EKONOMETRIA ECONOMETRICS 3(45) • 2014

ISSN 1507-3866

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THE INFLUENCE OF ORDER PICKING ZONE'S CONFIGURATION ON THE TIME OF THE ORDER PICKING PROCESS

Summary: The pressure connected with cost cutting parallel to an increase in consumer service quality as well as speeding up the flow of goods are the result of a worldwide economy trend connected with big competition in the market. That is why in modern economy even small movements of goods at short distances are becoming more and more important. The order picking problems in a warehouse are an important aspect in improving the productivity of modern logistic hubs. According to various estimates, the costs associated with order picking in a warehouse are from 55 to 65% of the total material handling costs. The author, using simulation tools, examines the influence of order picking zone's configuration on the time of the order picking process. By means of the implemented simulation methods, it is possible to match the appropriate order picking process to the needs of a given enterprise.

Keywords: logistics, order-picking, simulation tools, warehouse management.

DOI: 10.15611/ekt.2014.3.10

1. Introduction

In standard solutions, concerning products flow through supply chains, the main attention is given to transfer processes and stocks at the points of stop on the way; that is warehouses, logistic centers, terminals or distribution centers. Solutions connected to transfer processes concern, most of all, transportation issues, in which basic factors are the time and the quantity of transferred loads. Whereas, as far as points of stop are concerned, attention is given to the amount of stocks accumulated there. There is little or none interest in consolidation operations and proper load storage and distribution in abovementioned points. Meanwhile, a thorough observation of activities which create flows in supply chains, especially in supplies within a big distance, indicates that an inappropriate control of flows, inaccuracy in creating overall loads, lack of coordination while creating shipment sets can have a negative impact on the speed of transport operations and significantly lower the effectiveness of supply chains operations.

Various research studies which have been carried out in different research institutes show that more attention should be given to operations, in logistic hubs, connected with goods flow. In a modern logistic system, every materials' manipulation is verified at the stage of planning. Even small transfers of goods start to play an important role. These transfers take place in the premises of a building (warehouse, production facility), and between the object and transport agent. The aim of the paper is to describe how different factors can influence the main important process in a logistics hub – the order picking process.

2. Order picking as a research subject

The order picking process is not defined in a unified and consistent way. Ghiani [2004] states that order picking is a system of operational and organizational logistic activities. It is based on a juxtaposition of given subsets (articles) from a complete set (assortment), on the basis of demand information in the form of an order. At the same time, the state of material storage changes into the state of material shipment. According to Petersen, Aase, Heiser [2004] order picking is searching for and picking up, in storage areas of a logistic hub, given products which are on the order list placed by clients, and in agreement with their requirements. In the author's opinion order picking is a notion which treats products flow through logistic hubs in a complex manner. It includes operational activities (picking) and informational, such as: documents and information flow, giving instructions. It also contains a legal liability for performed actions.

Order picking is the most labour-intensive process, which, according to different research studies, constitutes 55% [Frazelle, Apple 1994] to 65% [Coyle, Bardi, Langley 2002] of all the operational costs incurred in logistic hubs. Due to the results of those research studies, the issue of order picking system improvement became significant in scientific papers and theories, as well as practical projects, which aim at improving the effectiveness of the process and cutting costs at the same time.

There are many different order picking systems in logistic hubs. A human element is the main factor with respect to which a given system can be classified (see Figure 1).

Order picking systems employing humans, that is those where a human being is the most important element, with its most popular example: "picker to a part", because of their universality, are the most important topics described in this paper. They owe their popularity to some economical reasons, i.e. lower costs of implementation and the fact that, unlike automatized strategies AS/RS type, they work well when there is a need to pick products with different shapes and sizes.

On the basis of the research carried out in the warehouses of logistic operators in Germany, results were obtained, showing the percentage share of given times in the total time of order picking (see Table 1).

As shown in Table 1, the dominating element of the order picking process is route time which constitutes 50% of order picking total time. It is no wonder that

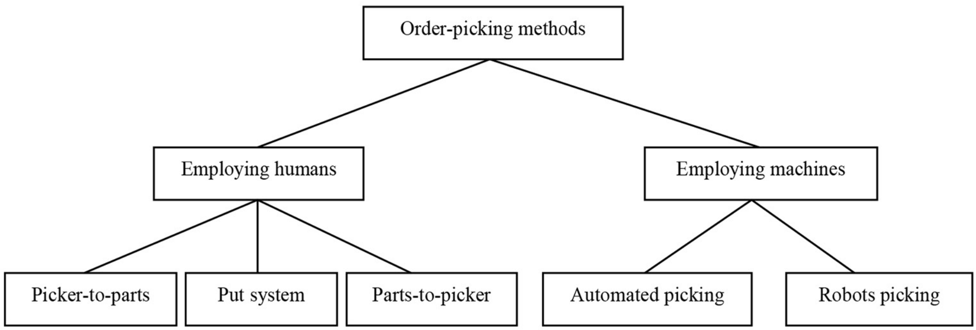

Figure 1. The classification of order picking systems

Source: De Koster [2008, p. 54].

scientists and logistic practitioners focus their attention on issues connected with the minimization of time needed for covering a given route between the points of order taking, products picking and release [Kłodawski, Jacyna 2009]. Among many algorithms which try to solve the problem of the minimization of the order picking route, the most popular are heuristics algorithms, such as S-shape, Return, Largest-gap, Midpoint, Combined (a detailed description can be found in the paper by De Koster, Le-Duc, Roodberger [2007]) and algorithms with accurate solutions [see Ratliff, Rosenthal 1983], which have a lot of limitations when put in practice.

Table 1. Percentage share of operations time in the whole order picking time

Basic order picking time groups	Percentage share in order picking
Base time	5–10%
Route time	About 50%
Stoppage time	10–25%
Picking time	25–35%
Additional activities time	Depending on the company's conditions

Source: own elaboration on the basis of Martin [2002].

Additional issues which are studied in terms of order picking are storage policies. This term denotes a strategy, proper for a given enterprise, of assigning products to storage places in warehouse space. There are two basic questions here: technical and management. The first looks for an answer what techniques and tools should be used in order to provide best possible conditions for storing a product, at the same time, using the allotted warehouse space to the utmost. The second question focuses on the application of a correct organizational strategy which will allow storing a given product in a way that enables a warehouseman to find it quickly and cheaply with the improvement of order completion quality. Among management strategies used while choosing a products storage method, there are two approaches which deserve special attention. First – randomly storage policy can minimize the time needed for storing a given good; however, many a time it results in prolonging the time of the order picking process. In this approach t products are stored in a warehouse area where there is a place and space for it at a given time. The worker, taking products to a warehouse, puts them in a location chosen at random following the rule of *closest open location*) [De Koster, Le-Duc, Roodberger 2007]. The second strategy, which is called *assign storage policy*, assigns products to some specific locations which can be distinguished taking into consideration many factors, but the most crucial is the one which introduces a simple rule: products with the fastest rotation times should be located as close as possible to the points of release so as to minimize work needed for their picking [see Kłodawski, Jacyna 2009; Frazelle, Apple 1994]. In this case, the most popular is ABC classification and laying out the products according to the rule of volume-based storage (see [De Koster, Le-Duc, Roodberger 2007]).

The third point which is analyzed in many scientific papers is a way in which work is organized while order picking (it is thoroughly described in works by Gibson, Sharp [1992] and Gademann, Van den Berg, Van der Hoff [2001], among others).

There is relatively little research concerning factors which should be taken into account at the stage of order picking system planning. The choice of an appropriate layout of an order picking zone is one of such factors. It is worth mentioning that a detailed analysis of all the activities done by a worker while setting and forming orders, taking into consideration some factors which appear at the stage of order picking system planning, allows us to fully evaluate the efficiency of order picking.

3. Research description

Four real order picking zones which may be possibly used by a logistic operator were analyzed. Some assumptions were made on the basis of literature analysis and the author's practical observations and experiences. The variables examined in the paper are different ways of movement in a warehouse, products storage policies, the size of the order picking zone and the number of products in an order. The parameters of a forklift truck, used for order picking, the total number of pallets stored in a given zone as well as alpha and beta parameters taken into account in products division in ABC classification are fixed.

In order to set a route in an order picking zone, basic and most commonly used in practice heuristics methods and Ratliff Rosenthal's optimal algorithm were assumed. The allocation of products was presented according to the random storage rules and methods which employ ABC classification in products division according to picking frequency *volume-based storage* (*within-aisle storage*, *across-aisle storage*, *perimeter storage* and *diagonal storage*). The idea of storage police is described by De Koster, Le-Duc, Roodberger [2007, pp. 481–501].

The number of products in an order fluctuates and equals a multiple of five. The smallest orders have 5 items and the biggest – 30 (this assumption makes the calculations easier, at the same time considering a big range of order picking items).

In the research four configurations of an order picking zone are considered. All of them are built according to a similar outline which is very typical of many logistic hubs (see Figure 2). The choice of such configurations results from the fact that it is possible for them, using Rattliff and Rosenthal's algorithm, to set an optimal route.

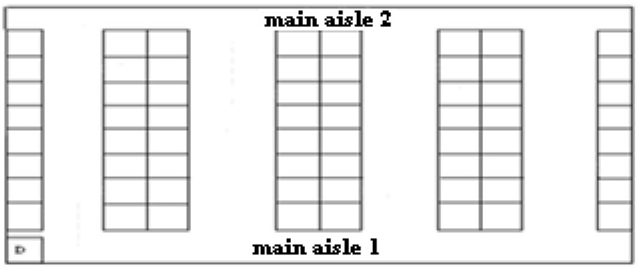

Figure 2. Order picking zone layout analyzed in the research

Source: own elaboration.

The configuration of order picking zones 1 and 3 consists of storage products places called rows in which loads are stored on pallets without the use of pallet racks. The second and fourth layout uses row-pallet racks which consists of modules popularly called nests (see Figure 3). Every pallet place is treated as a single location in the order picking zone.

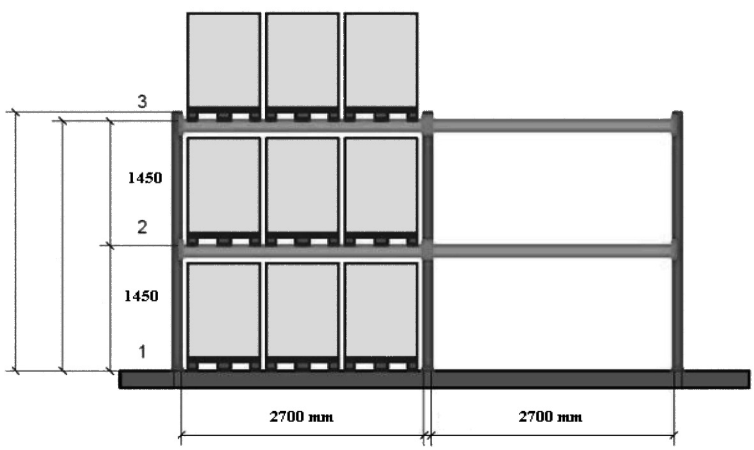

Figure 3. The outline of a euro-pallet rack.

Source: own elaboration.

Table 2. Input data of zone 1 configuration

Configuration 1	
Number of pallets	1200
Number of pallet rows	12
Number of pallets in a row	100
Number of side passages	6
Number of main passages	2

Source: own elaboration.

Table 3. Input data of zone 2 configuration

Configuration 2	
Number of europallets	1200
Number of rack rows	12
Number of storage levels in a rack	2 (level 0, level 1)
Number of pallets at every rack's level	50
Number of side passages	6
Number of main passages	2

Source: own elaboration.

Table 4. Input data of zone 3 configuration

Configuration 3	
Number of europallets	1200
Number of pallet rows	24
Number of pallets in a row	50
Number of side passages	12
Number of main passages	2

Source: own elaboration.

Table 5. Input data of zone 4 configuration

Configuration 4	
Number of europallets	1200
Number of rack rows	10
Number of storage levels in a rack	3 (level 0, level 1, level 2)
Number of pallets at every row's level	40
Number of side passages	5
Number of main passages	2

Source: own elaboration.

No matter if products are stored on racks or directly on the floor, pallets are put in rows, one next to another, connected with longer sides. A detailed description of used order picking zone configurations is included in Tables 2–5.

The width of side passages which separate pallet rows are the same for every configuration of the order picking zone and they are 2.2 meter. Main passages have width of 3.4 meter and their length depends on the number of rows in a studied example.

In the research, the author used forklift truck work norms which were published by Fijałkowski [2003] and own calculations which were done for the sake of this experiment.

Table 6. Fork lift truck's work time norms used while order picking products in four described configurations of the order picking zone

Activity	Symbol	Unit	Time (min)
Acceleration after stop (empty truck)	AE	Full period	0.0300
Acceleration after stop (full truck)	AL	Full period	0.0300
Speed (3 km/h) – full truck	FL	Per one meter	0.0200
Speed (3 km/h) – empty truck	FE	Per one meter	0.0200
Stop (empty truck)	SE	Full period	0.0200
Stop (full truck)	SL	Full period	0.0360
Turn left (moving forward)	TFL	Full operation	0.0550
Turn right (moving forward)	TFR	Full operation	0.0550
Putting a pallet on the fork	NP	Full operation	0.1333
Scanning and putting the load on the pallet	CP	Full operation	0.1733
Putting a pallet on the storage place	OP	Full operation	0.2000
Laminating a ready pallet and sticking a printed label	OFP	Full operation	0.3533
Lifting a man with a pallet one floor up (height 1.8 m) without the load		Full operation	0.1667
Lifting a man with a pallet one floor up (height 1.8 m) with the load		Full operation	0.2000
Lifting is stopped (during the operation the operator is stabilizing his or her position after lifting)		Full operation	0.0670
Lowering a man with a forklift truck one floor down (always with the load)		Full operation	0.1333

Source: own elaboration on the basis of Fijałkowski [2003].

While *volume-based storage* rules are used, classification ABC is employed. Its parameters are treated, as it is applied in subject literature, as model ones (parameter alpha equals 20% beta is 80% of the examined quality).

In group A there are products which constitute 20% of the assortment and they generate 80% of picking. In group B there are products which constitute 30% of the assortment and generate 15% of picking. Group C is represented by the remaining 50% part of the assortment, and picking constitutes only 5%. Applied parameters are pre-arranged and are not verified during the research (see Table 7).

Table 7. ABC classification results

Class	Number of europallets	Picking frequency in %
A	240	80
B	360	15
C	600	5

Source: own elaboration.

When random storage policy is used, the likelihood of picking every product, regardless of storage area in the order picking zone, is the same.

4. Research results

The research was carried out in a simulation manner by means of a simulation tool dedicated to it and written in the C++ technology. As many as1000 replications were done, in which one replication included one working day in a warehouse. The orders were generated stochastically from a unified schedule. With the storage rules based on ABC classification, probability is different for every class (see Table 7), for random storage probability is the same for every picking place. Times of orders flow to a logistic hub are stochastic as well .

The objective of the research is to determine the influence of the order picking zone on the time of order completion in a logistic hub.

Table 8 shows average order picking times for four studied configurations of the order picking zone.

Table 8. Comparison of average order picking times for different configurations of the order picking zone

Order picking zone layout	Average order picking time of all orders	Percentage of worsening the solution comparing to the best one
Configuration 4	27:35	–
Configuration 2	28:50	4.55%
Configuration 3	33:40	22.02%
Configuration 1	39:18	42.49%

Source: own elaboration.

Comparing the examined order picking zones (see Table 8), we can observe that the average order picking time for the first configuration is over 42% worse than in the fourth configuration. With the small number of products in an order the differences are even bigger and they can equal 59%.

Symbols m1, m2, m3 and m4 in Figures 4–9 denote an examined order picking zone configuration in the order: first, second, third and fourth, respectively.

Significant differences can be observed in order completion in a logistic hub when different order picking zone configurations are used. The differences are visible between the examined variants as well as in their scope. The choice of a wrong storage rule and movement through the order picking zone has great importance in configuration 1 and 3. The difference in the average order completion time between the best and the worst order picking rule is over 50%.

The lack of pallet racks is a distinctive feature of the first and third configuration. Pallets are stored in rows on the floor. Taking into account the width and length of their area, they are the biggest. Big storage area results in the fact that a fork lift truck has to cover long distances, which extends order completion time. In configuration 1 there are the longest side passages between the rows. There is no possibility to change one passage into another quickly. In configuration 1, a very popular movement method in practice, *s-shape* gives really bad results. Building an order picking zone with long side aisles is ineffective in practice. That is why the order picking areas have to be designed in a way which allows workers to often change passages next to which products are stored. The choice of an order picking zone layout depends on many factors, among which the most important are: the type of a fork lift truck used for order picking, number of products in an order and order picking methods applied in a given logistic hub.

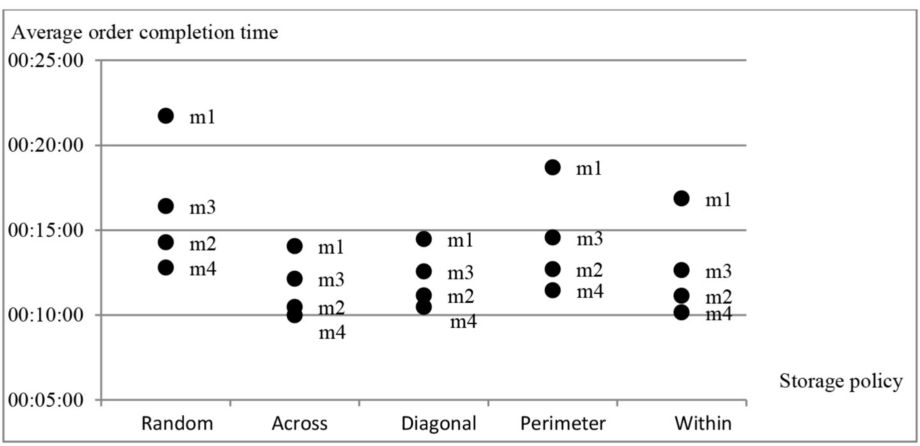

Figure 4. The average order picking times of 5 products in an order for the optimal method and different storage policies in four configurations of the order picking zone

Source: own elaboration.

Figures 4–9 show that the choice of the order picking zone layout has a significant influence on the order completion time. In the figures, order picking zone layouts are marked with symbols m1, m2, m3, m4.

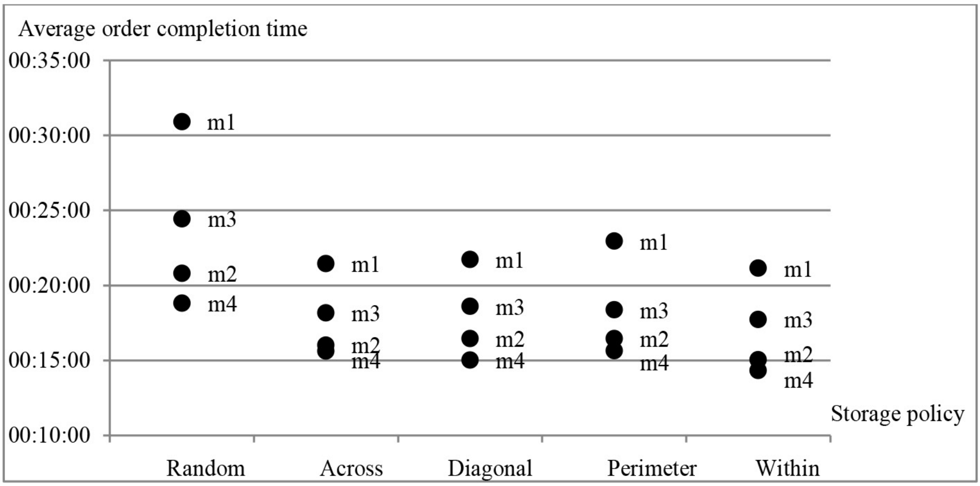

Figure 5. The average order picking times of 10 products in an order for the optimal method and different storage policies in four configurations of the order picking zone

Source: own elaboration.

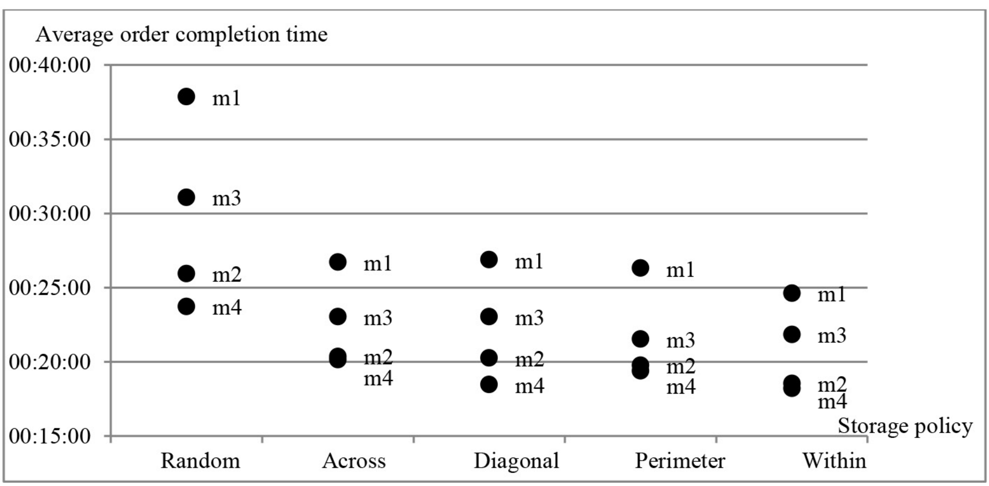

Figure 6. The average order picking times of 15 products in an order for the optimal method and different storage policies in four configurations of the order picking zone

Source: own elaboration.

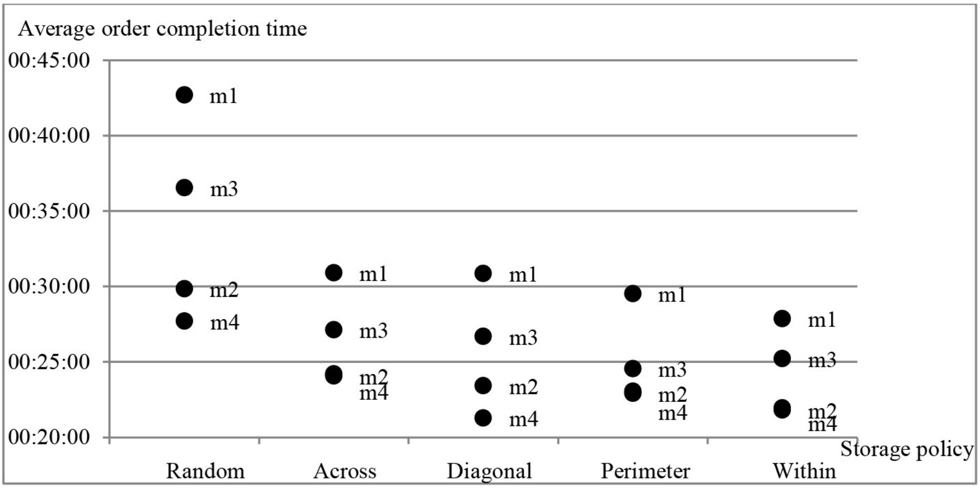

Figure 7. The average order picking times of 20 products in an order for the optimal method and different storage policies in four configurations of the order picking zone

Source: own elaboration.

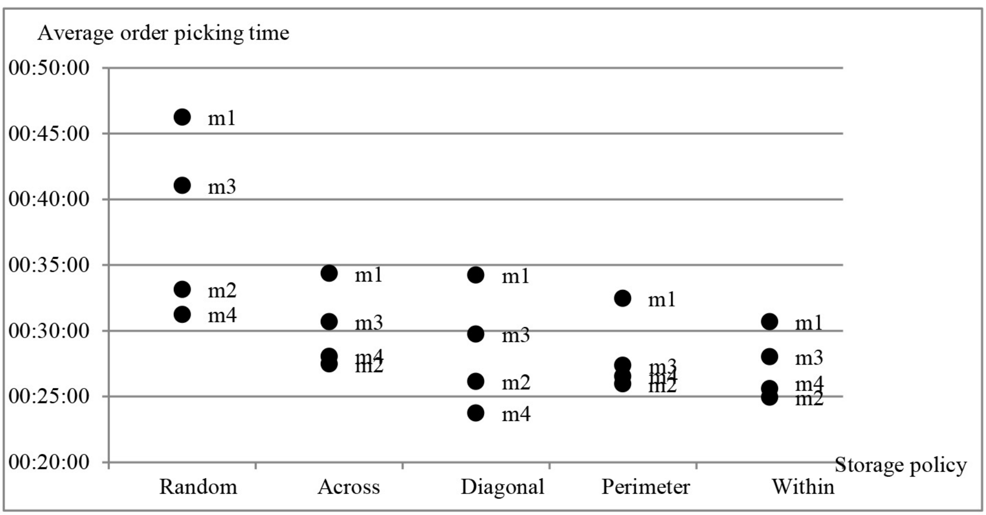

Figure 8. The average order picking times of 25 products in an order for the optimal method and different storage policies in four configurations of the order picking zone

Source: own elaboration.

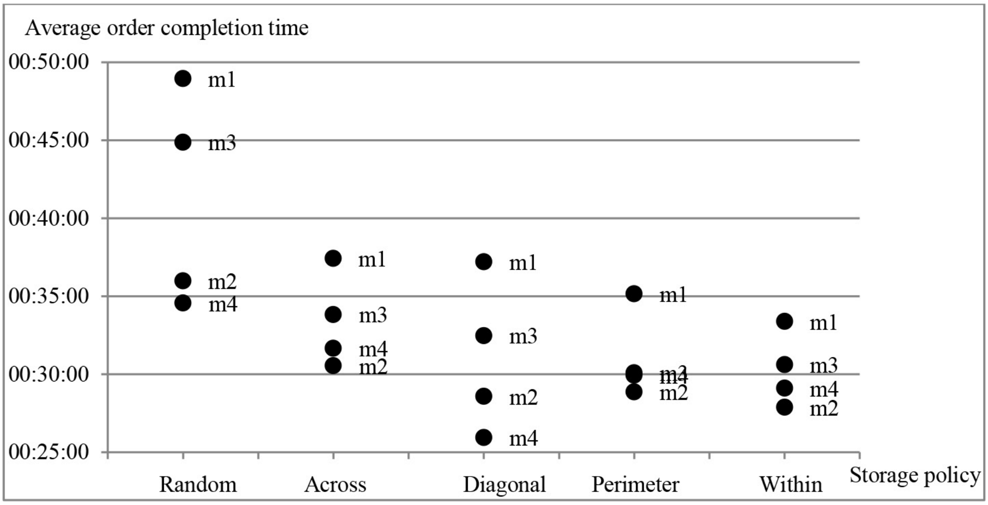

Figure 9. The average order picking times of 30products in an order for the optimal method and different storage policies in four configurations of the order picking zone

Source: own elaboration.

Order picking zone configuration is one of the most important question in the choice of the order picking process in a warehouse. Decision problems regarding an efficient order picking process include mainly five factors: routing, storage, batching, zoning and order release mode. All these factors should be related to one another.

5. Conclusions

The choice of an inappropriate order picking zone configuration results in the fact that even when the best storage and movement methods are applied, it is difficult to improve the efficiency of the order completion process in a logistic hub. As a result, some conclusions can be drawn that a decision concerning the choice of the appropriate layout of an order picking zone should be preceded by many analyses. Its importance for a company is strategic for customer service improvement. The role of the diagnosis of the present and future expectations for an order picking system has a key role in the subsequent management of the order picking process.

The implementation of simulation programs allows us to check different order picking variants. We are also able to choose the variants which are the best in a given situation. Simulation methods help to make decisions, when it comes to designing, management and execution of different activities in a warehouse. The computer program, which was created, allows examining and considering different order picking variants for different warehouses in different conditions.

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WPŁYW KONFIGURACJI STREFY KOMPLETACJI NA CZAS REALIZACJI PROCESU KOMISJONOWANIA ZAMÓWIEŃ

Streszczenie: Presja związana z obniżeniem kosztów przy jednoczesnym podniesieniu jakości obsługi klienta i przyspieszeniu przepływu produktów jest rezultatem ogólnoświatowego trendu zwiększania konkurencji na rynku. We współczesnej ekonomii nawet małe przesunięcia produktów na krótkie odległości zaczynają odgrywać coraz większe znaczenie. Problemy kompletacji zamówień odgrywają znaczącą rolę przy podniesieniu wydajności funkcjonowania nowoczesnych węzłów logistycznych. Według różnych szacunków koszty związane z komisjonowaniem zamówień w magazynie stanowią około 55%–65% wszystkich kosztów operacyjnych. Autor, wykorzystując narzędzia symulacyjne, analizuje wpływ różnych konfiguracji strefy kompletacji na czas procesu komisjonowania. Poprzez zastosowanie metod symulacyjnych możliwe jest dopasowanie odpowiednich reguł komisjonowania do potrzeb danego przedsiębiorstwa.

Słowa kluczowe: logistyka, komisjonowanie, narzędzia symulacyjne, zarządzanie magazynem.