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AUTOMATION IN CREATING SUPPLY CHAIN AMBIDEXTERITY

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Purpose: The aim of the article is to show how automation affects the ambidexterity of the supply chain and the problem on which the study was focused comes down to answering the question: What market-oriented changes have occurred in the logistics center as a result of process automation? The hypothesis was verified: The automation of logistics processes has a positive impact on supply chain ambidexterity (by simultaneously enhancing resilience and agility).
Design/methodology/approach: The research methods and techniques used included, among others: content analysis, non-standardized interview, selected methods of qualitative analysis, case study.
Findings: The article reviews selected definitions of resilience, agile and ambidexterity supply chain. Automation creates the ability of the supply chain to withstand unexpected disruptions in the short term, as well as the ability to adapt to change and growth in the long term. Based on a literature review, the A–R/A–A (Automation–Resilience/Agile–Ambidexterity) model is proposed, identifying the mechanisms through which automation enhances both resilience and agility, creating a synergy effect that leads to SC-Ambidexterity. Theoretical considerations are supplemented with a case study - that demonstrates the benefits of automation, including operational, cost and organizational aspects.
Research limitations/implications: The empirical part of the study has limitations because a single observation does not allow for broad conclusions and generalization of results. Further research projects in this area should include a larger research group.
Practical implications: The presented benefits of implementing automation in a logistics center may serve as a point of reference for other entities.
Social implications: Automation increases the demand for digital competences, which implies the need for employee training (e.g. in the use of robots and AI systems).
Originality/value: This work demonstrates the importance of automation for synergizing supply chain resilience and agility. The presented case study serves as an example of good practices in logistics center automation to achieve supply chain ambidexterity.
Keywords: ambidexterity supply chain, resilience supply chain, agile supply chain, automation, Industry 4.0.
Category of the paper: research paper.

1. Introduction

Operating in a VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) environment requires a redefinition of the approach to supply chain design (Bukowska-Piestrzyńska et al., 2022). High volatility and uncertainty in the environment—exacerbated by the COVID-19 pandemic and geopolitical conflicts—have rendered traditional management models inadequate. Research indicates that companies operating in a turbulent environment must develop dynamic capabilities that enable them to quickly respond to changes and maintain operational continuity (Kołodziej et al., 2024). The literature highlights two complementary approaches: supply chain resilience (SC-Resilience) and agility (SC-Agile), as a response to contemporary challenges. Both are key elements in building competitive advantage, especially in conditions of unpredictable disruptions. Their synergy results in ambidexterity (SC), the ability of an organization to simultaneously achieve resilience and agility—the ability to balance two goals: leveraging existing capabilities (efficiency and cost reduction) and exploring new solutions. Research indicates that companies which can balance these areas achieve higher efficiency and better market results (Alsawalhah, 2025).

In the digital era, ambidexterity is particularly important – technologies such as AI, IoT, predictive analytics, and blockchain enable both risk monitoring and rapid response to changes (Berko, 2025). Automation and robotics increase flexibility, minimizing human error and adapting an entity's operations to changing demand. Thanks to these solutions, supply chains can better respond to the challenges of modern markets, achieving higher efficiency and customer satisfaction in global networks.

The aim of this article is to identify the essence and significance of ambidexterity – rooted in resilience and agility – o in modern supply chains, and to determine the impact of selected Industry 4.0 technologies on its development. The hypothesis will be verified: The automation of logistics processes has a positive impact on supply chain ambidexterity (by simultaneously enhancing resilience and agility). The proposed A-R/A-A (Automation–Resilience/Agile–Ambidexterity) model synthesizes insights from a comprehensive literature review and explains the mechanisms through which automation shapes organizational resilience and agility, ultimately strengthening their synergy in the pursuit of ambidexterity. Theoretical assumption are complemented by an empirical illustration based on the case of Arvato SCS Ltd., which supports the investigation of the research question: *What market-oriented changes have occurred in a logistics center as a result of process automation?* The analysis demonstrates that automation constitutes a critical driver of competitive advantage in turbulent environments. The article is theoretical and empirical in nature.

2. Literature review

2.1. Resilience and agility in developing Supply Chain Ambidexterity

Supply Chain Resilience – defined in the literature at the beginning of the century (Christopher, Peck, 2004) – is the ability of a system to prepare for disruptions, absorb their effects, and quickly return to a state of equilibrium or achieve a new, stable level of functioning. The literature emphasizes that resilience encompasses both structural elements (e.g., resource redundancy) and behavioral elements (e.g., an organizational culture that promotes flexibility) (Kołodziej et al., 2024). The main actions that increase supply chain resilience include: supplier diversification, information integration, employee competency development, and the implementation of digital technologies enabling real-time risk monitoring (Wang, 2023). From an analytical perspective, resilience is not a state but a continuous process, and in conditions of permanent volatility, it should include (Craighead et al., 2007; Sheffi, 2021):

- systematic identification of threats/disruptions,
- absorbing their effects and assessing the vulnerability of individual links,
- testing alternative operating scenarios and reconfiguring processes,
- implementing solutions that increase flexibility and shorten response time – returning to a stable operational level.

SC-Resilience – as complex adaptive systems – is capable of not only surviving periods of instability but also quickly rebuilding its operational potential and returning to market competition, often strengthened with new competencies and advantages. This means consciously and systematically strengthening mechanisms that enable business continuity and the capability to quickly responding to changes in the environment (Azevedo et al., 2013). In the context of competitiveness, resilience allows enterprises to limit losses resulting from disruptions, maintain supply continuity, and build a reputation as a reliable business partner. In summary, supply chain resilience is a decisive factor for long-term success – thanks to flexible, reliable and comprehensive logistics solutions supported by digital tools, real-time transparency and intelligent automation, entities can maintain/increase their competitive position in the market.

Supply Chain Agile is a concept that has become crucial in recent years of logistics, when pandemic-related disruptions in supply chains significantly impacted the functioning of enterprises. A responsive supply chain enables rapid response to market changes – it refers to the ability to quickly react to changes in demand, market conditions, and customer requirements (Christopher, 2000). That is particularly important in industries with high demand volatility and short product lifecycles, as it ensures rapid response to customer needs through flexible logistics processes (Gligor, Holcomb, 2013). Analyses confirm that agile supply chains achieve higher operational efficiency and better financial results thanks to their ability to quickly adapt to market changes (Alfalla-Luque et al., 2023). This includes, among other things, shortening lead

times, flexible production planning, rapid resource reconfiguration, and effective information management.

Contemporary definitions of agile logistics revolve around the following interpretations (Gligor, Holcomb, 2013):

- responsiveness – quick response to changes in demand,
- resource flexibility – the ability to reconfigure networks and processes,
- data visibility – the role of big data, IoT, and analytics,
- customer focus – logistics designed "backwards.

Assuming that agile logistics is the ability to quickly reconfigure a logistics network through the integration of physical and information infrastructure, automation solutions and Industry 4.0 technologies (e.g., the use of big data and analytics for rapid decision-making) are crucial for its implementation (Obora, 2020).

In today's economy, agility and resilience are intertwined – agility enables rapid response to change, while resilience allows for resilience to withstand disruptions. Together, they form the foundation of the so-called ambidextrous supply chain, meaning one capable of simultaneously exploring new opportunities and utilizing existing resources (Khan, 2024). Logistics ambidexterity can be thought of as the ability to quickly reconfigure flows and resources in response to disruptions and demand variability (Tushman, O'Reilly, 1996). Research also indicates that supply chain ambidexterity is a strong predictor of Supply Chain 4.0 maturity (Alamsjah, Yunus, 2022). The literature indicates that companies that combine resilience and agility achieve the greatest competitive advantage. Integrating these approaches allows for both minimizing risk and maximizing flexibility, which is crucial in conditions of uncertainty (Khan, 2024; Kołodziej et al., 2024).

2.2. Automation in the Catalog of Industry 4.0 Solutions

The economy is witnessing a rapid acceleration in the automation of logistics centers (investments in mobile robots, autonomous systems, digital twins, and advanced data analytics). Logistics is becoming an area of intense digitization, and logistics centers are transitioning from a manual work model to one based on data and automation. Based on research by Boustan et al. (2022), it can be concluded that automation:

- stabilizes processes,
- reduces dependence on human labor,
- increases precision and repeatability,
- enables scalability of operations.

And although it also carries risks: system failures, dependence on technology suppliers, and high investment costs, the benefits resulting from it cannot be overestimated. In practice, it encompasses not only the use of robots, stacker cranes, and conveyors (to maintain operational continuity without relying on personnel), but also enables:

- automatic inventory tracking and identification of goods in warehouses and the reduction of inventory errors (RFID systems),
- monitoring the location of vehicles and shipments, enabling route optimization and delay detection (GPS sensors),
- monitoring deviations and ensuring compliance with standards in cold chains, e.g., food and pharmaceuticals (temperature and humidity sensors),
- detecting damage during transport, supporting proactive logistics (shock and vibration sensors).

Industry 4.0 is contributing to the emergence of new solutions supporting the functioning of modern supply chains, including by increasing process transparency, reducing human error, shortening response times, and enabling data-driven decision-making. The most popular solutions in the area of Industry 4.0 information technology include: the Internet of Things (IoT), the Internet of Services (IoS), the Internet of Things (IIoT), big data and data analytics (BD/BDA), cloud computing (CC), Blockchain technology (BC), additive manufacturing with 3D printing (AM/3D-P), augmented and virtual reality (AR/VR), and artificial intelligence (AI) with its supporting algorithms, machine learning (ML) and deep learning (DL) (Nascimento et al., 2019). These can be used in logistics to create ambidextrous supply chains: capable of real-time adaptation, intelligence, and self-organizing. Example applications include:

- real-time monitoring of material flows (thanks to IoT), which supports the pull system,
- supporting optimization of schedules and transport routes, automated decision-making, and waste detection in processes (using AI),
- supporting the identification of waste sources, optimization of transport routes, demand prediction, and lead time reduction (thanks to BDA),
- supporting standardization and error elimination (thanks to mobile robots (AMRs), autonomous vehicle guidance (AGVs), and automated warehouse systems (AS/RS),
- increasing supply chain transparency, reducing documentation errors, and strengthening the "right first time" principle (thanks to BC capabilities). - centralization of data from WMS/ERP to forecast disruptions (BD/BDA),
- simulation training and rapid location of goods in crisis (VR/AR).

Literature points to implementation barriers such as high investment costs, lack of employee digital competencies, resistance to change (Piercy & Rich, 2009), lack of a coherent process improvement strategy, and difficulties in integrating IT systems. Despite this, investments in automation and digitization generate ROI by reducing costs and increasing flexibility and are a step towards ensuring sustainable ambidexterity of supply chains.

2.3. Automation and Ambidexterity

Assuming that automation directly impacts both the resilience and agility of the supply chain, a model of this relationship can be presented – see the figure. The authors attempted to present a model combining three key elements:

- automation (understood as the implementation of technologies and systems that increase the efficiency and standardization of logistics processes),
- resilience (understood as the system's ability to maintain operational continuity and quickly respond to disruptions),
- agility (referring to the flexibility and speed of adaptation to changing market conditions) of the supply chain.

The result of an integrated approach to supply chain security is ambidexterity. It is determined primarily by the quality of system integration, employee competencies, and the level of process standardization, closely related to the level of automation in the logistics center.

The figure 1 shows examples of the impact of automation on supply chain resilience and agility. Automation solutions and the application of Industry 4.0 technologies enable:

- absorption of disruptions, ensuring stability and business continuity, increasing supply chain resilience,
- easier reconfiguration and scalability of resources, and increased response speed, thus improving supply chain agility.

This results in the creation of an ambidexterity supply chain, which can be described as:

- data is a key element, and its proper use (e.g., predictive analytics supporting decisions) enhances the synergy of combining resilience and agility,
- optimal supply chain resilience and agility is achieved through a hybrid approach, combining automation with flexibility and human competencies. Therefore, a balance between these elements is necessary – related to investments in technology, employee development, and contingency planning,
- automation is a tool supporting resilience and agility, but it does not completely replace the role of humans in the supply chain.

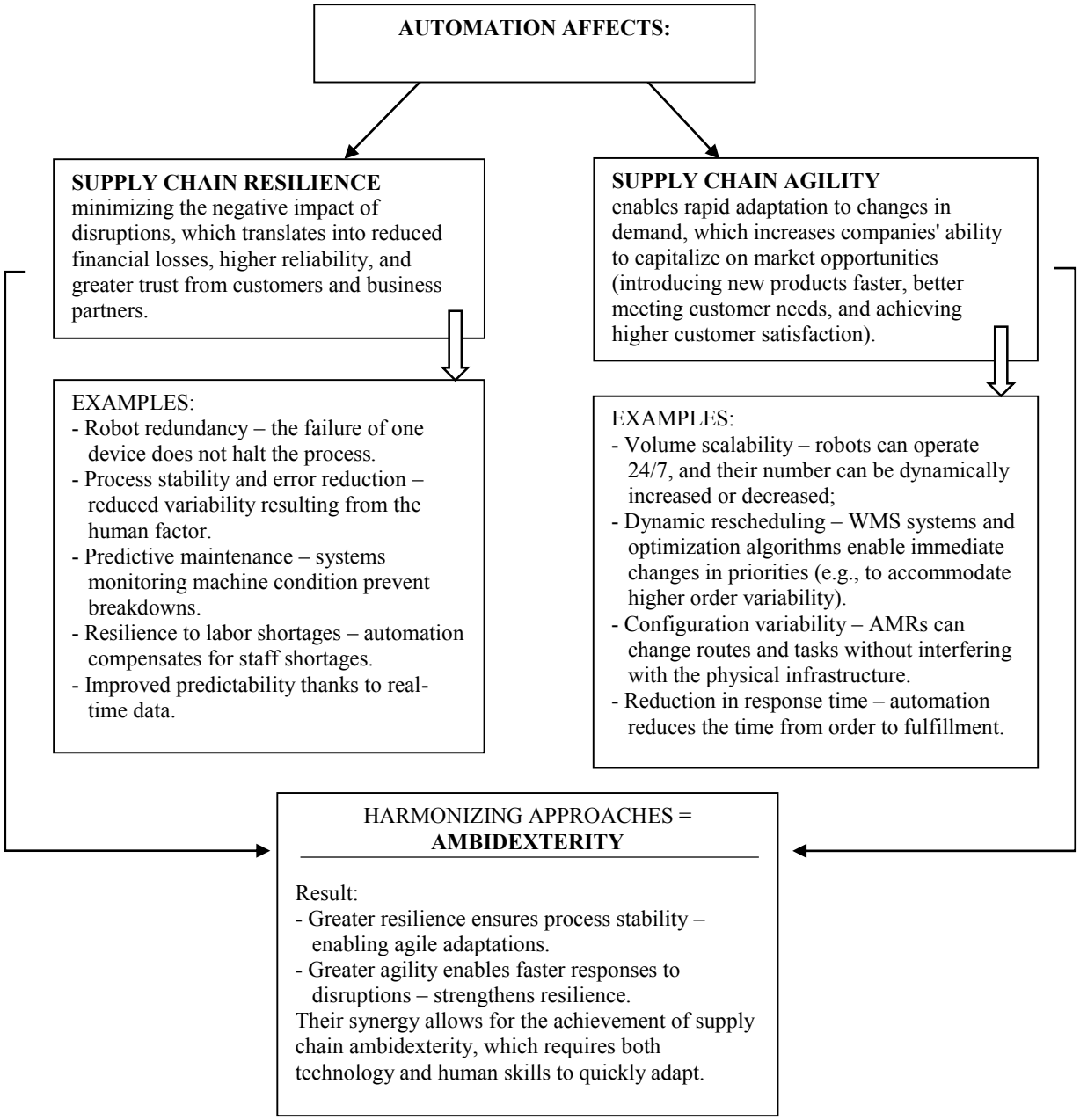

Figure 1. Model A – R/A – A (Automation – Resilience/Agile – Ambidexterity).

Source: own elaboration.

In summary, data plays a key role as an element integrating both dimensions: agility and resilience – thus creating a new approach to supply chains: ambiexterity. Automation should be designed modularly and scalably to simultaneously increase resilience without hindering agility. Therefore, it is crucial to:

- invest in employee digital skills,
- consistently and continuously develop monitoring and cybersecurity systems,
- use digital twins to test disruption scenarios.

3. Methods

Selected research methods and techniques were applied to achieve the study's objective. Descriptive analysis was used to characterize the research subject. The method of literature analysis and criticism proved useful for systematizing current scientific findings and the state of knowledge regarding the specific nature of contemporary supply chains and the role of automation in their functioning. The literature review followed the classical methodological approach.

The empirical part of the study employed qualitative research methods, specifically a case study (based on a study visit conducted on 26-28 March 2026) and an unstructured interview**.** The interview involved the warehouse operations manager and a WMS specialist. They were asked among other things:

- how automation had influenced supply chain resilience and agility,
- what changes had occurred in the flow and duration of logistics processes,
- how the implementations had affected the center's ability to handle disruptions,
- what changes had taken place regarding staffing and the scope of employee responsibilities.

The primary data source consisted of direct observations of warehouse processes**,** including picking, packaging, returns handling, internal transport, and human–robot interactions. Additional insights were obtained from an unstructured interview with the operations manager of the logistics center. It should be emphasized that a single observation limits the scope of inference and does not allow for broad generalization of the results to other entities; however, it provides a valuable reference point for further research.

The analyzed entity was Arvato SCS Ltd., located in Stryków-Pieńki near Łódź, one of the key logistics centers serving the global H&M network in Central and Eastern Europe. The facility functions as a regional distribution hub integrating warehousing, picking, automation, and omnichannel order-fulfillment processes. In recent years, the company has implemented extensive modernization initiatives, including the automation of warehouse operations and the deployment of the Shuttle system[1] (supplied by KNAPP).

[1] The system occupies 10,000 m², has a capacity of 270,000 cartons, and employs 144 trolleys (moving at speeds of up to 70 km/h along 15 aisles on 16 storage levels). The total operational area is 98,000 m² (including mezzanine space) thanks to a high-bay warehouse facility using reach trucks to service 8.7-meter-high racks.

4. Results

Arvato SCS Ltd., as a logistics operator serving a global fashion brand, operates under conditions of high demand volatility, seasonality, and time pressure. Therefore, market conditions require the resilience and agility of the supply chain to be maintained. Ambidexterity is particularly important for Arvato, as it handles both its business partner's stores (B2B) and e-commerce customers (B2C). In the fashion industry, logistics is a key factor in building a competitive advantage, so the operator responsible for it must operate in a way that not only meets sales targets but also responds quickly to short-term trends (which, especially under the influence of social media, can change overnight).

Before making the investment, a diagnosis of the main operational risks was conducted at Arvato SCS Ltd. to identify areas requiring special attention. Among other things, the following were identified[2]:

- demand disruptions – sudden changes in H&M's order volumes, especially during sales and marketing campaigns,
- operational risks – infrastructure failures, overloaded manual processes,
- HR risks – seasonal employee shortages.

These identified risks became the basis for implementing automation as a tool to increase supply chain ambidexterity. The drive to quickly respond to changes (bypassing them or shortening the time from occurrence to repair/elimination) and, on the other hand, strengthen the ability to survive disruptions (through reactive response and recovery) was intended to help achieve higher functionality and better meet customer needs (both in B2B and B2C). The main expected effects of automation at Arvato SCS Ltd. include[3]:

- an increase in picking efficiency by 30-40%,
- a 25% reduction in operational errors,
- a 15-20% reduction in order fulfillment times and the achievement of an "order today – receive tomorrow" delivery model.

To achieve these goals, the company implemented solutions including[4]:

- the Shuttle automated storage system, which provides high storage capacity and utilizes an extensive fleet of forklifts operating across multiple rack levels. This solution significantly increases operational flexibility; the system can dynamically adapt to changing order volumes.

[2] Based on internal company documents *Risk & Continuity Assessment 2023*.
[3] Internal document *Operational Excellence Report 2023*.
[4] Internal *Automation Roadmap 2022-2025.*

- advanced logistics automation – designed to improve process stability and reliability. Full automation of the goods receipt process[5] (from the loading dock to product placement in the Shuttle[6]) eliminates downtime, reduces errors, and accelerates product flow. The proprietary "Leleka" robotic system is responsible for retrieving fashion items from bulk packaging and precisely placing them in the pocket sorting system. Thanks to a vision system (based on AI), it determines the optimal arrangement of goods (even irregularly shaped ones) in the container, checks barcode readability, and ensures correct product orientation. An extensive internal transport system, based on conveyor belts[7], integrates various warehouse zones. The use of AGVs traveling in loops over 4 km long, automated picking systems (AS/RS), high-performance sorting systems, automated packaging lines, and multi-level mezzanines increases the independence of processes from random factors. Automation ensures repeatability and high efficiency, eliminating the risk of human error and bottlenecks in the picking process. This allows for maintaining a high level of customer service under increased load. Additionally, dynamic replenishment algorithms are used to control the flow of goods between the high-bay and picking areas, minimizing the risk of bottlenecks that could disrupt operational continuity.
- Digitalization and predictive analytics (Big Data) – process visibility is the foundation of ASC, and operations management is supported by the SAP system, which allows for real-time monitoring of flows. Thanks to Big Data analytics, Arvato is able to forecast resource requirements (people and equipment), preventing infrastructure overload during peak sales periods. Advanced WMS systems with predictive modules support real-time decision-making and dynamic location management[8], significantly increasing chain ambidexterity (e.g., rapid response to potential disruptions – such as manufacturer delivery delays or courier transport problems).

[5] As goods are unloaded from a delivery truck, conveyor belts extend to support the unloading process. They adjust to the vehicle's depth, streamlining the unloading process and reducing the workload for employees. The goods are then transported to their designated location via conveyor belts. They are automatically scanned during the movement, allowing for smooth and rapid product movement.

[6] The Shuttle High-Bay System streamlines warehouse space management and accelerates order picking by automatically delivering goods to operators. This reduces the need for employees to move around the warehouse, reducing errors, increasing operational efficiency, and improving work ergonomics.

[7] Telescoping Conveyor Belts enable rapid loading and unloading of goods (directly into trailers and containers). Their flexible design significantly shortens the time of reloading operations while reducing physical exertion on workers, improving ergonomics and occupational safety.

[8] In the event of a sudden increase in demand for a given group of goods/the appearance of a new collection, the system automatically allocates it the places closest to the packing zone to shorten the time (which guarantees quick adaptation to the change).

- Regularly conducting resilience tests, which include[9]: volume stress tests (simulations of surges in orders), automated system failure tests, IT continuity tests, and scenario analyses of transport disruptions. Test results form the basis for further process improvements (in line with the Kaizen philosophy).
- Improving employee competencies[10] – employee training is conducted in the use of automated systems and the development of the analytical potential of operational teams, which facilitates the creation of interdisciplinary teams (combining IT, operations, and planning). Cross-skilling is crucial for operational employees – employees are trained to handle various operations (multiskilling) to increase operational flexibility and accelerate process execution. A culture of continuous improvement is promoted.

Al-Banana et al. (2023) point to the growing convergence of research on resilience, investment in digital technologies, and the Industry 4.0 transformation. The authors found that organizations increasingly view digital investments as a strategic tool for building resilience and agility.

Industry 4.0 technologies significantly enhance supply chain ambidexterity by increasing flow visibility, enabling faster detection of and response to disruptions, and streamlining decision-making processes (including real-time decision-making) (Totorella et al., 2022).

5. Discussion

Creating the foundation for such advanced infrastructure would not have been possible without the full commitment of employees from both Arvato SCS Ltd. and its partner, H&M. The three-year expansion of the center now allows the logistics service provider to fully utilize SC-Ambidexterity in practice and reap the benefits of the implemented solutions – implementing the "order today – receive tomorrow"[11] delivery model while maintaining scalability of operations (meaning significantly reduced order fulfillment times and the ability to process significantly higher order volumes during peak periods, such as Black Friday, without the need for a proportional increase in staffing). Examples of the specific benefits achieved through the three-year investment are presented in the table 1.

[9] In accordance with the procedures described in the Business Continuity Plan 2023.
[10] In accordance with the guidelines of the internal document People & Skills Development Report 2023.
[11] In the e-commerce industry, this is one of the most important competitive factors.

Table 1.
Benefits of the implemented automation changes at Arvato SCS Ltd.

Levels of effects of implementing automation and digitization at Arvato SCS Ltd.	Examples of benefits
Technological changes	- real-time system integration, leading to increased process efficiency, • increased use of operational data, • transition from reactive to predictive systems, - development of IoT infrastructure.
Operational changes	- Reduction in picking times, - Process stabilization – robots eliminate variability resulting from human labor, e.g., during peak periods, - Reduction in errors and complaints, - Increased throughput and process stability – standardization and automatic alerts allow for shorter response times to disruptions, - Greater scalability of operations during periods of increased demand, without the need to increase staffing levels or reorganize the warehouse, - Better inventory control, - Automation of internal transport,
Cost changes	- reduction of labor costs, - optimization of space costs,
Organizational changes	- reducing the need for heavy physical labor, - new job positions, e.g., robotics technicians, or increasing the number of data analyst and system operator positions, - flattening the management structure and changing the role of managers – from operational supervision to data management, - increasing the role of interdisciplinary teams,
Competency changes	- increased demand for digital skills, - training in the use of robots and AI systems, - shifting the nature of work from manual to supervisory.
Competitiveness of a company	- increased flexibility and responsiveness to market changes, - faster order fulfillment and greater product availability with fewer order errors improves the quality of customer service (in both B2B and B2C), - increased technological advantage. - potential for scalability and further automation, - shortened order fulfillment times, - reduced operating costs.

Source: own elaboration.

The operations of the Arvato logistics center in Sosnowiec-Pieńki for H&M demonstrate that implementing the SC-Ambidexterity concept is not only possible, but also necessary in modern logistics to build long-term cooperation with a business partner.

Further actions that could impact the SC-Ambidexterity of the analyzed company could include:

- introducing smart glasses/wristbands/watches for employees, which would inform them in real time about changes in priorities and notify them of errors[12]. This would enable seamless human resources management,

[12] In the event of a bottleneck (e.g. a failure), an IT employee could easily and quickly delegate one of the warehouse employees who is closest/has the appropriate competences to deal with the problem (e.g. repair the fault).

- predictive analysis using AI could go beyond standard planning (assessing traffic situations) and, for example, introduce algorithms that can predict sudden demand for specific clothing models based on weather or social media trends,
- introducing a full Digital Twin – moving from simple process visibility to hyper-predictability – a virtual copy of the warehouse would enable testing of crisis scenarios (e.g., simulating crises – a failure of the main sorter or border closures – without interrupting operations). This would allow for optimizing flows and identifying bottlenecks before they actually occur, and developing ready-made response procedures.

The results obtained from the case study confirm that automation should not be viewed solely as a cost-reduction tool, but rather as a strategic instrument for building resilience, agility, and long-term competitive advantage. While the analysis of changes within a single entity limits the generalizability of the findings to other logistics centers, it can serve as a benchmark for comparative analysis. The obtained results can be linked to the findings of Belhadi et al. (2021), who indicate that Industry 4.0 technologies alone do not ensure improved supply chain performance. A key role is played by digital transformation supported by organizational ambidexterity, which enables the simultaneous improvement of existing processes and the creation of new operating models. Thus, ambidexterity acts as a mediator between Industry 4.0 capabilities and operational outcomes.

The conclusions indicate that successfully fostering ambidexterity requires not only technological investments but also data integration, process standardization, and the development of employees' digital competencies—a challenge for both the workforce and the organization. Ultimately, the greatest value is generated by hybrid operational models that combine automation capabilities with human potential, enabling organizations to respond effectively to disruptions, capitalize on emerging market opportunities, and maintain high competitiveness in a turbulent environment.

Research by Ghobakloo et al. (2025) also indicates that Industry 4.0 technologies enhance the resilience and agility of supply chains.

In summary, Arvato SCS Ltd. in Stryków is an example of a modern, resilient, and agile logistics center, where process automation, customer collaboration, and employee competency development create a coherent system that increases stability and operational efficiency. The implemented solutions align with the concept of complex adaptive systems, enabling the company to function effectively in conditions of volatility and uncertainty typical of the fashion and TFL industries.

6. Conclusions

The increasing unpredictability of the external environment has become a defining characteristic of 21st-century economic reality, making enhanced adaptability and agility essential imperatives for strategic supply chain management**.**

Dynamic market fluctuations, rising customer expectations, and growing pressure to reduce order-fulfillment times have positioned logistics centers as a critical domain of digital transformation. Technologies such as automation, robotics, IoT, predictive analytics, and artificial intelligence are reshaping warehouse operations, enabling greater flexibility, resilience, and efficiency.

A comprehensive literature review indicates that SC-resilience and SC-agility constitute the foundation for achieving competitive advantage in today's turbulent business environment. Resilience allows organizations to withstand disruptions and maintain operational continuity, whereas agility enables rapid responses to market changes and the ability to seize emerging opportunities. However, the greatest competitive value arises from integrating both approaches – an orientation known as SC-ambidexterity. Firms that develop dynamic capabilities, invest in digital technologies, and cultivate an organizational culture that promotes flexibility and innovation achieve superior levels of resilience, agility, and overall market performance.

Automation is a significant factor in strengthening SC-ambiexterity. It creates the supply chain's ability to withstand unexpected disruptions in the short term, as well as the ability to adapt to change and thrive in the long term (Pettit et al., 2010). Its impact is visible primarily on three levels: operational (changing the way processes are performed), information (improving the quality and speed of data flow), and structural (changing the resource architecture). Properly designed automated systems increase companies' ability to respond to disruptions, maintain business continuity, and adapt to changing market conditions.

In logistics centers, Industry 4.0 tools and operational improvements significantly improve SC-Ambidexterity, enabling real-time monitoring, disruption prediction, and rapid adaptation. Digitalization leverages IoT for real-time monitoring, AI for disruption prediction, and big data for process optimization. Automation and robotics, such as autonomous unloading, increase flexibility, minimize human error, and adapt to fluctuating demand. Digitalization makes supply chains more resilient to crises, for example, through real-time forecasting and centralized inventory management. The results include shorter lead times, higher efficiency, and improved customer satisfaction across global networks. And predictive analysis enables agile behaviors that allow for organizational flexibility.

The logistics center operated by Arvato SCS Ltd. illustrates the practical implementation of the ambidextrous supply chain concept. The application of advanced IT systems for warehouse management enables real-time monitoring of material flows, inventory levels, and the coordination of order-picking and shipping activities. This capability supports the rapid

identification of operational irregularities and the timely introduction of corrective measures. Digitalization enhances overall process transparency, which is particularly critical in environments characterized by high product volumes and intensive warehouse traffic, such as the apparel sector.

Although the study examined a single logistics center—thereby limiting the generalizability of the findings—it nonetheless allows several broader observations:

- Resilience and agility do not stem from robotization alone but from the integration of data and the process standardization that automation necessitates.
- Automation should be viewed as an element of a broader SC-Ambidexterity strategy rather than solely as a tool for cost reduction.
- The development of hybrid human–robot work models is becoming increasingly important, and logistics centers should invest in strengthening employees' analytical and technical competencies.

Furthermore, the insights gained from this case study will enable the authors to develop a structured interview questionnaire that can be used in research at subsequent logistics centers.

Based on the relevant literature (Belhadi et al., 2021; Tortorell et al., 2022; Wang et al., 2023), the authors consider the research direction concerning the Supply Chain Ambidexterity model—supported by Industry 4.0 technologies—to remain within their scope of interest.

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