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MODELLING OF E-COMMERCE PACKING LINE IN THE WAREHOUSE – CASE STUDY

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Purpose: The purpose of this paper is to create a simulation model of a packing line in an e-commerce activity from the perspective of a logistics operator, along with identifying recommendations for further model improvement as part of digital transformation.
Design/methodology/approach: This paper uses results obtained by simulation analysis of a computer model of a process built in BPMN 2.0 notation. Data for the model was collected from process analysis, analysis of data obtained from WMS and sensors on the packaging line and from participant observation in the process.
Findings: Based on the analysis, it can be concluded that the logistics operator is able to create a simulation model of the process and optimise its operations using the simulation results. The model presented can also be the basis for building a Digital Twin in the distribution network for e-commerce flows.
Practical implications: The logistics operator can extend its package of services to include the construction of simulation models and, in future, can also take on the task of creating value for the network on the basis of the Digital Twin created.
Originality/value: The paper presents a real-life case study related to the first phase of Digital Twin implementation, namely the creation of a simulation model to create value in the flows and improve the logistics processes involved in serving the e-commerce market.

Keywords: logistics service provider, third-party logistics, e-commerce, simulation model, BPMN 2.0.

Category of the paper: case study.

1. Introduction

The decision to use 3PL operators is often justified by strategic considerations, where a company recognises that one or more elements of its business need to change (Murphy, Wood, 2011). It is driven by, for example, a desire to focus on core activities, a desire to increase responsiveness to changes in the environment, a desire to increase customer satisfaction, improve quality or reduce investment in logistics. Savings, knowledge diffusion, emphasis on areas of core competence and increasing IT sophistication are also factors driving the choice of a logistics operator. However, when considering whether to enter into cooperation with an operator based on outsourcing, it is also necessary to bear in mind the risks of using such services, which may include the following (Grabowska, 2012): lack of control over distribution, less contact with customers and disruptions to information flows. These risks can be reduced, for example, by a properly established relationship with the outsourcing provider. Outsourcing a range of services to operators gives manufacturers the opportunity to continuously improve their products and their quality. A logistics operator is defined as a contractual service provider that is focused on maximising the use of its assets and improving its operational activities (Skowron-Grabowska, 2011). It is a logistics service provider that delivers different types of logistics activities on behalf of a manufacturer or larger retailer. An important role during the selection of a logistics operator can be played by (Kramarz, Kramarz, 2013): the execution time of the different activities and process, the need for technical and human resources, as well as the way in which the process is carried out and its total cost. The struggle of operators in today's market is mainly carried out by offering not only the lowest price anymore, but by ensuring visibility in the supply chain, reliability and a positive approach to innovation (Cichosz, 2018).

One trend in the logistics services industry is the increase in the comprehensiveness of services and the demand for so-called logistics service packages (Zelkowski et al., 2018), which are often also referred to as bundled services. This trend also applies to one of the basic services performed by operators, i.e. transport and forwarding services, which are encapsulated by numerous different accompanying activities (Witkowski, Kiba-Janiak, 2012). Companies in networks are increasingly going beyond limiting themselves to contracting single activities and are looking for companies that provide multiple services. It can therefore be concluded that logistics operators can be more competitive not only by offering logistics-related services, but also on the basis of multiple complementary services, to which product demand forecasting could also come down. According to the author, a factor that deserves special attention within logistics outsourcing is the development of information systems and digitalisation.

The development of IT has shaped the basis for the creation and use of information systems, which are based on computer-based techniques for developing and transmitting data (Rut, Kulińska, 2015). Modern distribution is an area of activity where the use of such developing IT solutions is essential. This is due to the fact of increasing globalisation and the needs for fast processing and synchronisation of large amounts of data (Kauf, Pisz, 2017). Appropriate IT systems allow for: the modernisation of distribution networks, as well as the development of technologies directly or indirectly related to distribution (Drożdż, 2018). The development of logistics systems is closely linked to IT technologies. Some of the main developments include: the use of IT systems to define logistics strategies, IT-integrated business management, computer-assisted management of external transport, paperless picking of shipments, the creation of data warehouses to improve agility in supply and demand projects, as well as the computerisation of retail outlets and the implementation of EDI (Electronic Data

Interchange) (Kauf, Pisz, 2017). Currently, around 50-70% of companies' logistics activities are outsourced (Cichosz et al., 2020), so this provides an opportunity to look for digitisation solutions dedicated typically to logistics service providers.

The purpose of this paper is to create a simulation model of a packing line in an e-commerce activity from the perspective of a logistics operator, together with the identification of recommendations to further improve the model as part of digital transformation. Based on a case study, the paper will consider two research hypotheses. Logistics service providers will be referred to interchangeably with logistics operators and 3PLs (third-party logistics) in the paper.

2. Theoretical background

2.1. E-commerce logistics in today's market

One of the biggest trends of recent times, not only in the logistics industry, is the rapidly growing e-commerce. The last few years have seen the development of e-commerce, during which market players have emerged who, it would seem, have dominated the market (Cao et al., 2021). However, the pandemic situation related to the restrictions caused by the COVID- 19 virus, among others, pushed some of the companies to shape their online sales channels more quickly (Jiang et al., 2021).

E-commerce therefore dominates the business models of companies (Yu et al., 2016), including companies directly involved in the implementation of e-commerce operations. E-commerce channels, in relation to the logistics industry, are strictly market-oriented, so logistics operators and other logistics companies face challenges in providing reliable and personalised solutions in the online sales market (Yu et al., 2020), as well as diversifying demand and increasing the flexibility of operations. The specificity of orders being fulfilled has changed. From the fulfilment of large batches to specific pick-up points to the fulfilment of small batches, but in very geographically dispersed areas (Yu et al., 2020). A comparison between traditional logistics and e-commerce logistics can be found in Table 1.

Table 1.
E-commerce vs traditional logistics

Factors	Traditional	E-commerce
Size of consignments	Large	Small
Type of consignment	Homogeneous	Heterogeneous
Number of consignments	Large	Small
Number of destination points	One or more	Plenty
Delivery errors	Some	Plenty
Frequency of deliveries	Low	High
Delivery time sensitivity	Low	Large

Cont. table 1.

Number of means of transport required	Low	High
Size of means of transport	Large	Small
Costs per consignment	Low	High

Source: Xing et al., 2011.

According to the main tenets of e-commerce, modern logistics should improve the efficiency of flows, reduce logistics costs, and ensure that even small shipments are handled (Yu et al., 2016). E-commerce consolidates current and potential logistics resources to perform activities related to the delivery of products to end customers (Li, Huang, 2019). It is most often identified with B2C trade and traditional distribution with B2B trade (Yu et al., 2016). Of course, B2B trade can also refer to e-commerce activities (Xing et al., 2011). It is acknowledged that 3PLs are predisposed as being among the best companies to perform high-quality e-commerce flow management functions (Cao et al., 2021; Delfman et al., 2002; Kou, 2015). This is mainly due to the mindset of such companies to add value in flows. Some authors explicitly emphasise that it is the 3PL activities that are essential in the implementation of e-commerce activities (Yan et al., 2006). E-commerce has caused, among other things, a change in customer behaviour (Jiang et al., 2021) and a reconfiguration of supply chains (Xing et al., 2011). There are studies related to the demonstration of a positive correlation between the level of synchronisation of the different distribution channels and the logistics costs that accompany the implemented flows (Yu et al., 2020). It is also noted that the quality of logistics services provided influences customer loyalty and loyalty in the e-commerce industry (Cao et al., 2021).

Many types of e-commerce can be distinguished such as insourcing logistics, dropshipping, fulfilment service and one stop e-commerce (Kawa, 2017). However, regardless of the form, among the main functions of logistics (considered in the literature), last mile delivery can be mentioned (Jiang et al., 2021); however, this is not the only activity to be performed on the logistics side. E-commerce support activities can also include warehousing, transportation and value-creating processes, among others (Zhong et al., 2019). Five main orientations of logistics activities in the e-commerce area can be sought (Zhong et al., 2020):

- Orientation geared to satisfying marketing activities (e.g. flexible response to promotions).
- Demand orientation aimed at predicting future demand volumes and organising activities to meet them.
- Orientation focused on reducing the resource constraints associated with the implementation of e-commerce activities.
- Orientation focused on building relationships and partner networks in supply chains.
- Orientation geared towards regulations and matching activities to them.

Many times, the use of e-commerce-based distribution channels is associated with negative effects, e.g. in the area of demand fluctuations, which disrupt the operations of traditional distribution channels. Sometimes, companies also seek to rationalise online sales in order to reduce their negative effect (Qin et al., 2020). Challenges faced by an enterprise when creating e-commerce channels most often include: the negative effects of using outdated IT architecture, unoptimised data acquisition models, lack of optimisation in resource planning and unstructured automation solutions (Kong et al., 2020). There are several approaches related to flow synchronisation that can reduce the mentioned negative effects of e-commerce. Among the most important, some authors mention (Yu et al., 2020): synchronisation already in the production area and synchronisation through distribution centres that try to align their flow management activities and synchronise different channels. The development of channels towards omnichannel and digitalisation can also be found among such solutions. Undoubtedly, it can be stated that e-commerce is one of the main drivers for the transformation of logistics (Yu et al., 2016) and, on the other hand, effective ecommerce is impossible to achieve without a properly functioning logistics system (Babu et al., 2020). Thus, it can be concluded that there is a mutual relationship here.

2.2. Processes digitalization in logistics

It is possible for operators to play a large role in the configuration of entire distribution networks. They are considered by some authors to be able to take a leadership role in supply chains. They may undertake management activities, related, for example, to the management of transport, distribution, customer service and warehousing, and other activities, related, for example, to the continuous improvement and reconfiguration of distribution networks and supply chains (so as to meet customer requirements). In addition, it is recognised that the growth of logistics operators is one of the determinants of the development of entire supply chains, and within them distribution networks. Customers are striving for increasingly sophisticated services that are offered by operators and operators are capable of reconfiguring distribution networks. Inherent in the activities of logistics operators in today's market is the possession by them of an adequate IT infrastructure. The use of IT systems is recognised as one of the main elements driving the operation of companies in networks by, among other things, standardising areas related to logistics, such as distribution, production, as well as procurement and inventory management (Kisielnicki, 2015). Information systems, the development and implementation of existing concepts such as EDI, as well as new trends such as the use of artificial intelligence, for example, are extremely important in many areas of companies (Calza, Passaro, 1997). The implementation of modern IT solutions is recognised as one of the key elements in the development of innovation in logistics (Rai et al., 2018). Value creation, one of the core functions of logistics operators, is identified as one of the starting elements of digital transformation (Cichosz et al., 2020), with many authors emphasising that customer service is significantly influenced by the digitalisation of activities performed at the service provider (Moldabelkova et al., 2021).

Digitalisation is considered one of the most important factors that provide advantage in today's market. Digitalisation is pushing companies to redefine their business models towards the implementation of cross- and omnichannel solutions (Rai et al., 2018) (including the exposure of e-commerce-enabled solutions) and towards broadly understood innovation-based business models (Gruchmann et al., 2020). Digitalisation in logistics is growing at a high rate and, according to estimates, the trend of rapid development will continue at least until 2025 (Cichosz et al., 2020; Rythramati, Sivakumar, 2022). Digitalisation also provides an opportunity for more sustainable development (Gruchmann et al., 2020) and is most often associated with Industry 4.0 (Abideen et al., 2021; Moldabelkova et al., 2021). When considering digitalisation in the current market realities, it is impossible not to mention one particular type of digitalisation, namely the Digital Twin.

The Digital Twin is a virtual representation of a physical object or system used to understand and predict potential issues across its lifecycle (Lee, Lee, 2021). The Digital Twin supports solutions related to IoT (Internet of Things) (Guo et al., 2021) and is considered one of the most important solutions for Logistics 4.0 (Zander and Lange, 2021). The Digital Twin should also have the characteristics of a decision support system. Thus, it should have knowledge of the current state, knowledge of a possible future state, the ability to identify disruptions and the ability to generate different situation scenarios (Korth et al., 2018). The Digital Twin allows real-time visualisation of object behaviour, performance monitoring, and process simulation and optimisation (Lee, Lee, 2021). It therefore seems reasonable to implement Digital Twin also in e-commerce operations. The Digital Twin improves the accuracy of managerial decision-making and on predicting disruptions and detecting process disruptions in real time (Park et al., 2020). It consists of physical objects, virtual objects and the connections between them (Lee, Lee, 2021). It should include at least a basic model, metadata and model run logic (Park et al., 2020), where many authors consider simulation models to be an essential component (Abideen et al., 2021).

3. Methods

The focus of this paper is to create a simulation model of the packing process on a line serving B2B (Business To Business) and B2C (Business to Customer) sales channels, where the B2C channel is a channel entirely reserved for e-commerce operations. The packing line is operated by a 3PL (third-party logisitcs) company and is located in a warehouse owned by the company. This line handles shipments to more than 50 POS (points of sales) in B2B trade and an average of 1,200 cartons per day in B2C trade. The main steps in the analysis are presented in figure 1.

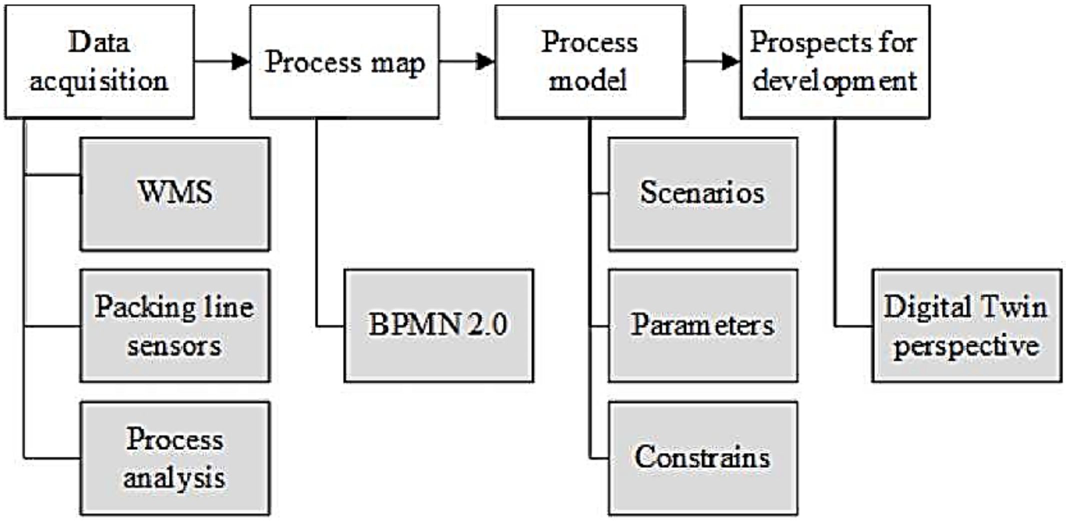

Figure 1. Main research steps.

Data acquisition was based on the analysis of line performance recorded in the WMS (Warehouse Management System) and recorded by the sensors and scanners with which the line is equipped. The range of data thus acquired for analysis covered a 6-month history and mainly concerned the number of cartons in the input flow and information on how B2B and B2C pallets were formed in the output flow. In addition, data extracted for the process mapping was collected through participant observation of the process and analysis of process documentation and process documentation of the line operation. Participant observation was carried out for one month of line operation.

In the next step, a process map related to the packaging of orders for POS and e-commerce was created. The process map was created in the standard notation BPMN 2.0 (Business Process Modelling and Notation 2.0). The process map was the basis for the creation of a computer model of the process, in which the simulation scenario and the parameters of the individual model elements were developed based on the process analysis and the analysis of the data obtained according to the initial stage. Finally, opportunities for development were presented, mainly related to the development of the presented model within the Digital Twin concept.

The paper poses two research questions:

RQ.1: Is the logistics operator, through its value-adding activities in logistics flows, able to optimise the performance of the packing line?

RQ.2: What are the benefits of applying the Digital Twin concept within an e-commerce logistics operation?

The first question is related to the current activities of the operator who provides the outsourcing services. The main function of operators is to create added value for logistics flows, including e-commerce flows. The question is related to the operator's ability to create simulation models and draw conclusions from the simulations carried out in the area of process improvement and added value.

The second question is to isolate the benefits of fully integrating simulation models with data captured in logistics flows within the Digital Twin concept for operator e-commerce activities. Based on the research questions posed in this way, two research hypotheses were created, which the conducted case study was intended to verify. The hypotheses are as follows:

H.1: The logistics operator is able to improve the packing line based on the simulation model.

H.2: Access to data collected from packing line activities and a simulation model provide the basis for the operator to develop a Digital Twin in the e-commerce industry.

The first research hypothesis relates to the possibility of improving the packing process in the e-commerce industry (in a distribution network operating a multichannel for B2B and B2C shipments) by means of a simulation model based on analysis and process data obtained from the perspective of a logistics operator. The second hypothesis concerns the possibility for a 3PL to initiate the initial step in building a Digital Twin in an e-commerce industry connected in a multichannel with B2B commerce.

4. Results

On the basis of the process analysis, data from the Warehouse Management System (WMS) and sensor data from the individual packaging line locations, a process model in BPMN 2.0 notation was created. Due to the complexity of the process, the multitude of specified and mapped elements and the desire to simplify the perception of the process, in this paper the author has only included a general process diagram consisting of a few key elements in the form of aggregated activities (figure 2**).**

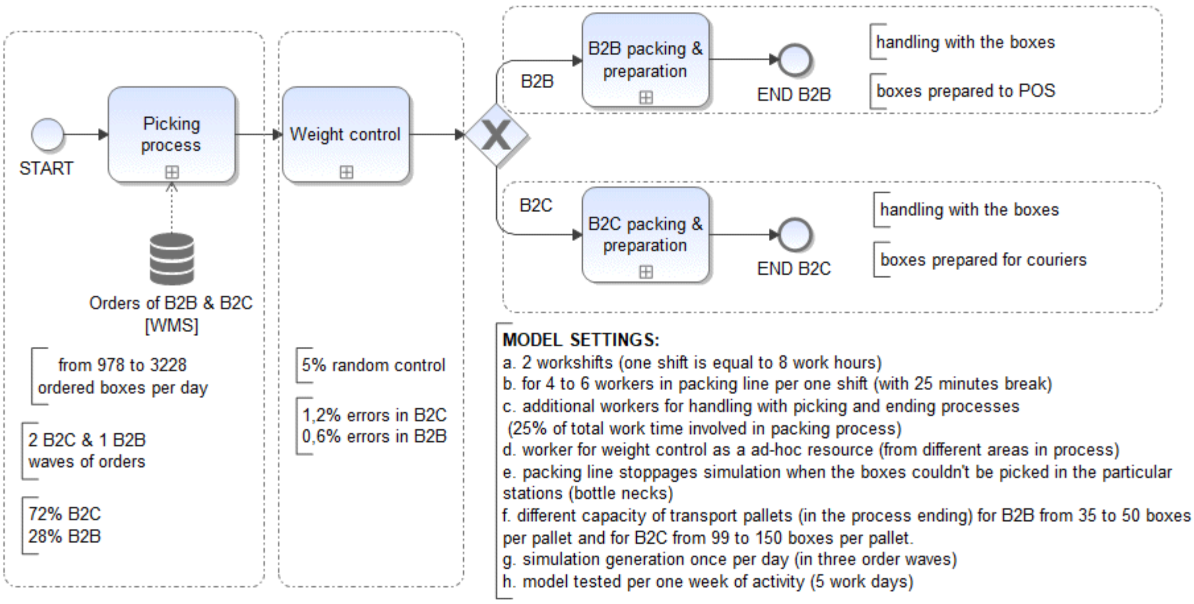

Figure 2. General model of the process performed within a packaging line.

The simulation model tested the behaviour of a semi-automated packing line. Where elements related to the flow of cartons on the line and elements related to weight control and carton closing are automated. The line simulates the daily handling of orders to POS (Point of Sales) for B2B - 28% of all orders generated for the line - and 72% of orders to individual customers, where orders are placed online (B2C). The number of cartons arriving on the line was calculated based on picking data from the WMS (the data analysed was for the last 6 months of activity), where the upper limit of the number of cartons ordered refers to the average value plus the standard deviation value for the data analysed, and the lower limit as the average value minus the standard deviation. The number of cartons at each generation of the simulation was therefore randomised from 978 to 3228 (the randomisation was based on a normal distribution), where orders came in three waves per day (at varying hours). The model was tested for a standard week of activity with two work shifts with a defined number of workers assigned to the model (from 4 to 6 with constraints of break time averaging 25 minutes per day per worker and with a forklift worker manipulating pallets on completion at a process commitment level of 75%) - worker rotation between B2B and B2C activity and a weighting control is allowed. A weight check is generated for 5% of random cartons and for cartons whose weight does not agree with the weight set according to the system (weight errors occur for 1.2% of B2C carton cases and for 0.6% of B2B cases). The times of the individual activities in the model were determined according to the following formula:

$$t_{min} = \frac{\sum t}{n} - \sigma$$

$$t_{max} = \frac{\sum t}{n} + \sigma$$

where:

t_{min} - minimum activity time,

t_{max} - maximum activity time,

$\sum t$ - sum of times for a 6-month activity history for a given activity,

n - number of measurements taken for a given activity in a 6-month activity,

σ - the standard deviation calculated in the dataset for a given activity,

The time taken into account in the simulation when a particular activity occurred was each time randomised from a range of $[t_{min}; t_{max}]$ based on a normal distribution. The main limitations of the model are the static data acquisition (historical data, once imported into the simulation model), the lack of differentiation into handling different types of cartons (a limitation due to incomplete data acquired automatically by the IT systems in the warehouse and on the line) and the small research sample of only one case study. Based on the model created, the flow of cartons per working week was simulated (Table 2). Based on the simulation assumptions, the simulator took about 10,000 cartons as orders that were to be fulfilled within the packing line activity (about 75% of the orders were related to the ecommerce channel).

Table 2.
Results of basic simulation - one work week

Simulation parameter	Result
Total boxes to processing	10 276 boxes
Quantity of boxes in B2B	2,543 boxes
Quantity of boxes in B2C	7,733 boxes
Quantity of boxes in weight control	80 boxes
Quantity of boxes in weight control in B2B	1 box
Quantity of boxes in weight control in B2C	79 boxes
Quantity of processed boxes in B2B	1 271 boxes (49.98%)
Quantity of process boxes in B2C	7 733 boxes (100.00%)
Quantity of created pallets in B2B	29 pallets
Quantity of created pallets in B2C	68 pallets

As can be seen from the table presented, the packing line was able to process all B2C orders, but was not able to process all B2B orders. At first glance, this may seem paradoxical, as there are far fewer B2B orders, but upon deeper analysis of the issue, the problem is created by the bottleneck of having to process many e-commerce orders. This is due to the structure of the packing line, where the B2B order handling zone occurs first and the B2C zone is located behind it (every B2C carton has to pass through the B2B zone). This suspicion was confirmed by interviewing the employees performing the work on the analysed packing line and by an additional analysis of the resources used in the simulation carried out (figure 3).

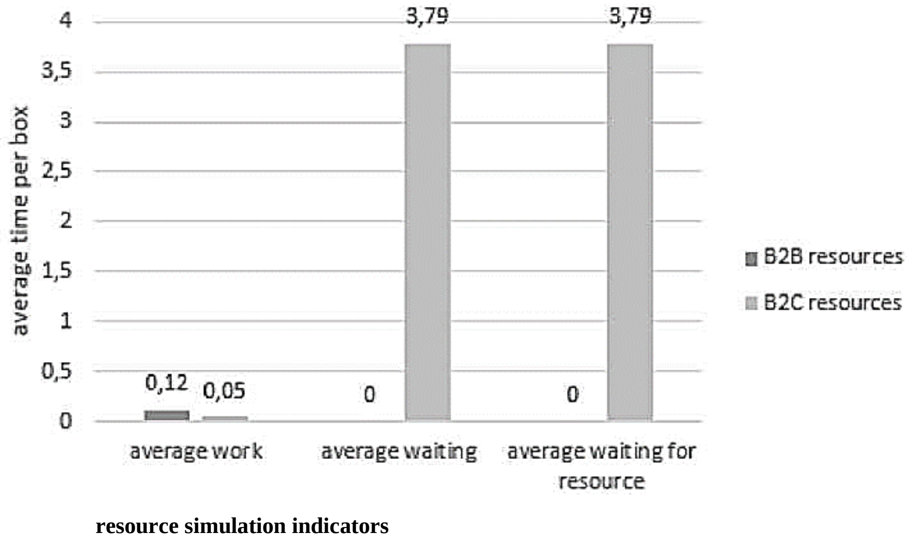

Figure 3. Resource parameters results - basic simulation.

As can be seen from the graph shown, resources (employees) spend an average of 0.12 minutes on activities directly related to B2B cartons and 0.05 minutes on activities related to B2C cartons (these times only take into account when resources are involved in activities directly on cartons that have not yet been classified as ready-to-ship cartons). Employees in the B2C area spend less time in their activities per carton due to the relatively high degree of automation of the activities involved in packing these cartons (for example: automated liding or wrapping machines). However, these uncertainties are most emphasised by the high waiting time for a free resource in the case of B2C cartons. This means that, in the simulation model, there are frequent and long resource requests in the B2C area - in other words, cartons block the packing line waiting for the capacity to be released, i.e. for the moment when a worker is able to retrieve them. The average waiting time of one carton for a free worker is more than three minutes. These volumes depend on the timing of the line's operation in the schedule and increase as the input values increase in the form of further B2C orders.

Analysing the line under consideration on the basis of a simulation model, the author outlined three scenarios that could serve to improve the efficiency and capacity of such a line. The scenarios mentioned are:

- Scenario 1. Separation of physical B2B lines from B2C lines.
  This involves separating the B2B and B2C flows in the packaging line, which will break the interlocking relationship of the B2B flow at a time of increased demand for B2C. In this scenario, the assignment of employees within the areas concerned is also considered, with no change to their base number.
- Scenario 2. Re-ordering of areas on the line.
  This scenario involves relocating the B2C area with the B2B location, so that the cartons relating to e-commerce orders are processed first and the area for handling orders to the POS is second (relocation of the bottleneck in the process sequence). The use and handling of resources remains unchanged.
- Scenario 3. Replicate the B2C area in the sequence currently occurring.
  The scenario consists of adding a twin B2C area after the current B2B area with an increase in the number of employees involved in the process (doubling the number of employees for B2C).

The results of the simulation carried out are shown in Table 3.

Table 3.
Results of different simulation scenarios - one work week

Simulation parameter	Basic	Scenario 1	Scenario 2	Scenario 3
Total boxes to processing	10276	9004	9084	10263
Quantity of boxes in B2B	2543	2543	2544	2530
Quantity of boxes in B2C	7733	6461	6540	7733
Quantity of boxes in weight control	80	80	80	80
Quantity of boxes in weight control in B2B	1	1	1	1
Quantity of boxes in weight control in B2C	79	79	79	79
Quantity of processed boxes in B2B	1271	2543	2544	2530
Quantity of process boxes in B2C	7733	6461	6540	7733
Quantity of created pallets in B2B	29	59	59	58
Quantity of created pallets in B2C	68	56	58	67

In the individual simulations, varying input volumes mapping order quantities in B2B and B2C channels were taken into account - this was generated according to the initial model assumptions, which did not change for the individual scenarios. The changes in the models only concerned the changes specified in the description of the individual scenarios. Based on the simulation, it can be concluded that for all, modified, simulation scenarios, full realisation was achieved in terms of packed and prepared cartons in both channels (B2B and B2C) - this is also shown in figure 4.

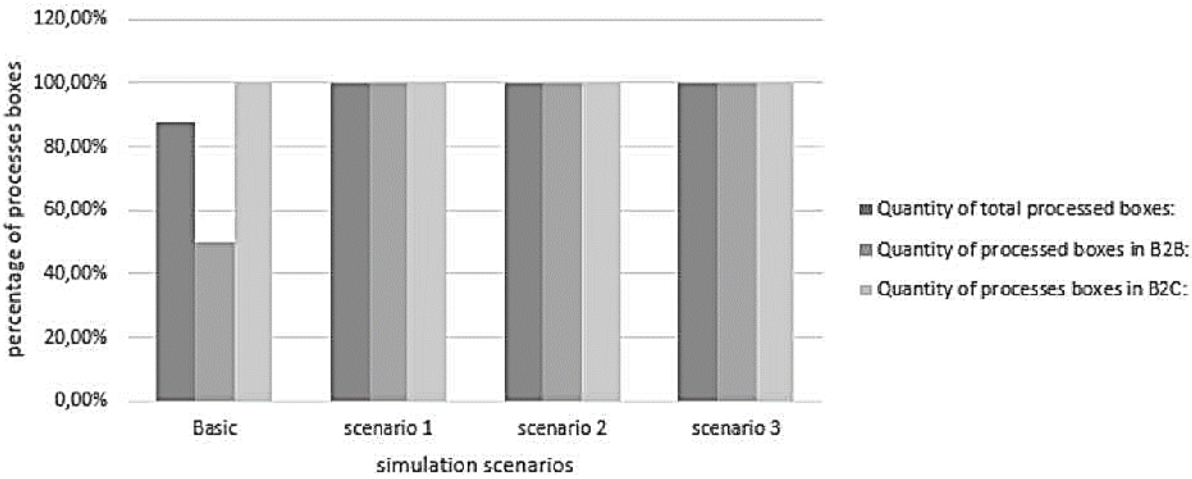

Figure 4. Simulation results in different scenarios.

As can be seen from the figure, the modified simulation models succeeded in eliminating the process bottleneck associated with too many B2C orders blocking order processing in the B2B area. The scenarios presented can be seen as a starting point for implementing improvements to the process performed on the packaging line. The benefits of this can be to increase the line's efficiency and provide a better quality of service to the end customer within the POS and online retail channels, which in turn translates into the performance of the entire distribution network. A prerequisite for validating the proposed operating scenarios, however, is additional consideration of the cost intensity of the various solutions - both in terms of the implementation of the solution itself and its subsequent use. The simulation models shown can also be used as a basis for reflecting the logistics process data within the framework of digital reflection in the Digital Twin concept. The data provided from the WMS and the data provided in real time from the sensors on the packaging line in combination with the simulation model shown can give the possibility to build the Digital Twin in the future, which confirms the second hypothesis.

5. Discussion

Packing line simulation model

Some authors propose a complete redesign of the business processes of logistics operators in order to adapt them to e-commerce activities (e.g. based on BPR - Business Process Reengineering) (Yan et al., 2006) - in the author's opinion this is too radical an approach, because in most cases the adaptation of 3PLs to e-commerce is possible through an evolutionary change of processes and through the introduction of computer simulation methods into process analysis. Process analysis is currently being performed in 3PL companies and it is geared towards increasing the value of the processes implemented in outsourcing services. As shown during the analysis, the logistics operator is capable of creating a simulation model and optimising the process using simulation scenario analysis. However, as already noted by some authors, the use of only historical data for any kind of process analysis is already starting to be considered a relic (Abideen et al., 2021). An extremely important issue is the need to obtain selected real-time data to support the operation of the simulation model. Such an assumption can be encountered in works that consider so-called simulation-based Digital Twins (Gyuali, Bergman, 2020), which allow the use of extended and reality-adapted simulation models.

Supporting the simulation model with predictive data

Demand planning system is an enabling tool in the field of e-commerce. Strategies based on VMI (Vendor Management Invetory) are most often cited as the most effective (Babu et al., 2020), but analyses can also be made under more distorted conditions (e.g. in B2C or B2B where VMI is not possible), e.g. based on product demand forecasts. According to existing knowledge, a logistics operator is able to forecast demand in the network (Kramarz, Kmiecik, 2022) and perform logistics coordination actions (Kmiecik, 2022). The forecasting tool could also be an interesting complement to simulation models, which could be supported by predictive data. This could improve operational work by, for example, being able to simulate the behaviour of a process with specific predicted quantities (figure 5).

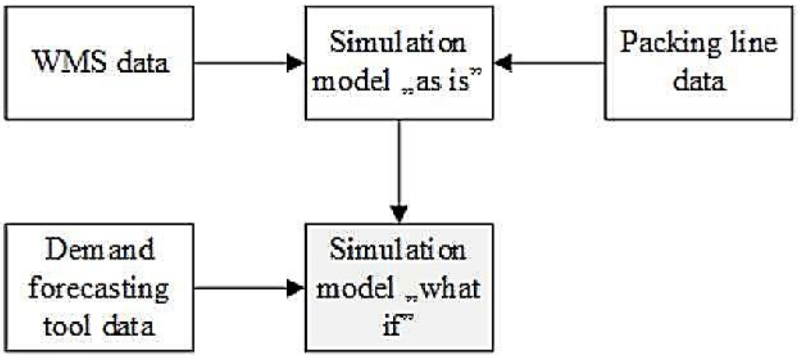

Figure 5. The general concept of supporting the simulation model by a demand forecasting tool

The What-if scenarios can be used to optimise the management of work on the packing line (e.g. scheduling resources to serve the line in advance or preventing negative effects of release picks). The Digital Twin (Abideen et al., 2021) can also be used to build The What-if scenarios, where the use of predictive data is also proposed to build such models.

Simulation model as a basis for building the Digital Twin.

The literature highlights the fact that centralised or semi-centralised decision models are best for handling e-commerce in the form of developed omni-channels (Zhong et al., 2020). Such a management model, according to the author, can be supported by the Digital Twin supported by a simulation model (figure 6).

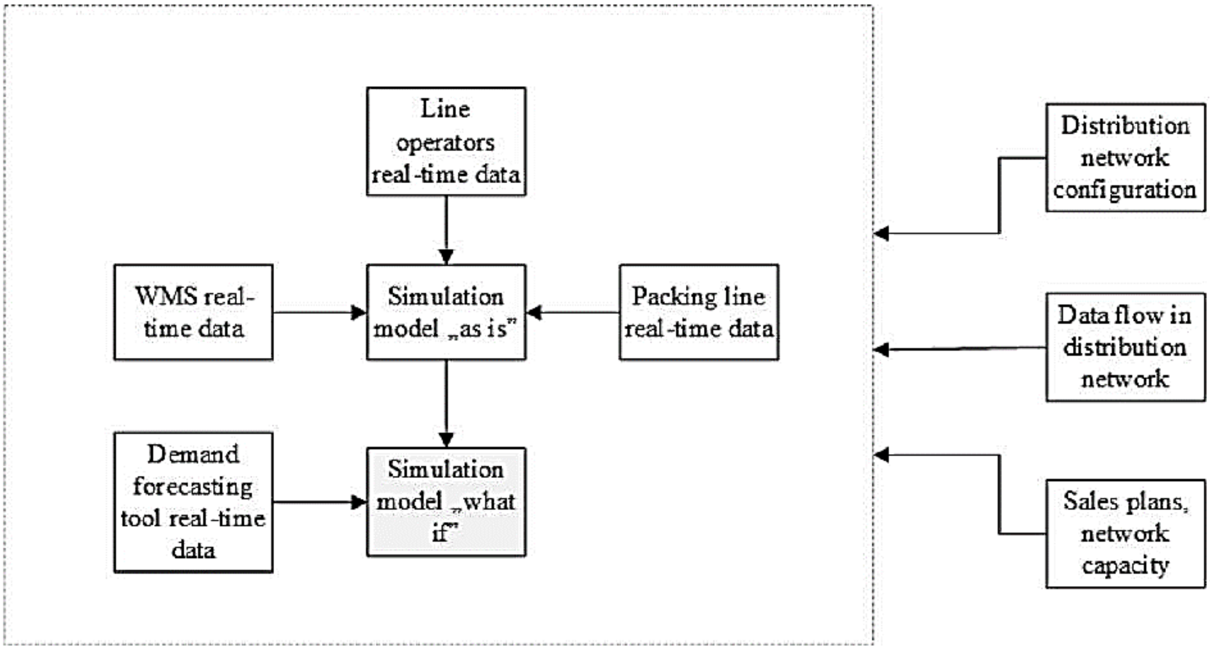

Figure 6. The general concept of supporting the distribution network by the Digital Twin simulation model.

Such a centralised system would also require the exchange of information in the distribution network, its appropriate configuration and additional elements that collect data in the process and transmit them to the simulation model to the different stages of the process. An interesting solution to support the collection of data from logistics operations is one related to equipping not only the infrastructure used in logistics processes with sensors, but also the process participants themselves (Kong et al., 2020). The aforementioned concepts are ideas that require further research to verify their validity, therefore, according to the author, future research in the topics presented in the paper should focus on:

- Exploring the possibility of creating the Digital Twin within the distribution network, which would be overseen by a 3PL company.
- Exploring the possibilities associated with the use of modern methods and techniques of information exchange for the collection and delivery of real-time data to the simulation model.
- Exploring the distribution network's willingness for a 3PL to take over as master coordinator of logistics processes, whose activities would be based on digitalisation and the Digital Twin.

In summary, the paper met the stated objective and the research hypotheses set were verified correctly.

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