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ChatGPT IN SUPPLY CHAIN MANAGEMENT – A RESEARCH MODEL

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Purpose: The aim of the research is to indicate potential areas of application for ChatGPT in the supply chain and the associated outcomes with reference to specific examples. The purpose of the deliberations is also to propose a research model, which will serve as an empirical matrix for examining case studies and, as this technology becomes more widespread, for quantitative research.
Design/methodology/approach: In the first stage of the research, a qualitative review of scientific literature was conducted. Subsequently, selected items were assigned to thematic modules, guided by knowledge of the sequencing of processes in the supply chain. The collected material allowed for the identification of research gaps in the discussed topic.
Findings: As a result of the undertaken work, a measurement tool has been proposed, useful for future research on the use of ChatGPT in supply chains, consisting of several constructs and dozens of test items. This is also the first such proposal in the world literature. It has been found that the application of ChatGPT at its current stage of development and empirical evidence is primarily illustrated in relation to logistics and marketing management, mainly in customer service and transport tasks. The effectiveness of chat application has been confirmed, among others, in the area of supply chain configuration, supplier selection, inventory management, production, and transportation. However, these are individual studies. There is a lack of empirical studies on the use of GPT in freight forwarding, logistics operators, distribution, and reverse logistics. Research is also needed on the connections between the described technology and other Industry 4.0 technologies used in the supply chain. Such correlations have been examined in relation to blockchain, 3D, but the potential in this area is much greater.
Research limitations/implications: The article integrates knowledge of supply chain management and the potential of one of the most advanced Natural Language Processing models. This area is exceptionally under-explored compared to previous works in the field of ChatGPT.
Practical implications: Enterprises implementing ChatGPT in their supply chains can generate specific business benefits outlined in the research model.
Social implications: The described technology can have positive effects in all dimensions of sustainable activities.
Keywords: chatGPT, industry technologies 4.0, logistics, research review, AI.
Category of the paper: research paper.

1. Introduction

The subject of consideration is ChatGPT in the context of its potential applications in the supply chain. ChatGPT fits into the framework of Generative Artificial Intelligence (GAI), which is based on transformation. Alongside Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs), this model constitutes one of the most common types of generative AI models currently used. Generative Artificial Intelligence encompasses more than conversational intelligence, as it involves creating various types of data, not just text. Since Generative Artificial Intelligence utilizes machine learning techniques to learn and generate new data, it is a subset of it. Large Language Models (LLMs) form a subset of GAI, based on deep learning (DL) and natural language processing (NLP).

ChatGPT, based on GPT-4, constitutes a deeper layer of LLM and thus a deeper layer of GAI. The historical context of GAI, LLM, and the place of ChatGPT in this evolution is cited in numerous publications (Abedi et al., 2023; Budhwar et al., 2023; Kar, Varsha, Rajan, 2023).

Based on the analysis presented in the latest Deloitte report (2024), it can be stated that from the perspective of supply chain management, GAI is useful in areas such as demand planning (Consumer Sentiment Analysis), inventory analysis, global trade-logistics analysis, contract adherence & anomaly detection, scenario simulation, and language translation for global trade. However, empirical evidence on Gen-AI's effects in SCM remains limited (Wamba et al., 2023b).

Due to the novelty of ChatGPT, which has not yet received widespread theoretical grounding, many insights are published based on knowledge drawn from so-called gray literature (Kar, Varsha, Rajan, 2023). This statement applies even more to supply chains (Frederico, 2023).

Nevertheless, there is an increasing number of peer-reviewed review papers pointing to potential applications of ChatGPT; however, the issue of supply chains is discussed indirectly by referring to customer service or mentioned briefly. There is a lack of a separate delineation of a research field for supply chains (Arman, Lamiya, 2023; Aggarwal, 2023; George, George, 2023; Kalla, Smith, 2023). Javaid and colleagues (Javaid, Haleem, Singh, 2023) identified segments such as management of logistics, quality control in manufacturing, and automated inventory management among the extensive list of ChatGPT applications, but these proposals do not cover a broader spectrum of functionalities across the entire supply chain. The only available review articles addressing the issue of supply chains refer to non-peer-reviewed literature (Frederico, 2023). The latest post-conference review publication, in turn, covers only a few areas related to supply chain management and does not provide a model-based approach (Feki, Dudézert, 2024).

There is a wide range of scholarly works dealing with the role of artificial intelligence in supply chains; however, the role of ChatGPT is either signaled only marginally (Hendriksen, 2023) or not at all, due to the brief historical overview of this technology (Helo, Hao, 2022; Younis, Sundarakani, Alsharairi, 2022).

Therefore, the following research questions were formulated in the study:

RQ1. *What are the potential spheres of application of ChatGPT in the supply chain, and what research model can be proposed accordingly?*

RQ2. *In which areas is the integration of ChatGPT with the operational sphere of supply chain management currently being conducted, and in which areas is there an evident research gap?*

Their originality is reflected in a holistic view of the supply chain.

2. Application Opportunities of ChatGPT in the Supply Chain

Due to the lack of available research models on the applications of GPT in the supply chain, it is not possible to expand or supplement existing proposals. Therefore, a literature review was adopted as the research method, primarily focusing on case studies. A typical bibliometric statistical review cannot be applied due to the low number of records generated on the given topic. In order to search for materials related to ChatGPT in the realm of the supply chain, a search path was introduced in SCOPUS using phrases such as "Generative Pre-trained Transformer", "generative pretrained transformer", "chat GPT", "chatGPT", "GPT-4", or "GPT- 3.5". Subsequently, the search was narrowed down to the subject area of "business, management, and accounting". A total of 431 entries were generated from a pool of eight and a half thousand entries on this topic. Among them, only a few were in any way related to supply chains or logistics. However, due to the low number of records, the search scope was expanded to include other disciplines and the Web of Science and Google Scholar databases. This yielded approximately forty entries.

During the qualitative analysis, materials were eliminated that:

- contained only research based on prompts and contributed little to the model,
- addressed topics such as urban logistics systems,
- did not refer to the GPT acronym as a technology.

To illustrate the potential usefulness of ChatGPT in the supply chain, selected examples of research were cited, covering areas such as procurement, production, distribution, storage and inventory management, as well as the transportation, freight forwarding, and logistics-marketing industry supporting supply chains. A synthetic review of the literature, based on which test questions were created, is presented in Table 1.

For instance, this method is useful in the procurement phase for supplier evaluation. Wang and Wu (2024) demonstrated through empirical experiments and comparisons that traditional Multi-Criteria Decision Making (MCDM) models can be replaced by ChatGPT-based MCDM models. Augmented with various techniques like Chain-of-Thought Technique (CoT), Demonstrations, and Voting Ensemble, the ChatGPT model exhibits enhanced performance. Typically, quantitative and qualitative data are collected using methods such as surveys among industry experts. Then, experts proficient in MCDM techniques employ methods such as Analytic Hierarchy Process (AHP) and Fuzzy Comprehensive Evaluation (FCE), or other multi-criteria methods. MCDM supported by AI enhances the efficiency of such work.

There is also evidence that ChatGPT is useful in the realm of production. For example, Badini et al. (2023) correlated ChatGPT with Additive Manufacturing (AM, also known as 3D printing) technology, which enables the creation of complex products and parts for final products. The key stage of the AM process is the generation of Gcode, which controls the movements of the printer extruder and the layer-by-layer creation process. Researchers trained ChatGPT using existing "unoptimized" Gcode data to generate optimized Gcode. They proved that ChatGPT can monitor the printing process, make changes to the Gcode in real-time, and improve the quality of the final product, leading to significant time and material savings and improved print accuracy. Considering fifteen printing parameters such as material type, printing temperature, printing speed, fan speed, layer thickness, and others, ChatGPT optimally manages their optimization and explains why each parameter was changed. Based on the research, the authors concluded that ChatGPT was able to computationally optimize these parameters in just one hour, which would take about three weeks in experiments. Empirical research also demonstrates that ChatGPT has the potential to improve the accuracy of inventory management plans necessary for production realization in both the short and long term (Skórnóg, Kmiecik, 2023). A comparative analysis of the effectiveness of ChatGPT and ARIMA (Autoregressive Integrated Moving Average) forecasting models showed that the ChatGPT algorithm achieves higher levels of forecasting accuracy.

In another study, researchers (Jackson, Jesus Saenz, Ivanov, 2024) experimentally demonstrated that ChatGPT can be used to automatically generate simulation models for inventory management. During the experiment, they used both English and Python programming language. They proved that through collaboration between humans and ChatGPT, greater benefits are obtained than through individual work. This results from the possibility of mutual learning. The human expert provides a textual description of the inventory and queueing system, which is then used by artificial intelligence to generate Python code. The code is used to automate the development of simulation models. A detailed review of queueing inventory models illustrates how complex this problem is. Depending on whether it is inventory of a commercial unit, a production unit, or if the initial conditions are different, a dedicated model is created.

On the other hand, Shipwell, the leading transport management platform (Price, 2023), was the first in the industry to integrate an advanced ChatGPT language model with its transportation management system (TMS) platform. This allows freight forwarders and carriers to communicate with the Shipwell platform in natural language. Automated communication also helps streamline the onboarding of new carriers and shorten carrier qualification time. ChatGPT also automatically identifies an email request for freight pricing, retrieves the request to the Shipwell ML pricing pipeline, generates a response, and then sends the pricing by email to the customer. Shipwell provides real-time shipment status updates, including tracking information and any delays.

In the context of transportation, Voβ (2023) also demonstrates that ChatGPT can assist truck drivers in navigating unfamiliar terminals, even in languages they typically do not use. Due to the fact that ChatGPT, as a natural language AI model, currently lacks access to real-time data or specific information about events occurring in real-time, it should be integrated with other systems, such as sensors or digital twins.

In other transportation-related studies, Wen et al. (2023) conducted tests using GPT-4V in various autonomous driving scenarios. The results indicate that GPT-4V exhibits capabilities that have the potential to surpass existing autonomous driving systems in aspects such as understanding traffic scenarios, recognizing intentions, and making driving decisions. However, the authors emphasize that GPT-4V also has certain limitations, including issues with direction recognition, identification of traffic lights, and a lack of spatial reasoning in 3D.

On the other hand, Kim Junghwan, and Jinhyung Lee (2023) compared responses provided by ChatGPT and experts regarding solutions to transportation problems in the United States and Canada. ChatGPT proposed transportation solutions related to the implementation of intelligent transportation systems, alternative forms of transportation, infrastructure improvement, consideration of sustainable development and resilience, and investment in low-emission transportation options, among others. The researchers demonstrated that in both countries, the responses obtained by ChatGPT were consistent with the positions developed by experts.

ChatGPT may also find application in marketing, particularly in creating product reviews. Hangyu Chen (2023) conducted research involving the generation of review comments based on the ChatGPT model using customer source data. The author found that they exhibit high similarity to reviews written by humans. The author believes that this could help e-commerce platforms expedite this process, thereby increasing product exposure and sales, which in turn translates to orders and volume of goods flow.

Furthermore, Shabrina Nadhilah (2023) presents the results of marketing research conducted using ChatGPT. The marketing research included preferences of customers from different countries regarding car purchases, among other aspects. The obtained results were compared with a report from a professional research firm. It can be observed that ChatGPT competently conducted the described experiment, replicating a real survey. The author believes

that marketers could be supported by ChatGPT in building a research platform. The advantage of conducting surveys using ChatGPT is the quick pace of work and low costs. Conducting a real survey takes longer and requires higher expenses. The application of ChatGPT could save the brand's marketing budget and increase its efficiency. Efficient research helps better target offers to customers and thus reduce the level of reverse logistics.

Research on chat is also conducted at the level of the entire supply chain. For instance, Li et al. (2023) demonstrated that ChatGPT aids in configuring the supply chain. Using the example of the coffee supply chain, they investigated variations in the number of suppliers categorized by types for individual coffee roasters to meet the demand needs expressed by retailers. They thus optimized the costs associated with purchasing coffee from suppliers, roasting costs at each facility, and the cost of shipping the final product to retail points.

Some research, although not directly related to supply chains, can be applied in their context. For example, Zhang, Lu & Zhao (2024) proved that ChatGPT can automatically generate solutions for predicting energy loads of buildings and can detect and diagnose equipment failures in building energy systems, such as ventilation units, refrigeration units, and air conditioners. In supply chains requiring large warehouse spaces, especially in temperature-controlled chains, automatic, fast, and easy control of these parameters can generate significant savings. Since 2022, due to the geopolitical situation, a significant increase in energy prices has been particularly noticeable. Therefore, it is advisable to use GPT models for the design of passive, optimization of building facades and renewable energy systems to improve the analysis of energy efficiency (Saka et al., 2023).

ChatGPT also facilitates unskilled users in writing high-quality code and increasing programmers' productivity. In an experiment by Napoli and Gatteschi (2023), ChatGPT was asked to fix 143 smart contracts with well-known, marked bugs. Simultaneously, the authors utilized Slither, one of the most advanced error detection tools. It turned out that ChatGPT was able to fix errors in almost 60% of cases. Smart contracts, thanks to blockchain technology, are gradually becoming part of supply chain infrastructure (Farooq et al., 2024). Therefore, their role will continue to grow.

Chat also has great potential in training. For example, Freire and colleagues (Freire et al., 2023) conducted a study in a textile factory where chat was meant to support the training process for new production workers. The authors emphasize that chat can be adapted to more complex tasks. For instance, semantic search functionality can be added to the knowledge base, which selects appropriate domain documents. Visualization of the issue being asked by the employee could also be added to this.

3. ChatGPT in the Supply Chain – Constitutive Constructs of the Research Model

Based on the literature review, the constructs constituting the research model have been structured, which can be utilized at the level of a single case study, multiple case studies, as well as for quantitative research. Due to the fact that the application of GPT at the level of the supply chain is in a very early stage of research, there are currently no possibilities to conduct reliable quantitative research.

As a result of the undertaken work, several constructs were identified, some directly related to the supply chain, and several constructs with a significant indirect impact on the analyzed phenomenon. Each construct contains 3-5 test items (see Table 1).

Table 1.
The constructs, items, and sources - dependent variables

Items	***Activity - constructs and measurement scale***	***Source***
α	**Sourcing**	Feki, Dudézert, 2024; Frederico, 2023; Javaid, Haleem, Singh, 2023; Saka et al., 2023; Wang, Wu, 2024
α_1	Assistance in supplier selection	
α_2	Supply analysis in the context of disruptions	
α_3	Assistance in supplier evaluation	
α_4	Material selection	
β	**Warehousing**	Aljaž, 2024; Arman, Lamiya, 2023; Frederico, 2023; Jackson, Jesus, Saenz, Ivanov, 2024; Javaid, Haleem, Singh, 2023; Rane, 2023; Rathor, 2023; Skórnóg, Kmiecik, 2023
β_1	Processing product images into component lists and warehouse status correction	
β_2	Inventory level optimization based on estimated demand	
β_3	Inventory counting	
β_4	Optimization of warehouse equipment utilization	
γ	**Production**	Aggarwal, 2023; Badini et al., 2023; Doanh et al., 2023; Feki, Dudézert, 2024; Javaid, Haleem, Singh, 2024; Li, Guo, Zang, 2024; 2023; Saka et al., 2023; Verma, 2023
γ_1	Production planning	
γ_2	Alerts regarding production equipment maintenance	
γ_3	Optimization of machine work time utilization	
γ_4	Programming and parameterization of production equipment	
γ_5	Product quality verification	
δ	**Product**	Aggarwal, 2023; Javaid, Haleem, Singh, 2023; Chen, 2023; Kumar, Gupta, Bapat, 2024
δ_1	Designing new product patterns	
δ_2	Product valuation	
δ_3	Interactive product visualization	
δ_4	Customer co-creation of products	
ε	**Distribution**	Arman, Lamiya, 2023; Feki, Dudézert, 2024; Frederico, 2023; George, George, 2023; Kumar, Gupta, Bapat, 2024; Rane 2023; Verma 2023
ε_1	Management of e-commerce channels	
ε_2	Support for retail sales links	
ε_3	Evaluation and selection of distribution channels	
ζ	**Marketing**	
ζ_1	Report preparation (e.g., environmental)	Aggarwal, 2023; Frederico, 2023; George, George, 2023; Chen 2023; Haddud, 2004; Javaid Haleem, Singh, 2003; Shabrina 2023;
ζ_2	Market research, customer behavior analysis	
ζ_3	Text creation (social media, blogs, etc.)	
ζ_4	Website construction	
ζ_5	Marketing strategy development	

Cont. table 1.

η	**Communication**	Aggarwal, 2023; Feki, Dudézert, 2024; Frederico, 2023; Javaid, Haleem, Singh, 2023; Saka et al., 2023; Verma, 2023
η_1	Email editing	
η_2	Multilingual communication management	
η_3	Contract negotiation	
η_4	CRM-style management	
θ	**Market**	Aggarwal, 2023; George, George, 2023; Feki, Dudézert, 2024; Haddud, 2024; Shabrina, 2023
θ_1	Analysis of changes in customer structure	
θ_2	Evaluation of sales/demand potential in various markets	
θ_3	Assessment of competition in different markets	
θ_4	Evaluation of the impact of economic changes on purchasing power	
θ_5	General enterprise strategy development	
ι	**Reverse Logistics**	Javaid, Haleem, Singh, 2023; Saka et al., 2023; Verma, 2023
ι_1	Non-rotating goods management	
ι_2	Handling complaints	
I_3	Waste management	
κ	**Fleet**	Arman, Lamiya, 2023; Du et al., 2023; Frederico, 2023; Javaid, Haleem, Singh, 2023; Liao et al., 2024; Price, 2023; Rane, 2023; Rathor, 2023
κ_1	Development of modern transport fleets	
κ_2	Human-fleet collaboration	
K_3	Road-fleet-human collaboration	
λ	**Transport**	Saka et al., 2023; Frederico, 2023; Javaid, Haleem, Singh, 2023; Price, 2023; Rane, 2023, Rathor, 2023; Qalati et al., 2023; George, George, 2023; Voβ, 2023; Wen et al., 2023; Yenduri et al., 2024
λ_1	Route planning	
λ_2	Pricing/invoicing	
λ_3	Implementation of new carriers	
λ_4	Tracking shipments/order status	
μ	**Supply Chain**	Aljaž, 2024; Aggarwal, 2023; Frederico, 2023; Li et al., 2023; Rane, 2023; Li, Starly, 2024; Rathor, 2023; Sadiqet et al., 2024; Singh, Kaur, 2023; Verma, 2023
μ_1	Identification of critical points for flow fluidity	
μ_2	Allocation of resources used in logistics operations	
μ_3	Supply chain configuration	
μ_4	Data analysis and visualization	
μ_5	Increasing supply chain visibility	

Based on the collected material, a research model was outlined, which includes four modules related to the implementation of ChatGPT containing independent variables. These are:

- input logistics and production: procurement, warehousing, production,
- logistic-marketing management: product, distribution, market, marketing, communication, reverse logistics,
- transportation service: fleet, transportation,
- supply chain management in a holistic approach.

Additionally, dependent variables such as costs, logistics operations, and the market were identified.

The test items from the outcome page are included in Table 2.

Table 2.
The constructs, items, and sources - independent variables

Items	*Benefits - constructs and measurement scale*	*Source*
ν	**Financial**	Haddud, 2024; Wamba et al., 2023a; Richey, 2023; Singh, Kaur, 2023
ν_1	Reduction of human resources costs	
ν_2	Reduction of operating costs of fleet and equipment	
ν_3	Reduction of transaction costs	
ν_4	Minimization of product costs during the design phase	
ν_5	Reduction of reverse logistics costs	
ξ	**Operational**	Wamba et al., 2023a; Saka et al., 2023; Rathor, 2023; Richey, 2023
ξ_1	Elimination of disruptions in the operation of fleet and equipment	
ξ_2	Bullwhip effect mitigation	
ξ_3	Domino effect mitigation	
ξ_4	Reducing errors and saving time through process automation	
ξ_5	Improvement of service level in transportation logistics	
o	**Market**	Aljaž, 2024; Haddud, 2024; Wamba et al., 2023a; Saka et al., 2023; Javaid et al., 2023b; Richey, 2023; Deng, Lin, 2022
o_1	Increasing customer satisfaction	
o_2	Economies of scale	
o_3	Enhancing responsiveness through better recognition of customer preferences	
o_4	Elevating prestige through the adoption of innovative technologies	
o_5	Faster trend detection through the integration of ChatGPT with foresight methods	
π	**Related to sustainable development**	Deb et al., 2024; Fang et al., 2023; Lim, Siripipatthanakul, 2023; Rathore, 2023; Sadiq et al., 2024
π_1	Reduction of CO2 emissions	
π_2	Minimization of waste	
π_3	Savings of primary resources and materials.	
π_4	Improvement of ergonomics and human working conditions	
π_5	Faster economic development	

The constructed model can serve as a research matrix for a selected case study or quantitative research (see Figure 1).

To illustrate the logical derivation based on which hypotheses were formulated reflecting the associations in the model, examples linking a selected construct with the outcome part of the model were presented.

For instance, in the procurement processes, chat can generate precise reports on supplier performance and delivery times, providing companies with the necessary information to improve their logistics system and ensure fast product delivery (Javaid, Haleem, Singh, 2023). Additionally, it can expedite negotiations within certifications or supplier code of conduct agreements. The support of this technology in supplier selection is also important. For example, for this task, multi-criteria methods are used (Khan, Chaabane, Dweri, 2018), which can also appear in hybrids (Jato-Espino et al., 2014). It has been demonstrated that by leveraging the capabilities of autonomous GPT-4 agents as virtual experts, the decision-making process for selecting suppliers can be automated (Wang, Wu, 2024).

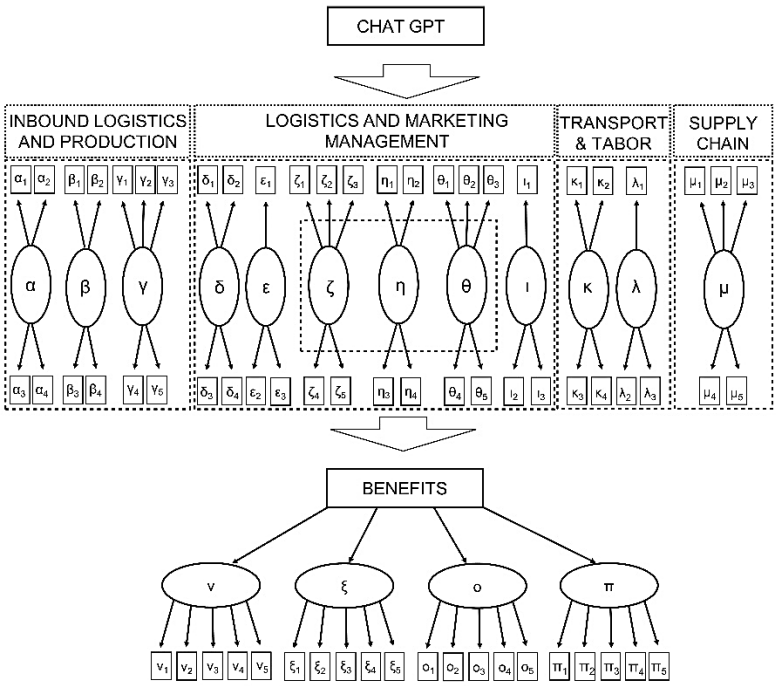

Figure 1. Implementation of ChatGPT in the Supply Chain - Research Model.

Improving the implementation of supplier codes of conduct can lead to their widespread adoption and enhance the positive image of the supply chain. This is particularly important when partners are seeking socially responsible partners who conduct transparent policies with their suppliers. The multicriteria selection of suppliers can also reduce transaction costs. Through improvements in supplier performance assessment, ChatGPT enhances the level of logistics service at the input of the supply chain.

Therefore, a hypothesis was formulated as follows:

The implementation of ChatGPT in procurement processes positively impacts logistics operations, costs, market aspects, and results related to creating sustainable supply chains.

In the transportation domain, chat can enable companies to construct autonomous vehicles (Arman, Lamiya, 2023). In particular, ChatGPT can assist in human-vehicle interaction, training intelligent vehicles (Du et al., 2023). These activities can significantly reduce costs by detecting errors during the implementation phase of fleet and human activities. The chatbot can also recommend the best route based on road conditions, find safe parking, connect with road infrastructure, provide information on road surface conditions, facilitate customs regulations, and help drivers adjust their driving behavior to optimize fuel consumption and thereby reduce CO2 emissions, prevent accidents, and comply with different traffic regulations in various countries (Du et al., 2023). ChatGPT can improve the Vehicle IQ assessment by providing an information exchange interface between humans and car manufacturers and external testing organizations. Additionally, through the integration of TMS systems with telematics solutions, chat can increase driving safety and monitor vehicle condition (Frederico, 2023). These functionalities translate into the comfort of performing logistics operations. Increased driving safety and enhanced monitoring can influence the decision-making choices of service

recipients. A company advocating the use of modern technologies may be perceived as trustworthy. The role of this factor increases for long distances, high-value cargo, the bankruptcy of many transportation companies, transports to dangerous or poorly known areas.

Therefore, it can be assumed that:

The implementation of ChatGPT in fleet and transportation management processes positively impacts logistics operations, costs, market aspects, and results related to creating sustainable supply chains.

ChatGPT can also play a significant role in managing bottom-up flows in the supply chain. It can streamline the management of claims for damaged goods or those purchased in excess in the e-commerce channel system. With the support of this technology, it is also possible to perform a financial simulation to determine whether it is more cost-effective to independently collect returns of goods and packaging or to outsource this task to an external entity. As demonstrated in the case of electric vehicle batteries, this technology can also support the optimization of the recycling process (Feng et al., 2024). On the stock exchange, it can collect relevant information from potential sellers about the attributes of used batteries and match them to interested buyers. Initiatives using ChatGPT in other areas also indirectly affect the logistics of returns. For example, data analysis of defective products may suggest ways to improve production processes to minimize waste. Tracking market trends allows for a more accurate matching of sales offers, thus leading to fewer returns from retail links.

Thus, it can be stated that:

Implementation of ChatGPT in reverse logistics management processes positively impacts logistics operations, costs, market aspects, and results related to creating sustainable supply chains.

Similar hypotheses can be derived for other constructs, the associations of which are indicated in the model. Due to the extensive content of the described phenomena, the depiction of the remaining dependencies will be presented in a separate document.

In practice, depending on the specifics of the supply chain, the influence of one area managed by ChatGPT on others, which are strongly correlated, can be further investigated.

In the future, it may be worth considering the introduction of moderating, mediating, contextual, and control variables. For example, the co-occurrence of other technologies, the type of supply chain, the level of integration, the number of business entities involved in the chain, the length of cooperation, and the degree of logistics task outsourcing can be examined to dynamize and condition the relationships between dependent and independent variables.

The obtained results can only be indirectly related to the proposals of Frederico (2023) and Feki and Dudézert (2024) because they are not model-based approaches. The first author discusses application areas and potential results as a whole. His considerations do not include the test positions listed in Table 1, which are part of the constructs "supply chain", "fleet",

"reverse logistics", "market environment", and "product", and he presents other issues selectively. Similarly, Feki and Dudézert (2024) also do not include the mentioned constructs. They propose five application areas and indicate an overall improvement in business performance on the results side. The proposed model thus covers a much broader spectrum of aspects. Additionally, the cited hypotheses facilitate the search for relationships between constructs. The holistic approach, encompassing flows up and down the supply chain, marketing aspects, and the product itself, represents a new approach (within the discussed topic) both theoretically and practically.

4. Conclusions and Theoretical and Practical Implications

From a theoretical perspective, research gaps in the application of chat in the supply chain have been identified and the state of knowledge in this area has been systematized. Methodologically, a research model has been proposed, which can be used for quantitative research, multiple case studies, and individual business cases. It also serves as a kind of guide for smaller entities for which acquiring specialized knowledge is difficult. Testing the model in the future will allow for the development of theories. Currently, this poses a research limitation.

Practical implications relate to identifying the areas in the supply chain where chat has application potential and the resulting benefits. Secondly, areas of chat implementation affecting supply chain management or individual links have been illustrated, showing their relationship with supply chain management.

Based on the conducted work, it can be stated that chat is helpful for reactive analytics (descriptive and diagnostic) when analyzing situations that have already occurred. For example, it allows determining the number of errors in the production process or the profitability of sales broken down by distribution channels. However, the more significant potential lies in ChatGPT's proactive analytics (predictive and prescriptive). Building the entire supply network and deciding on the level and type of inventory in each link generates very high costs. Therefore, ChatGPT can be used to predict the volume of goods flows, build scenarios for nearshoring, logistics outsourcing, or the location and creation of logistics centers. Particularly useful is ChatGPT's role in creating prescriptive analytics (Lepenioti et al., 2020). The ability to predict trends in supply chains or the behavior of their participants is important, but planning actions that enable the implementation of the most favorable plan is crucial in this area. However, there is still a lack of research in this area.

From the perspective of trends in supply chains, it is essential not only to conduct research on flows down the supply chain but also in the reverse direction. There are significant research gaps in both directions. Much more information can be obtained at the intersection of logistics and marketing management.

From the perspective of the benefits achieved, chat can be helpful both in optimizing logistic operations, reducing costs, market aspects, and creating sustainable supply chains. All these dimensions influence each other. For example, optimizing routes leads to reduced CO2 emissions and thus a lesser impact on the environment. This, in turn, results in lower costs associated with emissions. A company that emphasizes its concern for the environment is positively perceived in the market. Nevertheless, this problem is even more complex because the potential reduction in CO2 emissions must be compared to the amount of energy used during the training and usage of ChatGPT. This, in turn, requires the development of a more precise model for calculating the carbon footprint of AI products (Haque, Li, 2024).

In the future, it is advisable to conduct research on the integration of ChatGPT with information technology, artificial intelligence, and Industry 4.0 technologies. "ChatGPT can access the data for analysis since it has established an API connection to many data sources. These data sources include ERP systems like SAP S4 HANA, CRM platforms, inventory management software, and other relevant applications" (Rathor, 2023). It can also be integrated with other artificial intelligence technologies used in the supply chain, such as artificial neural networks, fuzzy logic and models, multi-agent and agent-based systems, genetic algorithms, general forms of AI, data mining, case-based reasoning, and swarm intelligence (Toorajipour et al., 2021). Positive effects of the joint operation of chat and various Industry 4.0 technologies (e.g., IoT, digital twin, virtual reality (VR), augmented reality (AR), blockchain, automated guided vehicles (AGV), big data) are already being demonstrated. It is therefore advisable to check if they correspond with the described technology in the context of supply chain management.

In summary, it can be hypothesized that ChatGPT is capable of revolutionizing supply chain management. The supply chain includes both business and non-business entities from various industries. Physical flows are accompanied by information and financial flows. Therefore, the application of ChatGPT in the proposed areas of the supply chain may be connected not only to the IT and technology sectors but may also impact work culture, legislation, healthcare logistics, emergency response, and a range of other socio-economic areas.

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