes remain flexible enough for the warehouse (distribution center) to respond promptly to changes in consumer and customer behavior and adapt relevant logistics operations to them in a timely manner.

3.4. Combination of Production and Supply

Demand-driven supply model orientation, as well as a holistic approach to digital transformation and intelligent logistics automation, include data integration and process collaboration between logistics and production. Coordinated material and warehouse management (WMS) with production sites is currently being linked in order to ensure not only timely and accurate supply of production lines and workplaces (line-feeding), but also parts preparation, handling of components and semi-finished products between workplaces, and transport of finished products to the dispatch warehouse. More and more manufacturing companies are approaching the dynamic synchronization of material flows not only within in-house (production) logistics but also in individual segments of the supply chain in order

to increase overall productivity. The synchronization of production processes and material deliveries is handled by sequential planning, JIT/JIS supply or overall operational strategy according to the Just in Time philosophy. Logistics data integration with production processes and real-time material flow monitoring allows companies to migrate to demand-driven planning while contributing to a partial expansion of process flexibility. This will allow companies to work centrally with data and continuously plan, analyze and accelerate qualified decision-making processes based on the availability of accurate and timely information [26].

The next step in increasing efficiency is the direct link between logistics management and production processes. This integration enables dynamic synchronization and individual adaptation of management strategies in individual parts of the supply chain. In addition to streamlining material flows and accurate deliveries according to the Just in Time method, dynamic synchronization also increases the agility of supply and production processes. This is mainly due to the use of a combination of dynamic methods and elastic strategies in individual parts of the material flow and automatic adaptation to changes in the market or in customer requirements and priorities. At the same time, dynamic strategies lead to more efficient management of available resources, which results in the optimization of warehouse and supply overhead costs [26].

3.5. Circular Logistics

Eco-logistics initiatives and concepts of environmental sustainability of supply will have an increasing tendency and importance. Digital technologies are already being used to reduce the carbon footprint by reducing fares and more efficient tracing in inter-company logistics. Greening practices in warehouses and supply management are also becoming increasingly common, particular:

- deployment of electrical handling and transport equipment (VZV, AGV, etc.),
- using smart warehousing strategies,
- installation of lighting systems with motion sensors and timers,
- use of natural light in the warehouse and operation,
- building natural ventilation systems,
- prioritizing solar energy,
- digitalization of administrative and financial processes in order to eliminate paper documentation (and the generated waste it generates) [27].

However, omnichannel logistics heralds another significant change in logistics sustainability. As part of the expansion of services and a more consistent focus on customer needs, operators want to achieve a situation where the return of goods would be as simple and smooth as their purchase. Therefore, reverse flows are also part of omnichannel logistics. To ensure efficient complaint and return management, the functionality of standard WMS systems had to be extended to reverse logistics and real-time inventory and order management synchronization. And that's especially because the ability to return goods easily and free of charge is now becoming a significant competitive advantage. Logistics thus serves not only to transport goods to customers but also to ensure the return of goods back to the warehouse (or distribution center). And this does not necessarily happen only during complaints, but also after the goods have reached the end of their service life. The two-way logistics type helps to close the life cycle of a product, which is

returned to the retailer or manufacturer, who can then renovate, recycle or dispose of it in an environmentally friendly manner [28]. Figure 3 and Gartner statistics show that up to 70% of supply chain leaders plan to invest in the circular economy.

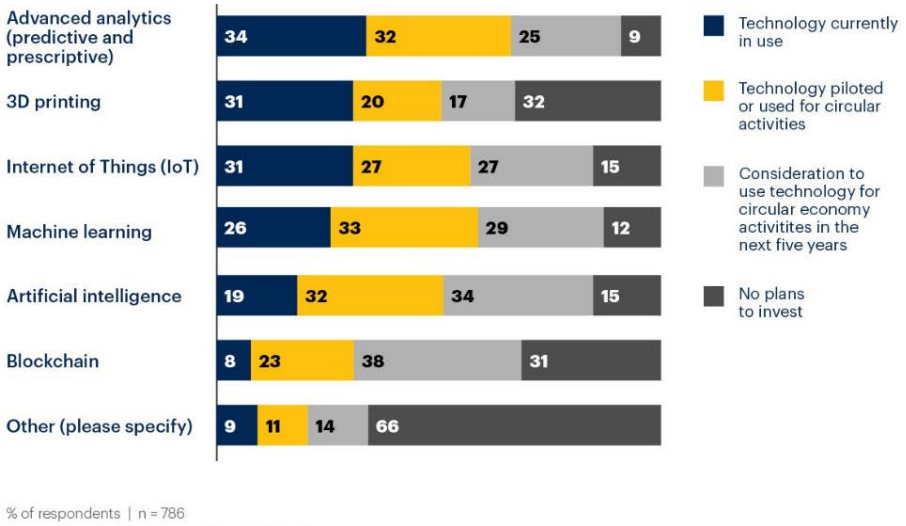

Figure 3. Digital technologies used to enable the circular economy [28]

This approach already heralds the transition from a linear economy to a circular economy, in which reverse logistics plays a critical role. The same principle as will be applied in consumer markets is already used among suppliers in the B2B environment, for example in the return of packaging and transport materials, which are used for further supplies of materials. Linear supply chains will be gradually transformed into circular ones. The world's leading companies have already started similar initiatives, for example in the clothing industry. Customers can return old and worn shoes, the material of which can be used in the production of a new pair. In addition, this form of sustainability will soon move from a corporate social responsibility (CSR) position to a statutory business position [28].

4. CONCLUSION

The consequences of the pandemic, such as the deceleration of globalization and the increase in regionalization, will also have an impact on the forthcoming supply chain structure. Digital technologies have already begun to transform the design and management of supply chains, as processes and procedures in different parts of the chain make it possible to manage decentralized models. The current era of digital transformation is also changing the very concept of automation, known as the Third Industrial Revolution, based on the use of PLC and robotics, which is gradually changing to smart automation. The main impetus is exponential technologies such as the Internet of Things (IoT) and services (IoS), digital twins and artificial intelligence tools. Land-based shops remain part of most sales channels, but as consumers move more digitally, retailers also need to adapt their sales strategies. In particular, by expanding the internet shopping platform or adding the possibility of selling on social networks, the so-called social commerce. The combination

of various shopping options in both virtual and physical space, together with other alternative sales channels, pushes the concept of omnichannel sales to the level of a new standard. In addition, the management of the flow of goods for stone operations, e-commerce and distribution centers has special specifics and requirements. For example, when servicing e-commerce orders, the shortest possible process of picking goods items, completing orders and sending them is expected. However, in the case of distribution centers, costs play a greater role than speed in handling and picking bulk orders. It is similar to transport units. In the distribution center, these are cartons and pallets, while in e-commerce warehouses, these are mainly goods units, resp. piece items.

The circular economy is also linked to further societal change in the adoption and setting up of environmental initiatives, as well as sustainable strategies and supply practices. These were the subject of the COP26 climate summit in Glasgow, which resulted in several commitments to decarbonize and reduce greenhouse gas and methane production. These measures also have a direct impact on supply chains, supply and logistics. In this regard, we can expect to set new standards for the sustainable operation of supply chains in order to minimize the negative impact of business activities on the environment. Consumers are already more interested in how businesses approach the environment.

In this article, we have briefly summarized the weaknesses in material flows and the lack of resilience of global supply chains due to the COVID-19 pandemic. The crisis situation presented the entire logistics industry with new problems and challenges, which were largely avoided by timely access to accurate data and more flexible operating processes. Thus, the article shows that with the evolving digital transformation, especially during the pandemic crisis, companies have begun to gain increasing access to relevant data. These were subsequently used to optimize operational performance and improve process efficiency.

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