THE DYNAMIC SIMULATION AS A TOOL FOR INNOVATIVE MANAGEMENT OF LOGISTIC PROCESSES IN LOGISTIC CENTRE: CASE STUDY

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Abstract

The current modern turbulent market environment is forcing companies to continuously increase their competitiveness, improve processes, reduce costs and optimize material, goods, information and financial flows. Companies must focus on identifying potential bottlenecks in the flow of material, goods and means of transport, movement of persons or the information flow in the field of logistic processes. The dynamic simulation of logistic processes is an innovative management tool and predictive method. The indisputable advantage of the dynamic simulation of logistic processes is the possibility to minimize the risks of any proposed changes. The dynamic simulation allows companies to simulate, test and optimize the consequences of various managerial decisions. This article focuses on the dynamic simulation of the logistic process – cross-docking in the real logistic centre. The cross-docking is the logistic process of unloading materials or goods from an incoming means of transport and loading these materials or goods directly into outbound means of transport, with little or no warehousing in between. The aim of this article is to simulate, test and optimize the logistic process of cross-docking in the logistic centre including the impact of various management decisions. The methods of dynamic simulation and case study are used.

Key words: logistic process, logistic centre, cross-docking, dynamic simulation

JEL Code: M19, M21, L87

Introduction

Most manufacturing companies with the increasing fierce global competition have become the most important challenge to improve production efficiency, reduce operating costs and reduce response time. The trend of synchronization of production and logistics has recently become very popular in order to increase the competitiveness of both parties (Luo, Yang & Wang, 2019). There has been a huge increase in trade volume worldwide in the last few decades. The role of freight terminals and distribution facilities is essential to electronically serve business volumes and distribute products in supply chains (Theophilus et al., 2019). Rapid changes in today's competitive markets point out that customer satisfaction have become critical to companies in logistics and cross-docking systems nowadays (Fathollahi-Fard et al., 2019).

The aim of this article is to simulate, test and optimize the logistic process of cross-docking in the logistic centre including the impact of various management decisions.

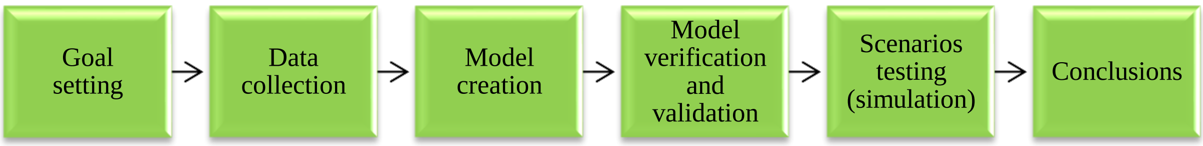
1 Theoretical Background of the Cross-docking

The cross-docking is a type of warehouse in the supply chain management that enables order preparation without going through the warehousing phase of products in the warehouse and then selecting them for delivery (Gelareh et al., 2020). Cross-docking is a logistics technology used in the retail and transportation industries to quickly solidify shipments from various sources and achieve economies of scale in outbound shipping. Cross-docking essentially eliminates the costly inventory-keeping functions of the knowledge centre, while allowing it to perform its consolidation and shipping functions. The key difference between a traditional warehouse and a cross-docking warehouse is that, unlike warehouses where products remain (sometimes for a long time) until cross-docking, customers are not allowed to remain cross-docking a platform 24 hours ago (Guignard et al., 2012). Sometimes it is required to be converted in less than an hour (Bartholdi & Gue, 2004). The advantage of cross-docking over traditional warehouses is the shorter warehousing time. Although the exact boundary is difficult, some other papers (Li, Lim & Rodrigues, 2004; Fard & Vahdani, 2019) define 24 hours as the maximum acceptable warehousing time in these centres. Cross-docking is considered a logistics strategy and has attracted much attention from many large companies. These companies seek to reduce their costs by reducing inventory and wasting time using this strategy. The basic idea of cross-docking is to transfer goods from incoming vehicles to outgoing vehicles without using the warehousing step. In traditional warehouses, goods are received, sorted and finally warehoused. Cross-docking intends to remove warehousing and order selection steps. This is because it is one of the most expensive stages of distribution (Ardakani, Fei & Beldar, 2020). Cross-docking is a logistics strategy that reduces total supply chain costs by leveraging economies of scale in transport through consolidation of demand and also by reducing inventory held at distribution centres (Shakeri et al., 2012; Shahmardan & Sajadieh, 2020). It is estimated that the implementation of cross-docking centres instead of traditional warehouses can reduce operating costs by up to 70% (Vahdani & Zandieh, 2010). Cross-dock operations get mixed results from the design of individual warehouses and a specific business operations processes (Wang & Alidaee, 2019).

2 Methodology

The logistic process of cross-docking was analysed, simulated, tested and optimized in a real logistic centre in the form of a case study. The case study is the method of the qualitative research based on the study of one or a small amount of situations for application of the findings for the similar cases according to Nielsen, Mitchell & Nørreklit (2015). The processing methodology is presented in the Fig. 1.

Fig. 1: The processing methodology



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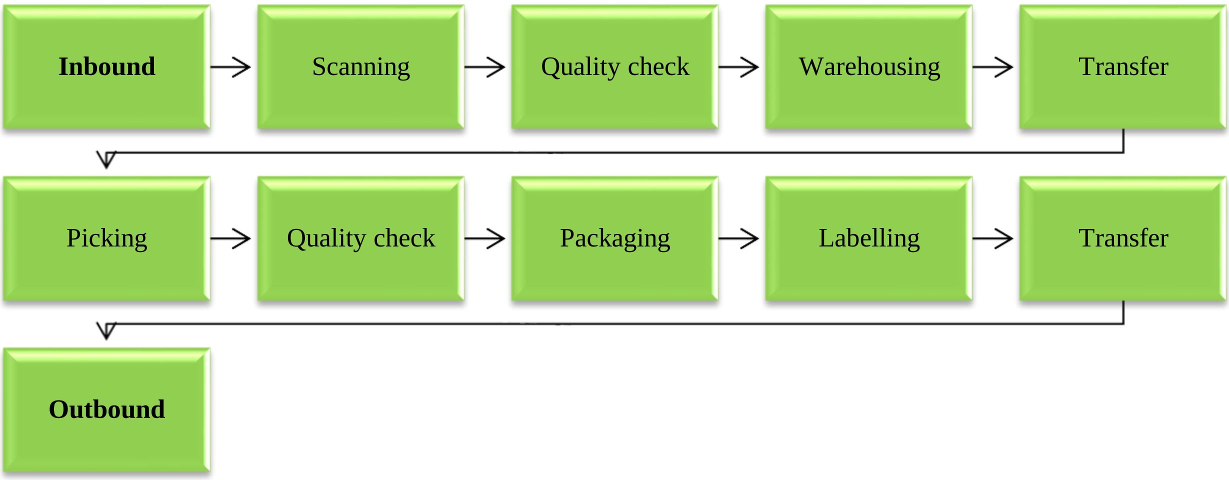
First, a goal was set: to simulate, test and optimize the logistic process of cross-docking in the logistic centre including the impact of various management decisions in the relation to the number of picking lines. Subsequently, data was collected on this logistic process, the model was created in the Witness Horizon (version 22.5b) specialized software for dynamic simulation. The model was verified and validated, eight scenarios were tested (in connection with the number of picking lines), bottlenecks were identified and conclusions have been defined. A total of eight scenarios (S1 – S8) were tested, where the scenarios differed only in the number of picking lines under otherwise identical conditions and parameters. Scenario (S1) contained one picking line, scenario (S2) contained two picking lines … and scenario (Sn) contained n picking lines. For the simulation results to be correctly generalized, there have to be multiple tests, and multiple possible scenarios have to be examined (Tischer, Nachtigall & Siroky, 2020).

The analysed cross-docking process involved value added logistic services such as quality check, completion, repackaging and labelling. The process consisted of the following steps presented in the Fig. 2: inbound, scanning, quality check, intermediate warehousing, transfer within the logistic centre, picking, final quality check, packaging, labelling, transfer to the outbound area and outbound.

Fig. 2: The analysed cross-docking process steps



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A total of 412 pallets (26 400 cartons) with five types of goods (part A – part E) were delivered to the logistic centre at the time corresponding to the first arrival (see Tab. 1). These pallets with goods had to be repackaged to create a total of 300 same pallets and each of these pallets would contain 24 cartons of goods A (part A), 22 cartons of goods B (part B), 16 cartons of goods C (part C), 11 cartons of goods D (part D) and 15 cartons of goods E (part E).

Tab. 1: Data on inbound and outbound of goods

Inbound					Outbound		
Goods	First arrival	Pallets	Cartons /pallet	Total cartons	Total pallets	Cartons /pallet	Total cartons
Part A	0:05	100	72	7 200		24	7 200
Part B	0:12	132	50	6 600		22	6 600
Part C	0:08	75	64	4 800	300	16	4 800
Part D	0:20	55	60	3 300		11	3 300
Part E	0:15	50	90	4 500		15	4 500

Source: authors

The durations of the individual sub-processes for creating the model were defined on the basis of the analysis of data on sub-processes in the logistic centre. The duration is assumed according to the triangular probability distribution with parameters a (minimum duration), b (mode of the duration) and c (maximum duration) for processes: inbound, scanning, quality check, warehousing, picking and packaging. The duration of two minutes was assumed for the other sub-processes (transfer to the intermediate warehousing area, quality check, labelling and transfer to the outbound area), see Tab. 2 (durations are given in minutes).

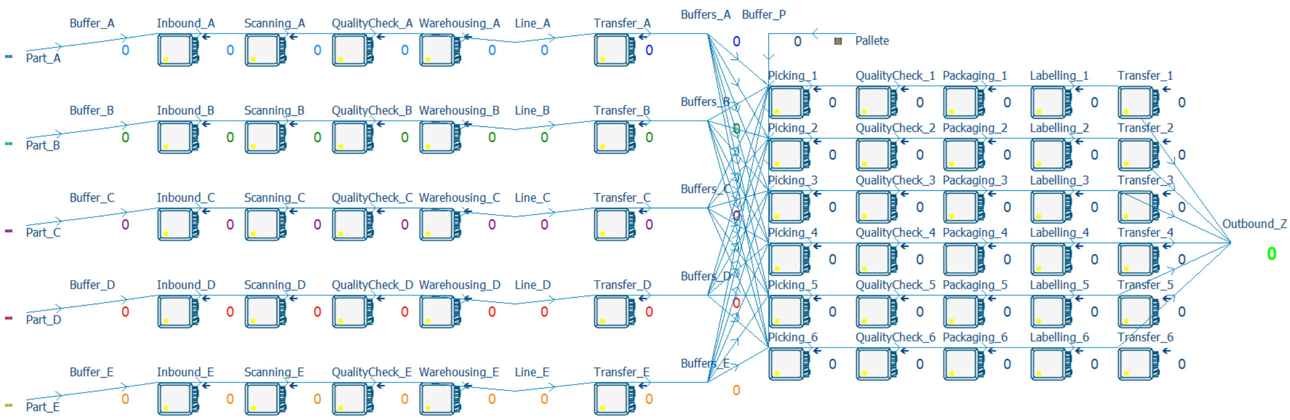
Tab. 2: Data about analysed cross-docking process, sub-processes and scenarios [min]

Sub processes	Part A			Part B			Part C			Part D			Part E		
Triangular d.	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Inbound	1	3	5	1	2	3	1	3	5	1	2	3	1	3	5
Scanning	2	5	8	2	4	6	2	5	8	2	4	6	2	5	8
Quality check	4	7	10	3	6	9	4	7	10	3	6	9	4	7	10
Warehousing	1	3	5	1	2	3	1	3	5	1	2	3	1	3	5
Transfer	2			2			2			2			2		
Scenario	S1			S2			S3			…			Sn		
Picking lines	1 pick. line			2 pick. lines			3 pick. lines			…			n pick. lines		
Picking	12	15	18	12	15	18	12	15	18	…			12	15	18
Quality check	2			2			2			…			2		
Packaging	1	3	5	1	3	5	1	3	5	…			1	3	5
Labelling	2			2			2			…			2		
Transfer	2			2			2			…			2		

Source: authors

Furthermore, a model was created using software Witness Horizon (version 22.5b), which was validated and verified. Individual scenarios (S1 – S8) were tested in the model. The variable of the total duration of the crossdocking process was monitored. Furthermore, the utilization of individual sub-processes was monitored and bottlenecks of the whole process were identified. An example of a model for scenario S6 is presented in the Fig. 3.

Fig. 3: The example of a model containing six picking lines (scenario S6)



Source: authors using software Witness Horizon (version 22.5b)

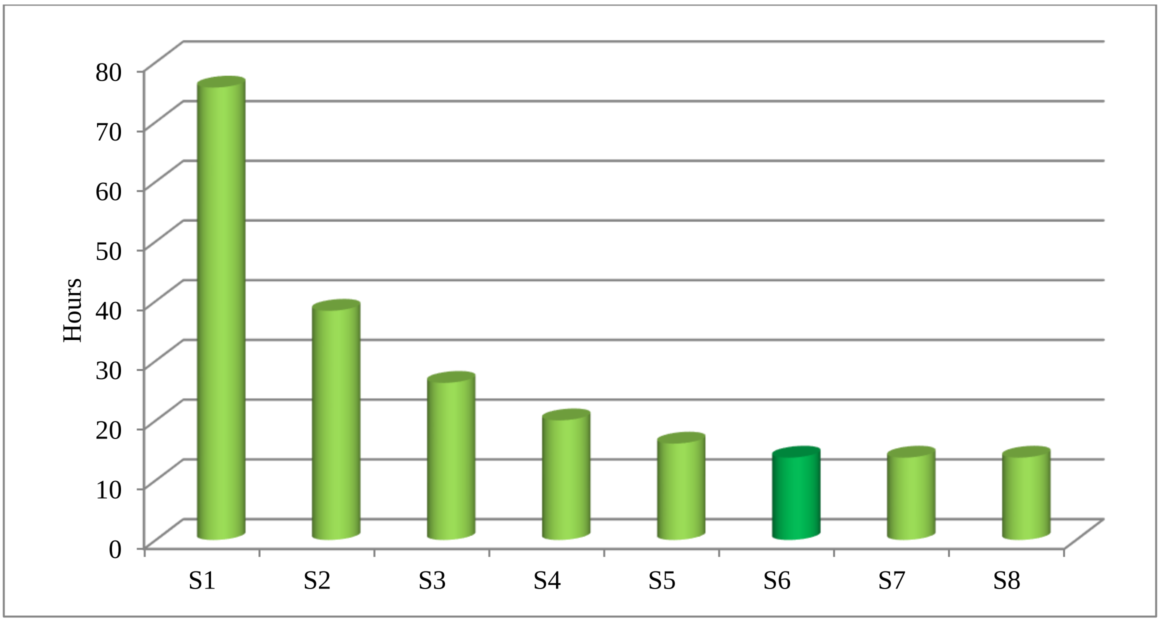
3 Results and Discussion

The time simulation of the first test scenario (S1) containing one picking line was 75.75 hours. The following bottleneck was identified due to the high utilization of the picking process (98.81% of the total time busy and 1.19% idle, but the idle time was recorded only for the first minutes of the simulation) in this scenario. Another picking line was added with each new scenario (S2 – S8), the total duration of the crossdocking process was monitored and bottlenecks were searched.

The results of other simulation scenarios were as follows: the total duration of the crossdocking process of the scenario (S2) was 38.35 hours and picking lines were used on average from 97.58% and again formed the bottleneck of the whole process. Similar results were recorded for scenarios (S3 – S5): the simulation time was 26.29 hours (S3), 20.01 hours (S4) and 16.12 hours (S5); the average utilization of the picking lines was 96.02% (S3), 94.62% (S4) and 93.99% (S5).

The scenarios (S6 – S8) achieved almost identical results from the perspective of the total simulation time. The total duration of the crossdocking process was approximately 13.77 hours (S6 – S8) and the average utilization of the picking lines were as follows: 91.34% (S6), 78.13% (S7) and 68.34% (S8). The overview of the total duration of the crossdocking process according to the scenarios in hours is presented in Fig. 4.

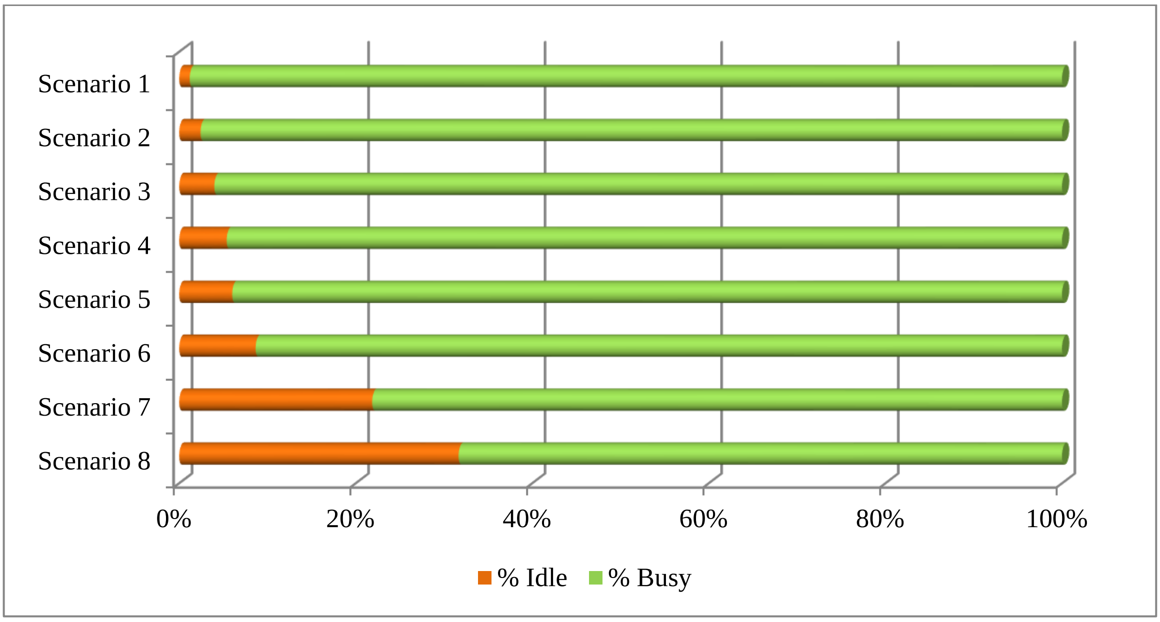
Fig. 4: The total duration of the crossdocking process according to the scenarios [hours]



Source: authors using software Witness Horizon (version 22.5b)

The comparison of the average utilization of the picking lines is presented in Fig. 5. The analysis showed that with the addition of each picking line, the average utilization of picking lines decreases, but the decrease in the average utilization of the picking lines between scenarios (S1 to S6) is 7.47% (from 98.81% to 91.34%). In the case that seventh picking line has been added, there was a significant decrease in the average utilization of the picking lines by 13.21% (comparison of the scenarios (S7 and S6)). In the case that eighth picking line has been added, there was again a significant decrease in the average utilization of the picking lines by 9.79% (comparison of the scenarios (S8 and S7)).

Fig. 5: The comparison of the average utilization of the picking lines [%]

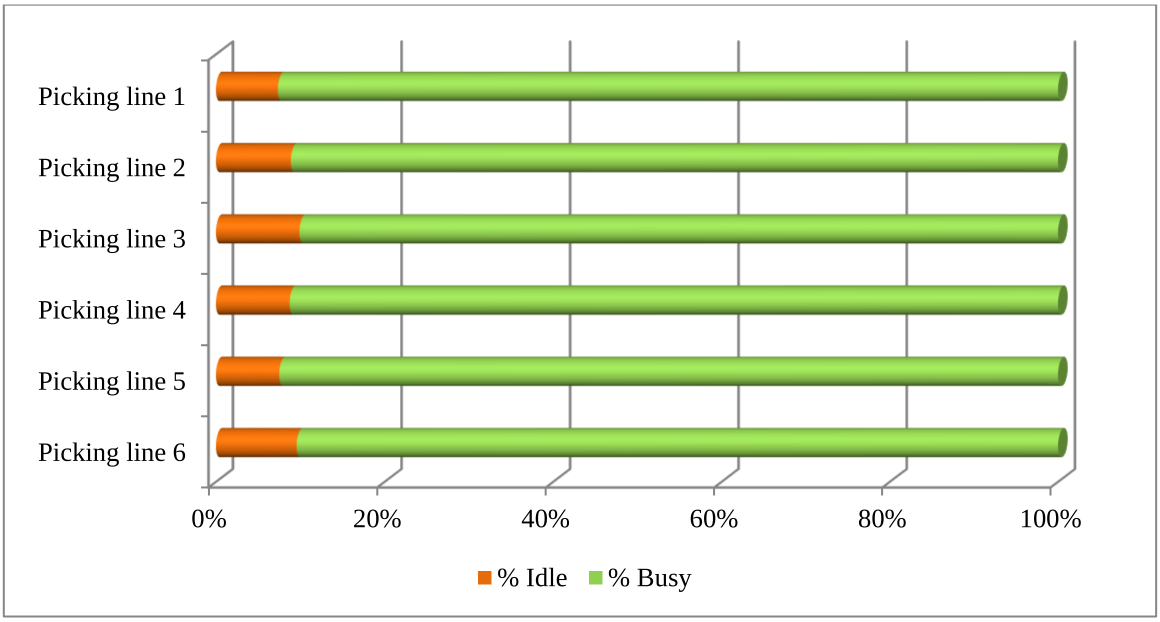


Source: authors using software Witness Horizon (version 22.5b)

With regard to the analysed variables (the total duration of the crossdocking process and the average utilization of the picking lines) it seems best to use six picking lines, because adding more picking lines does not shorten the total duration of the crossdocking process (see Fig. 4) nevertheless it significantly reduces the average picking lines utilization (see Fig. 5) and increases logistic costs.

The utilization of the individual picking lines in the scenario (S6) is presented in Fig. 6. The analysis of picking lines utilization shows that all picking lines achieve an average utilization of more than 90% (91.34% on average). Due to the fact that part of the time the picking lines cannot work objectively due to the fact that they do not have the necessary goods available, the results are satisfactory.

Fig. 6: The utilization of the individual picking lines in the scenario (S6) [%]



Source: authors using software Witness Horizon (version 22.5b)

It would be necessary to focus on the inbound sub-processes (scanning, quality check and intermediate warehousing), which are bottlenecks after the implementation of six picking lines (S6), in a situation where it would be even more necessary to speed up the crossdocking process.

Conclusion

The dynamic simulation is a very suitable tool for innovative management of logistic processes, because simulation allows companies to test impacts of the various managerial decisions in a very short time.

The aim of this article was to simulate, test and optimize the logistic process of cross-docking in the logistic centre including the impact of various management decisions in the relation to the number of picking lines whereas two variables were monitored: the total duration of the crossdocking process and the average utilization of the picking lines. A total of eight scenarios were tested within the created model and bottlenecks of the analysed process and sub-processes were identified. The best solution was identified for the given input parameters, which was the implementation of six picking lines, comparing the results of the variables for individual scenarios.

It can be expected to increase the use of innovative dynamic simulation tools to support decision-making in the field of logistic processes in the future.

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