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ORIGINAL PAPER

THE EFFICIENCY OF PRODUCTS CLASSIFICATION METHODS AND CLASSIFICATION CRITERIA

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ABSTRACT. **Introduction:** It is shown **i**n this paper, presented selected aspects of the impact that the distribution of products in a warehouse has on the picking of orders. This problem is particularly important for medium and large warehouses characterized by considerable rotation of goods. The aim of this study was to assess the impact of the method of classification of products that were used, on the efficiency of the order picking process.

Method: For each classification method, two cases of picking products were considered, one including the impact of the fact that the products can be piled, and the other, that they cannot be piled. Simulation studies were preceded by a sensitivity analysis in order to determine the impact of the criteria on the effectiveness of each of the methods.

Results: The best results were obtained after applying the product distribution in the warehouse on the basis of: COI Index or ABC analysis according to the number of units sold. It can be concluded that for large warehouses and for products with low susceptibility to stacking, the method based on COI Index proves to be the most effective.

Conclusions: If susceptibility to stacking is irrelevant in the products picking process, for average-size and large-size warehouses it is important to distribute products on the basis of COI Index. This method allows obtaining better results than in the case of free storage places by an average of 28.72%. For products with low susceptibility to stacking, applying COI Index also proves to be the most effective.

Key words: classification of products, ABC analysis, XYZ analysis, COI Index, sensitivity analysis, efficiency of order picking.

INTRODUCTION

For many companies, proper planning of a warehouse layout and the distribution of products in it, constitute major challenges. The modern world, the global market, allows not only local companies to compete, but also those located much further, even in the other hemisphere of the globe [Kuźnar, Lorenc 2017, Fomina, Samoylov 2017]. Therefore, numerous companies are competing with each other and main assets for them are: time and money simultaneously it is also important efficiency [Lorenc, Szkoda, 2015]. From the point of view of the global market, is not so important where the product comes from, but at what time and at what cost it will be possible to deliver it to the target customer [Group 2009, Rushton, Croucher, Baker 2014]. The cost of transport is often a significant part of the total logistics product cost, especially for products of relatively low value [Mason, Evans, 2015, Larco et al. 2017].

From the perspective of optimization, apart from improving the processes of handling goods in the warehouse, it is also important to properly plan the warehouse structure and to distribute goods accordingly inside it [Barreto et al. 2007]. If, however, the storage process is only a role of fortuity, it may turn out that products with higher demand will be located in the most remote part of the warehouse, and those least likely picked, the closest to the packaging zone [Vis, Roodbergen 2011,

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Petridis, Dey, Emrouznejad 2017]. In such a case, the magazine will be exposed to an unnecessary lengthening of the route of transport of goods, and therefore to the loss of time, the increase of the number of necessary staff and transport equipment [Richards, 2014, (Pyza et al. 2017]. Currently, in order to plan the distribution of products in a warehouse, products classifications methods are used [Zhao, Yang 2017, Sprock, Murrenhoff, McGinnis, 2017]. This means that different products are ascribed to groups of different ranks, and then they are distributed in the warehouse in such a way as to ensure the shortest access time to products of utmost importance [Chan, Chan 2011, De Koster et al., 2007, Lorenc, Więcek 2014]. Among the classical products classifications methods, there are the following analyses: ABC, XYZ and COI Index [Li, Li, Ming-Liang 2009].

The ABC Analysis due to its simplicity is the most commonly used analysis that allows the classification of products. Classical ABC Analysis enables the division of products into three groups of the percentage share of products values being: A – 80%, B – 15%, C – 5%. The ABC Analysis is a single-criterion analysis, which means that it is impossible to consider several input parameters simultaneously. It is possible, however, to perform the analysis various times, each time recognizing a different feature as a criterion and then to synthesize the results, contemplating the appropriate weight for each criterion (the result of the analysis) [Chu, Liang, Liao 2008].

The XYZ Analysis is an analysis which allows completing the ABC Analysis by an additional criterion, performing a classification inside separate groups. This criterion is usually the regularity with which the products are picked, determined based on historical sales data. In contrast to the ABC Analysis that was formerly mentioned, in which the products are classified according to their popularity or the number of units sold, the XYZ Analysis allows to evaluate them independently - based on an individual indicator for each product [Henn, Schmid 2013, Henn 2012].

COI Index (Cube-per-Order Index) enables to classify the products the easiest possible way. The analysis performed by this method is a two-criterion analysis, where the adopted criteria are product size and demand for it. As a product size, we can use its volume or weight, but as the demand: the number of pickings. By using the calculated COI Index, to distribute the products in such a way that those of the lowest picking ratio were the closest to the packaging zone, we shorten the route of the largest (heaviest) products. Dependence on the product size of a demand allows us to find an intermediate value between these two criteria.

GENERAL ASSUMPTIONS OF VARIANT ANALYSIS

In order to verify the impact of the change of the size of classification criterion onto the length of the picking process, the sensitivity analysis was conducted. In the simulations, an ABC, ABC combined with XYZ and COI Index were used. In the simulations, a percentage change in the explanatory variable (criterion) was made as follows:

- popularity: 5; 10; 11; 12; 13; 14; 15; 16; 17; 18; 19; 20; 30; 40; 50; 60,
- number of units sold: 5; 30; 33; 36; 39; 42; 45; 48; 51; 54; 57; 60; 90; 120; 150; 180,
- weight: 0.5; 3; 3.3; 3.6; 3.9; 4.2; 4.5; 4.8; 5.1; 5.4; 5.7; 6; 9; 12; 15; 18,
- volume: 0.1; 0.2; 0.3; 0.4; 0.6; 0.8; 1; 1.2

The analysis was performed for two variants:

Option I - in that option was assumed that there is no need to displace the products on a picking table throughout the entire picking process.

Option II - in that option was assumed that there is a need to displace the products on a picking trolley throughout the picking process. This need depends on a weight, volume and type of packaging (whether it can be stacked) - if there is the risk that the products on the fork-lift truck get damaged by those piled on top of them, it is necessary to change the positioning of the packages on the fork-lift truck (put the resistant ones on the bottom).

SENSITIVITY ANALYSIS

To perform a sensitivity analysis, the following formula was used:

$$ww = \frac{\frac{k_i - k_b}{k_b}}{\frac{z_i - z_b}{z_b}} \tag{1}$$

where:

ww – sensitivity coefficient on the change of the value of explanatory variable z,

k_i – picking time with an i-variable z_i,

k_b – picking time for the variable *of* $_b$

z_i – i-explanatory variable,

z_b – base variable z.

Sensitivity analysis conducted for Option I showed that the change of classification criteria has significant impact when modifying the explanatory variable to 60%, i.e.:

- popularity: 17
- number of units sold: 51
- weight: 5.1 kg
- volume of 0.4 m3.

Above those values, their change has no significant impact on the classification method and on the adopted criterion. For all analysed data, sensitivity coefficient values are in the range between -0.84 and 0.93 and are characterized by a standard deviation of 0.024, while the value of an average and median are, accordingly -0.023 and -0.013. In contrast, when comparing only the results of the above-mentioned limit of 60% of the sensitivity value, they are between -0.15 and 0.18 i.e. ww∊ (-0.15, 0,18) with a standard deviation of 0.072 of the average value of 0.005 and a median of -0.002. This is confirmed by the fact that in this range of parameter values, there is no statistically noticeable difference between the classifications of products made. Therefore, it can be concluded that each of these analyses may be applied independently from the average and from the standard deviation of the data used. The results of the analysis are shown in Figure 1.

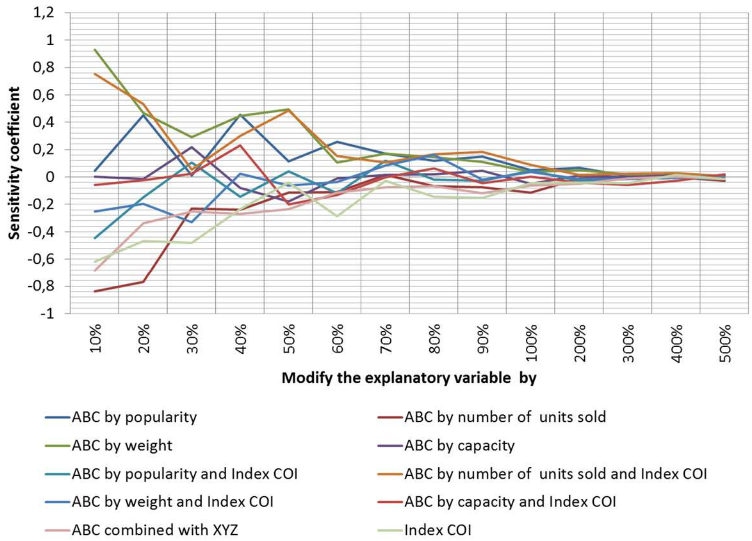

Fig. 1. Option I - sensitivity coefficient, depending on the modification of the base value of the parameter

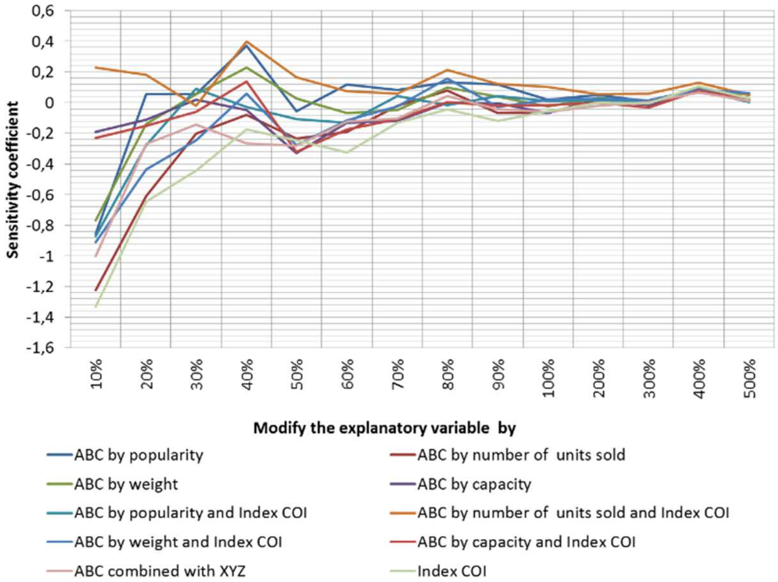

Fig. 2. Option II - sensitivity coefficient, depending on the modification of the base value of the parameter

The conducted sensitivity analysis for Option II showed that, similarly as in Option I, the change of the size of parameters that determine the characteristics of products does not have a relevant impact on the changes greater than 60%. Sensitivity coefficient values for all analyses are in the range between -1.33 and 0.04 i.e. $ww \in (-1.33, 0,04)$ and are characterized by a standard deviation of 0.280, while the value of an average and median values are, correspondingly -0.093 and -0.098. In case of modification above 60%, the sensitivity coefficient is in the range of -0.130 and 0.212, i.e. $ww \in (-0.13, 0,212)$ with a standard deviation of 0.067, the average value of 0.017 and a median of 0.015. A graphic presentation of the results of the analysis is shown in Figure 2.

Therefore, it can be concluded that above a range of 60%, each of these analyses may be applied independently from the average and from the standard deviation of the data used. What is also noticeable is the decrease of the sensitivity to the modifications of input parameters with the increase in this modification. In this case, it is crucial to take into account an additional time for the displacement of products on a picking trolley. Taking into account this process in the total time of the picking process reduces the sensitivity of all the analyses along with the increase of input parameters.

SIMULATION OF THE ORDER PICKING PROCESS

In order to evaluate the effectiveness of the order picking process, resulting from the used method of the distribution of products in a warehouse, a simulation method of order picking process was used. Product picking route was planned based on determining order picking route based on the closest point from the current location of a warehouse employee. This method contemplates the need to intervene in the order of products on a picking trolley in the event of a risk that a smaller product can be crushed by the larger one - sensitivity to stacking. To perform the simulation, copyright algorithms written in PHP language and MySQL relational databases were used. Thanks to this solution it is possible to use large batches of data, clearly, display the results and easily modify input parameters. Furthermore, it is also possible to integrate it with Matlab.

In each case of the evaluation of effectiveness, a simulation for 1000 picking lists was assumed. In the first step, a product ID is randomly selected from all available ones. Afterwards, coordinates of the product of this ID that is the closest (in terms of access time) of the starting point (packaging zone) are selected, marked as location (0, 0, 0). In this case, access time is read from a matrix of access times generated in the process of creating a warehouse structure. Coordinates of the target point are stored in three variables xdo(rack), ydo(row), pdo(level). Travel time from one place to another is added to the total picking order time.

Travel time from packaging zone to any place in the warehouse has been described by a formula (2).

$$t_p(x,y,p) = t_{lp}(D_{lr} \cdot (x - c_l(x)) + d_{cr} \cdot c_l(x)) + t_{lp}(D_{wr} \cdot (y - c_w(y)) + d_{cr} \cdot c_w(y)) + t_a + t(p) \quad (2)$$

where:

$t_p(x,y,p)$ – travel times in the warehouse,

x, y – positions in the matrix,

t^{lp} – time necessary to travel on a distance of 1 meter in a straight line,

t_a – time necessary to travel a curve,

D_{wr} – width of a rack (one pallet spot, length of a rack divided by a number of pallet spots),

D_{lr} – rack length,

d_{cr} – corridor width,

$c_l(x)$ – number of corridors running across the warehouse to the coordinate x,

$c_w(y)$ – number of corridors along the warehouse to the coordinate y.

t(p) – time of lifting and lowering the fork on a given storage level (p),

t(p) = [0; 58; 116; 174; 232; 290; 348; 406]

In addition, this requires a time correction t(p) if the rack is facing the packaging zone because it will not be necessary to travel an extra distance equal to the width of the corridor between the rows. Therefore the correction takes the forms as described in the equation (3).

$$\begin{aligned} &if \quad W(x, y-1) = 0 \\ &then \quad t_p = t_p - t_{lp}(D_{wr} + d_{cr}) \end{aligned} \quad (3)$$

EVALUATION FOR PICKING PROCESS FOR OPTION I

Option I was made for a magazine of the capacity of 200 pallet spots in each of 14 rows of products storage and 8 levels on which the products are stored. In the conducted simulation, 1000 different products were used, for which picking lists were prepared according to the described assumptions. The result of the simulation of picking a time of products is graphically shown in Figure 3.

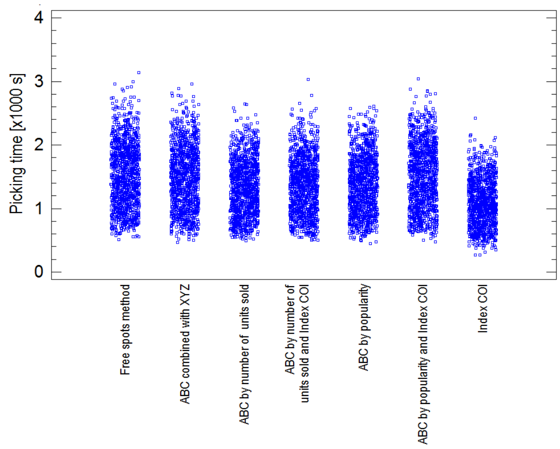

Fig. 3. Product picking time, depending on the products classifications methods, Option I

On the basis of figure 3 it can be stated that methods such as ABC combined with XYZ analysis, the ABC analysis according to the criterion of the number of units sold, the method of free storage locations for products, produce the results with the greatest range and standard deviation. This is also noticeable, based on the statistical characteristics presented in Table I. Values that exceed the average are marked with yellow.

For the conducted analyses, analysis of variance (ANOVA) was performed in order to test the significance of differences between average values. The ANOVA analysis divides the data variants into two components: a component between the groups and within the group. The F test indicator, which in this case was 116.97 is the ratio of assessment between the groups to estimate within the group. As the value of the p coefficient for F test is less than 0.05, this is a statistically significant difference between the average values from the performed analyses on the 95.0% of confidence level.

Table 1. Descriptive statistics of the performed analyses for Option I

	Avg.	Standard dev.	Median	Min	Max	Range
Free spots method	798.2	211.2	781.8	208.2	1572.0	1363.8
ABC combined with XYZ	799.6	207.7	784.3	295.2	1459.6	1164.4
ABC by number of units sold	793.6	206.1	779.1	125.6	1607.8	1482.2
ABC by number of units sold and Index COI	787.2	203.3	769.8	242.8	1648.4	1405.6
ABC by popularity	792.6	204.3	776.1	288.0	1550.6	1262.6
ABC by popularity and Index COI	790.4	201.9	770.6	257.4	1457.8	1200.4
Index COI	778.7	198.3	762.8	291.0	1454.6	1163.6
Total	791.4	204.7	775.3	125.6	1648.4	1522.8

In order to determine which groups differ statistically from each other, multiple comparisons were performed, a so-called post hoc test. To perform post-hoc tests, Scheffe, T Tukey (HSD), Fisher (LSD), Bonferroni, Newman-Keuls and Duncan tests are applied. In the analysed case, Scheffe test was used, which is considered one of the most conservative post hoc tests (Armstrong et al., 2014). Results of the test are shown in Table II and in Figure 4.

Table 2. Multiple comparison using Scheffe test at 95% of confidence interval

	Mean	*Homogeneous Groups*
Index COI	1092.06	X
ABC by number of units sold	1348.97	X
ABC by number of units sold and Index COI	1367.12	X
ABC by popularity	1387.24	X
ABC combined with XYZ	1488.30	X
ABC by popularity and Index COI	1509.66	X
Free spots method	1532.15	X

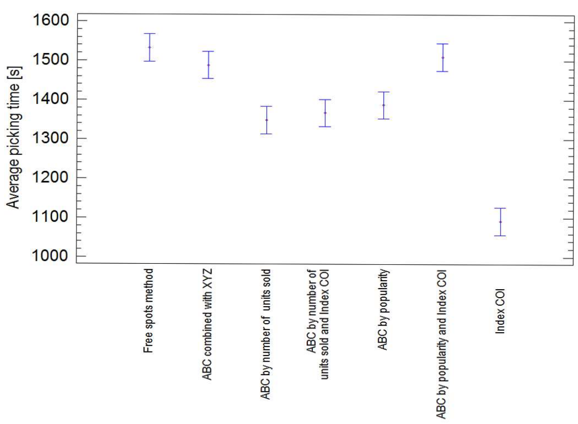

Fig. 4. Result of the comparison of average with Scheffe interval with 95% confidence interval

The last part of the analysis was to make a comparison of medians using the Friedman test. Zero hypothesis assumed that all the tests come from populations of the same median. The result of the test was 1796.58 and the parameter p equalled 0.00, which demonstrates that the groups differ significantly from each other. Figure 5 shows a graphical presentation of the results in form of box plot.

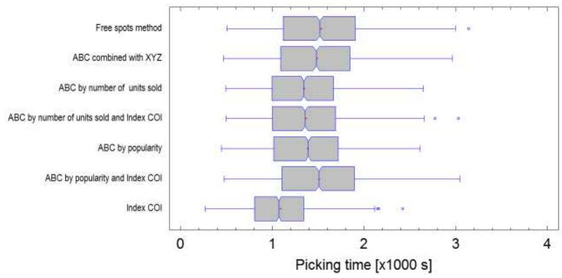

Fig. 5. Box-and-Whisker Plot for Option I

Making a comparison of average and median values, it was found that the best results were obtained after applying the product distribution in the warehouse on the basis of the COI Index (average: 1092.0, median: 1072.2). The ABC analysis in combination with XYZ, ABC analysis in combination with COI Index, according to the popularity criterion and the method of free storage places gives the worst results because of that their characterized by their high divergence and high average and median values. Therefore, for large warehouses, it is important to distribute the products on the basis of the analysis of COI Index. This method allows obtaining better results than in the case of free storage places by an average of 28.72%.

EVALUATION FOR PICKING PROCESS FOR OPTION II

Similarly to Option I, for Option II, simulations for a magazine of the same parameters were conducted. This variant assumed that the products have a limited susceptibility to stacking, therefore during their picking, it is necessary to change their order on the picking trolley, so as to avoid damaging them. A graphical presentation of the results of simulation of picking time of products was shown in Figure 6.

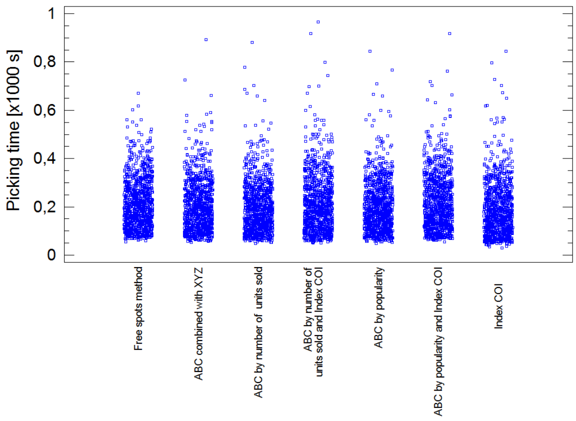

Fig. 6. Product picking time, depending on the products classifications methods, Option II

In Figure 6 it is difficult to see a significant difference between the groups of time picking results when using different products classifications methods. Statistical characteristics of the conducted analyses were shown in Table III. Values that exceed the average are marked with yellow.

For the performed analyses, an ANOVA variant analysis was conducted in order to test the significance of differences between average values. F test indicator, which in this case is 10.93 is the ratio of the assessment between the groups to estimate inside the group. As the value of the P coefficient for F test is less than 0.05, this is a statistically significant difference between the average values on the 95.0% of confidence level.

Table 3. Descriptive statistics of the performed analyses for Option II

	Avg.	Standard dev.	*Median*	*Min*	*Max*	*Range*
Free spots method	2139.1	1033.5	1973.8	553.4	6698.4	6145.0
ABC combined with XYZ	2041.1	1031.7	1858.2	517.6	8927.8	8410.2
ABC by number of units sold	1960.6	1044.3	1804.8	491.2	8801.3	8310.1
ABC by number of units sold and Index COI	2114.5	1181.5	1878.0	499.0	9649.1	9150.1
ABC by popularity	1964.7	1040.7	1759.6	477.8	8447.8	7970.0
ABC by popularity and Index COI	2187.1	1141.9	1992.8	560.3	9171.1	8610.8
Index COI	1872.6	1101.3	1639.7	298.6	8443.1	8144.5
Total	2039.9	1088.2	1842.8	298.6	9649.1	9350.5

Table 4. Multiple comparison using Scheffe test at 95% of confidence interval

	Mean	*Homogeneous Groups*
Index COI	1872.67	X
ABC by number of units sold	1960.62	XX
ABC by popularity	1964.75	XX
ABC combined with XYZ	2041.17	XXX
ABC by number of units sold and Index COI	2114.52	XX
Free spots method	2139.11	X
ABC by popularity	2187.11	X

In order to determine which groups differ statistically from each other, multiple comparisons were performed, a so-called post hoc test. Results of the test are shown in Table IV.

The last part of the analysis was to make a comparison of medians using the Friedman test. Zero hypothesis assumed that all the tests come from populations of the same median. The result of the test was 1121.65 and the parameter p equalled 0.0, which demonstrates that the groups differ significantly from each other. Figure 7 shows a graphical presentation of the results in form of box plot.

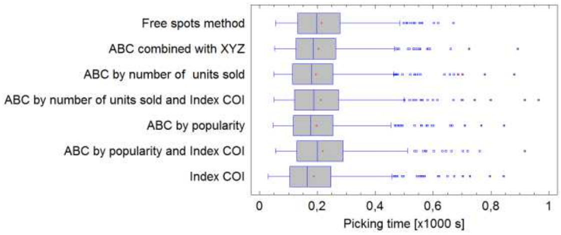

Fig. 7. Box-and-Whisker Plot for Option II

Making a comparison of average and median values, it was found that the best results were obtained after applying the product distribution in the warehouse on the basis of:

- COI Index, average: 1872.67, median: 1639.72
- ABC analysis according to the number of units sold, average: 1960.62, median: 1804.89

The worst results were obtained using ABC analysis combined with COI Index according to the popularity of products - the average amount of picking time was 2187.11 s, median: 1992.80 s, and the range of results: 8610.86. Therefore it can be concluded that for large warehouses and for products with low susceptibility to stacking, the method of distribution of products based on COI Index proves to be the most effective. This method allows obtaining better results than in the case of free storage places by an average of 12.46%.

CONCLUSIONS

If susceptibility to stacking is irrelevant in the products picking process, for average-size and large-size warehouses it is important to distribute products on the basis of COI Index. This method allows obtaining better results than in the case of free storage places by an average of 28.72%. For products with low susceptibility to stacking, applying COI Index also proves to be the most effective. However, in this case, this method allows obtaining better results than in the case of free storage places by an average of 12.46%. Nevertheless, it was confirmed that from among the tested methods this method always translates to an increase the efficiency of the order picking process.

REFERENCES

Armstrong R.A., Hilton A.C., Armstrong R.A., Hilton, A.C., 2014. Post Hoc Tests. In Statistical Analysis in Microbiology: Statnotes. Hoboken, NJ, USA: John Wiley & Sons, Inc. 39–44. http://dx.doi.org/10.1002/9780470905173.ch7.

Barreto S., Ferreira C., Paixão J., Santos B.S., 2007. Using clustering analysis in a capacitated location-routing problem. European Journal of Operational Research. 179(3):968–977. http://dx.doi.org/10.1016/j.ejor.2005.06.074.

Chan F.T.S., Chan H.K., 2011. Improving the productivity of order picking of a manual-pick and multi-level rack distribution warehouse through the implementation of class-based storage. Expert Systems with Applications. 38(3):2686–2700. http://dx.doi.org/10.1016/j.eswa.2010.08.058.

Chu C.-W., Liang G.-S., Liao C.-T., 2008. Controlling inventory by combining ABC analysis and fuzzy classification. Computers & Industrial Engineering. 55(4):841–851. http://dx.doi.org/10.1016/j.cie.2008.03.006.

Fomina I.G., Samoylov V.V., 2017. Applying of innovative methods in warehouse management. In 2017 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus). IEEE. 1337–1340. v10.1109/EIConRus.2017.7910814.

Group A., 2009. Warehouse Operations: Increase Responsiveness through Automation. Boston, MA: Aberdeen Group.

Henn S., 2012. Algorithms for On-line Order Batching in an Order Picking Warehouse. Comput. Oper. Res. 39(11):2549–2563. http://dx.doi.org/10.1016/j.cor.2011.12.019.

Henn S., Schmid V., 2013. Metaheuristics for Order Batching and Sequencing in Manual Order Picking Systems. Comput. Ind. Eng. 66(2):338–351. http://dx.doi.org/10.1016/j.cie.2013.07.003.

De Koster R., Le-Duc T., Roodbergen, K.J., Koster D., 2007. Design and control of warehouse order picking: a literature review. European Journal of Operational Research. 182(2):481–501.

Kuźnar M., Lorenc A., 2017. The impact of cargo monitoring systems usage on intermodal transport risk and costs. World Review of Intermodal Transportation Research. 6(4):336–351. http://dx.doi.org/10.1504/WRITR.2017.10009826.

Larco J.A., de Koster R., Roodbergen K.J., Dul J., 2017. Managing warehouse efficiency and worker discomfort through enhanced storage assignment decisions. International Journal of Production Research. 55(21):6407–6422. http://dx.doi.org/10.1080/00207543.2016.1165880.

Li M.-L., Li, Ming-Liang, 2009. Goods classification based on distribution center environmental factors. International Journal of Production Economics. 119(2):240–246.

Lorenc A., Szkoda M., 2015. Customer logistic service in the automotive industry with the use of the SAP ERP system. In 2015 4th IEEE International Conference on Advanced Logistics and Transport, IEEE ICALT 2015. http://dx.doi.org/10.1109/ICAdLT.2015.7136584.

Lorenc A.K., Więcek P., 2014. The routes optimization of picking up commodities in stock considering their natural characteristics. In CLC'2013 : Carpathian Logistics Congress, December 9th-11th 2013, Cracow, Poland : (reviewed version). Ostrava: TANGER Ltd. 307–312.

Mason R., Evans B., 2015. The Lean Supply Chain. Managing the Challenge at Tesco. London: Kogan Page.

Petridis K., Dey P.K., Emrouznejad A., 2017. A branch and efficiency algorithm for the optimal design of supply chain networks. Annals of Operations Research. 253(1):545–571. http://dx.doi.org/10.1007/s10479-016-2268-3.

Pyza D., Jachimowski R., Jacyna-Gołda I., Lewczuk K., 2017. Performance of Equipment and Means of Internal Transport and Efficiency of Implementation of Warehouse Processes. Procedia Engineering. 187:706–711. http://dx.doi.org/10.1016/J.PROENG.2017.04.443.

Richards G., 2014. Warehouse management: a complete guide to improving efficiency and minimizing costs in the modern warehouse.

Rushton A., Croucher P., Baker P., 2014. The handbook of logistics and distribution management. Understanding the supply chain. London: Kogan Page.

Sprock T., Murrenhoff A., McGinnis L.F., 2017. A hierarchical approach to warehouse design. International Journal of Production Research. 55(21):6331–6343. http://dx.doi.org/10.1080/00207543.2016.1241447.

Vis I.F.A., Roodbergen K.J., 2011. Layout and control policies for cross docking operations. Computers & Industrial Engineering. 61(4):911–919. http://dx.doi.org/10.1016/j.cie.2011.06.001.

Zhao Z., Yang P., 2017. Improving order-picking performance by optimizing order batching in multiple-cross-aisle warehouse systems: A case study from e-commerce in China. In 2017 4th International Conference on Industrial Engineering and Applications (ICIEA). IEEE. 158–162. http://dx.doi.org/10.1109/IEA.2017.7939198

OCENA WPŁYWU METOD KLASYFIKACJI PRODUKTÓW NA EFEKTYWNOŚĆ PROCESU POBORU ZAMÓWIEŃ

STRESZCZENIE. Wstęp: W pracy pokazano wybrane aspekty wpływu, jaki ma rozlokowanie produktów w magazynie na proces poboru zamówień. Zagadnienie to jest szczególnie ważne w średnich i dużych magazynach, charakteryzujących się istotną rotacją wyrobów. Celem pracy jest ocenienie wpływu zastosowanej metody klasyfikacji produktu na efektywność procesu poboru zamówień.

Metody: Dla każdej metody klasyfikacji wybrano dwie sytuacji poboru zamówienia, w jednej dopuszczalne jest sztaplowanie towarów, w drugiej nie jest. Następnie przeprowadzono symulacje i oceniono je przy pomocy analizy wrażliwości w celu określenie wpływu poszczególnych kryteriów na efektywność każdej z metod.

Wyniki: Najlepsze rezultaty w rozlokowaniu produktu w magazynie otrzymano przy oparciu metody na współczynniku COI oraz analizy ABC w stosunku do ilości sprzedanych jednostek produktu. Można wnioskować, że w przypadku dużych magazynów oraz dla produktów o niskiej podatności do sztaplowania, najbardziej efektywną metodą była metoda oparta o współczynnik COI.

Wnioski: Przy założeniu, że podatność na sztaplowanie nie jest istotna w procesie poboru towaru, w przypadku magazynów o średniej i dużej powierzchni, istotnym jest oparcie metody rozlokowania produktów na zastosowaniu współczynnika COI. Metoda ta pozwala na uzyskanie lepszych rezultatów średnio o 28, 72% aniżeli dla rozlokowania na zasadzie wolnego miejsca. W przypadku produktów słabo podatnych na sztaplowanie, również zastosowanie metody opartej na współczynnika COI jest bardziej efektywne.

Słowa kluczowe: klasyfikacja produktów, analiza ABC, analiza XYZ, współczynnik COI, analiza wrażliwości, efektywność wyboru zamówienia

EINSCHÄTZUNG DES EINFLUSSES VON METHODEN ZUR PRODUKTKLASSIFIZIERUNG AUF DIE EFFIZIENZ DES WARENENTNAHME-PROZESSES

ZUSAMMENFASSUNG. Einleitung: In der Arbeit wurden ausgewählte Aspekte des Einflusses, welchen die Zuordnung von Produkten im Lager auf den Warenentnahme-Prozess ausübt, dargestellt. Die Frage ist besonders wichtig in Mittel- und Großlagern, die eine wesentlich starke Warenrotation aufweisen. Das Ziel ist es, den Einfluss der angewendeten Methoden zur Produktklassifizierung auf die Effizienz des Warenentnahme-Prozesses einzuschätzen.

Methoden: Für jede Klassifizierungsmethode wurden zwei die Warenentnahme anbetreffende Sachverhalte ausgewählt: im ersten Sachverhalt ist das Warenstapeln zulässig, im anderen ist es nicht der Fall. Demzufolge wurden Simulationen durchgeführt und sie anhand der Empfindlichkeitsanalyse zwecks der Festlegung des Einflusses einzelner Kriterien auf die Effizienz der beiden Methoden bewertet.

Ergebnisse: Die besten Resultate bei der Zuordnung eines Produktes im Lager erzielte man in Anlehnung an den COI-Koeffizienten und die ABC-Analyse im Verhältnis zur Anzahl von verkauften Produkteinheiten. Daraus kann man schlussfolgern, dass im Falle größerer Lager und für die kaum stapelbaren Produkte die meist effektive die auf den COI-Koeffizienten gestützte Methode ist.

Fazit: Bei der Annahme, dass die Stapelbarkeit der Waren im Prozess der Warenentnahme im Falle der Objekte mit mittleren und größeren Lagerflächen unwesentlich bleibt, ist die auf die Anwendung des COI-Koeffizienten gestützte Methode der Zuordnung von Waren ausschlaggebend. Diese Methode ermöglicht es, um durchschnittlich 28,72% bessere Resultate als die Zuordnung gemäß dem Freiplatz-Prinzip zu erzielen. Im Falle der wenig stapelbaren Produkte ist auch die Anwendung der auf den COI-Koeffizienten gestützten Methode mehr effizient.

Codewörter: Produktklassifizierung, ABC-Analyse. XYZ-Analyse, COI-Koeffizient, empfindlichkeitsanalyse, Warenentnahme-Effizienz

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