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Sorting Products using the ABC-SWARA Model

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ABSTRACT

Inventory management has become one of the most important tasks and goals of logistics. For this reason, this paper conducts product grouping and examines its impact on the company's performance. Each company uses a special model and tactics for managing and optimizing inventory, as well as using its own way of controlling the current state of inventory. However, applying a model that will include several factors and give the best possible results is necessary. The SWARA (Stepwise Weight Assessment Ratio Analysis) method and ABC analysis were applied to ensure the final results are as reliable as possible. The SWARA method was used to define the weighting coefficients of criteria related to Electrolux appliances sold by the company "Mepromex". Determining the weights of the criteria using the SWARA method involves three main criteria: unit price, quantity, and annual procurement value. These three criteria play a crucial role in the final product sorting, i.e., in the ABC analysis. The applied ABC-SWARA model shows that out of a total of 93 products, Group A consists of 17 products, which require the most attention due to their highest values. Group B consists of 31 products, while Group C consists of 45 products, which have the lowest values. Sensitivity analysis was performed using the ABC-FUCOM model, and it can be seen that the products are grouped almost identically to those in SWARA-ABC. Group A consists of 19 products, which require the most attention due to their highest values. Group B includes 31 products, while Group C consists of 43 products, which are those with the lowest values.

1. Introduction

With the development of industry and the overall economy, we are witnessing the daily need for various quantities and types of goods. Logistics faces optimization challenges at multiple levels. One of the primary tasks is effective inventory management. All companies face the challenge of achieving the optimal inventory level that will successfully respond to market demands without excessive accumulation in warehouses. The aim of this research is to propose a method for classifying logistics services based on ABC analysis, which allows for the distribution of services according to their impact on production costs. The implementation of the method for classifying logistics products enables the identification of the types of services that need to be distinguished (Ziyadin et al., 2020).

A large quantity of inventory incurs significant costs, which is why many methods and analyses for inventory management are developed to help each company maintain optimal inventory levels, adapt to the market, and maximize profits as much as possible. Inventory consists of stored materials used to facilitate production or meet consumer demand. There are different types of inventory, making it important to understand which inventory is best suited for specific situations, as it is important to know what inventory management models exist. The problems of inventory management are different, and company executives are trying to solve them by applying different models. The goal of any calculation and developed model is to provide as much information as possible. How can we keep the inventory as small as possible while always meeting the requirements? How can we prevent overstock and, at the same time, be a competitor in the business world? How do you ensure that you have the right amount of inventory at all times?

The model applied in this paper includes the integration of the SWARA method and ABC analysis for sorting inventory based on varying importance criteria. This paper shows how ABC analysis can be adapted to fit specific needs and context, providing a valuable tool for inventory management and decision-making on product procurement priorities. There is also a clear difference between single-criteria and multi-criteria ABC analysis. The main advantage of this model is that it can be applied to different types of products, which is in the interests of the big companies that procure large quantities of different types of goods.

2. Literature review

The aim of ABC analysis as a technique for inventory planning and control (Ye Chan et al., 2008) is to be based on multiple criteria, thereby providing greater flexibility to managers. Grouping various items for more efficient inventory control and management is necessary to create an optimal model that contributes to business performance across different sectors (Millstein et al., 2014; Mehdizadeh, 2020; J. Liu et al., 2016). To maintain continuity in production and sales, and thereby customer satisfaction, a certain amount of inventory must be present (Šafran, 2021). ABC analysis has also contributed to a company involved in wood production and processing, as it has identified which products have the greatest impact on sales. Based on these insights, a new production plan has been proposed to rationalize the production process (Tomić, 2019).

ABC analysis serves as a specified inventory management system that assumes only a few materials deserve attention in terms of monitoring and control. These materials, however, represent a significant share in the total values, i.e., inventory costs. These materials are classified into Group A (extremely important products), while Group B (moderately important products) and C (relatively insignificant products) consist of materials whose share by type increases while their share by value decreases. In other words, most attention is given to Group A, less to Group B, and least to Group C (Erceg et al., 2019).

The objective of the thesis (Lehmusto, 2024) was to create a development proposal to optimize warehouse operations at Picosun, now part of Applied Materials Inc., by implementing strategic enhancements and conducting an ABC analysis. The study is grounded in a current state analysis of warehouse operations, utilizing data collected from company records, interviews, and other documented sources. Key development points identified include the optimization of space utilization and the refinement of inventory handling processes to align with the new corporate strategies post-acquisition.

The goal of study (Silaen et al., 2024) is to use ABC analysis in the company's inventory management to identify products in categories A, B, and C based on profitability and sales factors. The research phases include data collection, data preprocessing, exploratory data analysis, ABC analysis, key product analysis, and explanatory analysis.

ABC analysis is closely related to the Pareto principle, which states that there is often an inverse relationship between the percentage of items in each group and the significance of the groups, as shown in Figure 1. Pareto discovered this regularity through research on income distribution, and since then, it has been applied in many other areas (Stević et al., 2020).

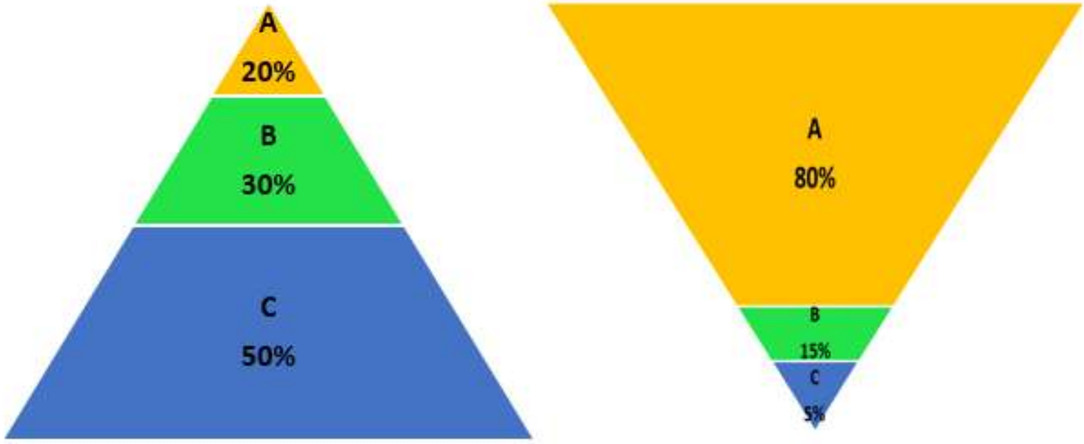

Figure 1. Pareto principle

The model applied in this paper includes the integration of the SWARA method and ABC analysis for sorting inventory based on varying importance criteria. The SWARA (Step-wise Weight Assessment Ratio Analysis) method was introduced in 2010 by Keršuliene (Keršuliene et al., 2010). This method has attracted significant attention for its application, particularly in situations that require selecting tools for machinery, choosing personnel, addressing corporate social responsibility and sustainability, product design, and selecting packaging design (Karabašević et al., 2015). The SWARA method was used to determine the weighting values of the three specified criteria.

MCDM methods, in combination with ABC analysis, give more credible results and enable the right decisions to be made in the business world.

In the paper (Miškić et al.,2021) SWARA method was applied to determine the significance of the criteria, while the classification of products was performed using the MARCOS method. According to the originally created MCDM model results, the products were grouped into three categories: A, B, and C. This study (Phruksaphanrat, 2024) includes ABC analysis, AHP, and DEA for classifying existing inventory items in a case study factory of a refrigerator company. Also, in the paper (Stević et al., 2023), an integrated ABC-FUCOM model is used to classify products.

3. Methodology

For the development of the ABC-SWARA model, the necessary data related to Electrolux products were first collected. Then three criteria were defined: unit price, quantity, and annual procurement value. Subsequently, the weighting coefficients of the criteria were defined, and ABC analysis was applied. Figure 2 illustrates the methodology used in the paper.

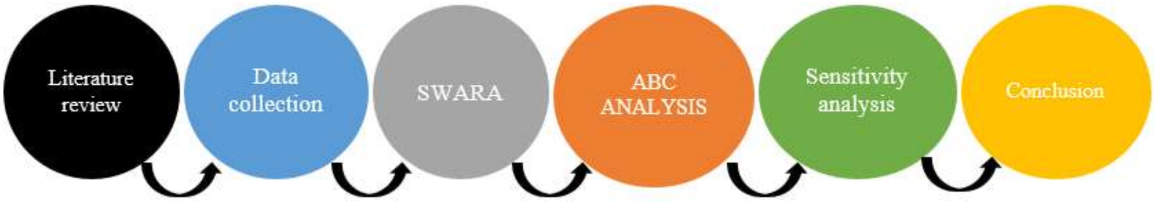

Figure 2. Methodology overview

3.1. SWARA

The algorithm for obtaining relevant weighting coefficients using the SWARA method is presented in the following steps (Keršuliene et al., 2010):

Step 1. The criteria are sorted in descending order based on their expected importance.

In this step, experts rank the defined criteria depending on their importance. For example, the most significant criterion is ranked first, the least significant criterion is ranked last, and the criteria in between are ranked accordingly.

Step 2. Starting from the second criterion, the relative importance of that criterion (criterion *j*) is determined in relation to the previous one (*j*-1), and this process is repeated for each subsequent criterion.

Step 3. Determining the coefficient k_j:

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \tag{1}$$

Step 4. Determining the calculated weights q_j:

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{q_{j-1}}{k_j} & j > 1 \end{cases} \tag{2}$$

Step 5. Calculating the weighting coefficients using the following formula:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \tag{3}$$

where w_j represents the relative weight of criterion *j*, and *n* represents the number of criteria (Karabašević et al., 2015; Stanukić et al., 2015; Vesković et al., 2018; Zolfani & Bahrami, 2014).

3.2. ABC ANALYSIS

The ABC analysis is a simple stochastic method. The aim of this analysis is to achieve the highest possible cost-effectiveness and productivity, thereby enhancing the overall efficiency and cost-effectiveness of business operations. It is particularly suitable for companies with a diverse range of products. One of the primary purposes of applying this analysis is to establish a functional system for control and management within marketing logistics and inventory management. The ABC analysis focuses on identifying the most important products that provide the greatest benefits (Chawla et al., 2024).

4. ABC analysis with the SWARA method

In this section, the ABC-SWARA model is applied. Table 1 below shows the sales data for Electrolux products for a period of twelve months, consisting of a total of 93 products, along with their codes, calculated quantities, and procurement values.

Table 1: Criterion values and total sum

Rank	Code	Product Name	Unit of measure	Sold Quantity	Procurement Price	Unit Price
1	6975525	MIXER WITH BOWL ELECTROLUX ESM3300	PCS	110	7253	65.936
2	6381389	HAND BLANDER ELECTROLUX E4HB1-6GG	PCS	61	3151	51.648
3	6970129	IRON ELECTROLUX E6SI1-2MN	PCS	53	2433	45.914
4	6620355	BLENDER ELECTROLUX E4TB1-6ST	PCS	52	3923	75.444
5	6574497	MIXER ELECTROLUX EHM3300	PCS	50	1829	36.584
...	...	....	...	...	...	...
90	6455287	STEAM IRON E7SI1-4WB ELECTROLUX	PCS	1	67	67.093
91	6424222	REFRIGERATOR ELECTROLUX ERT1501FOW3	PCS	1	312	311.897
92	6381426	BUILT-IN OVEN EOD5C50Z ELECTROLUX	PCS	1	582	581.651
93	6203332	BUILT-IN OVEN KOCEH70X ELECTROLUX	PCS	1	682	682.228
			Σ	961	134239	28042.570

After calculating the sums for each criterion individually, the share of each product is calculated, the values of which are shown in Table 2.

Table 2: Calculation of individual product shares

Rank	Code	Share of Q	Share of APV	Share of UP
1	6975525	11.45%	5.40%	0.24%
2	6381389	6.35%	2.35%	0.18%
3	6970129	5.52%	1.81%	0.16%
4	6620355	5.41%	2.92%	0.27%
5	6574497	5.20%	1.36%	0.13%

...	...	...	...	...
90	6455287	0.10%	0.05%	0.24%
91	6424222	0.10%	0.23%	1.11%
92	6381426	0.10%	0.43%	2.07%
93	6203332	0.10%	0.51%	2.43%

The next step is to calculate the weighting coefficients using the SWARA method. The values of the weighting coefficients for all three criteria are presented in Table 3.

Table 3: Values of weighting coefficients

Criteria	**C1**	**C2**	**C3**
WCj(k)	0.279	0.385	0.335

After calculating and obtaining the values of the weighting coefficients, the next step is to multiply the obtained weighting coefficients by the shares for each product individually. The calculation is shown in Table 4.

Table 4: Weighted percentage values of criteria

Rank	**Code**	**MCDM-Q**	**MCDM-APV**	**MCDM-UP**
1	6975525	3.19%	181%	0.09%
2	6381389	1.77%	0.79%	0.07%
3	6970129	1.54%	0.61%	0.06%
4	6620355	1.51%	0.98%	0.10%
5	6574497	1.45%	0.46%	0.05%
...	...	...	...	...
90	6455287	0.03%	0.02%	0.09%
91	6424222	0.03%	0.08%	0.43%
92	6381426	0.03%	0.15%	0.80%
93	6203332	0.03%	0.17%	0.94%

After weighting the criteria, the next step is to obtain the final percentage values for each product by summing MCDM-Q, MCDM-APV, and MCDM-UP. Then, the final percentage values are sorted from highest to lowest, and their cumulative values are the following step we undertake. All calculations are presented in Table 5. The final task in this section is to conduct the ABC analysis, i.e., classifying products into groups A, B, and C. The classification is performed based on the previously calculated cumulative values. Products classified into groups A, B, and C are also shown in Table 5.

Table 5: Percentage values, cumulative values, and product ranking

Ran k	Code	Final	Final	Cumulativ e	Group
1	6975525	5.09%	5.09%	5.09%	A
2	6381389	2.63%	4.89%	9.98%	A
3	6970129	2.21%	3.65%	13.64%	A
4	6620355	2.59%	2.63%	16.27%	A
5	6574497	1.96%	2.59%	18.86%	A
...	...	...	...	...	...
18	6586991	3.65%	1.60%	43.89%	B
19	6975489	1.94%	1.60%	45.49%	B
20	6970217	1.74%	1.51%	47.00%	B
21	6975524	0.53%	1.50%	48.50%	B
...	...	...	...	...	...
89	6574517	1.25%	0.09%	99.64%	C
90	6455287	0.14%	0.09%	99.73%	C
91	6424222	0.54%	0.07%	99.80%	C
92	6381426	0.97%	0.06%	99.86%	C
93	6203332	1.14%	0.04%	99.90%	C

Table 5 shows which products are classified into each group. Group A consists of 17 products, which require the most attention due to their highest values. Group B includes 31 products, while Group C consists of 45 products, which are those with the lowest values.

5. Single-criterion ABC analysis as sensitivity analysis

After calculating the ABC analysis based on multi-criteria decision-making using the SWARA method, we proceeded to create a single-criterion ABC analysis, which was specifically conducted for each specified criterion (quantity, procurement value, unit price). The first analysis was performed for the quantity criterion for the group of ELECTROLUX products, followed by the analysis for the unit price, and then the analysis for the procurement value criterion for all three product groups, as for the previous analyses. The quantities of all products were summed in the first step, ΣQj. The total sum of all Electrolux product quantities amounts to 961. The sum of procurement values of these products is 134,239, while the sum of unit prices is 28042,570.

The next step is to rank values from the highest to lowest ones, followed by the cumulative value calculation, and then the classification of the products into groups A, B, and C. Table 6 shows the calculated single-criterion ABC analysis for the ELECTROLUX products based on the quantity criterion, Table 7 presents the ABC analysis for the procurement value criterion, and Table 8 displays the analysis for the unit price criterion.

Table 6: ABC analysis for the quantity criterion of the Electrolux product group

Rank	Code	Product Name	UM	Quantity Sold	Share of Q	Ranking	Cumulative	Group

1	6975525	MIXER WITH BOWL ELECTROLUX ESM3300	PCS	110	11.45%	11.45%	11.45%	A
2	6381389	HAND BLENDER ELECTROLUX E4HB1-6GG	PCS	61	6.35%	6.35%	17.79%	A
3	6970129	IRON ELECTROLUX E6SI1-2MN	PCS	53	5.52%	5.52%	23.31%	A
4	6620355	BLENDER ELECTROLUX E4TB1-6ST	PCS	52	5.41%	5.41%	28.72%	A
5	6574497	MIXER ELECTROLUX EHM3300	PCS	50	5.20%	5.20%	33.92%	A
...	...	...	...	...	...	...	...	...
7	6574500	IRON EDB1720 ELECTROLUX	PCS	40	4.16%	4.16%	42.98%	B
8	6574498	BLENDER ELECTROLUX ESB2500	PCS	39	4.06%	4.06%	47.03%	B
9	6975526	MIXER WITH BOWL ELECTROLUX ESM3310	PCS	34	3.54%	3.54%	50.57%	B
...	...	...	...	...	...	...	...	...
28	6574516	BUILT-IN HOB EHF6232FOK ELECTROLUX	PCS	9	0.94%	0.94%	83.77%	C
29	6975522	COFFEE MACHINE EEA111 ELECTROLUX	PCS	7	0.73%	0.73%	84.50%	C
30	6574515	BUILT-IN HOB EHF16240XK ELECTROLUX	PCS	7	0.73%	0.73%	85.22%	C

Table 7: ABC analysis for the procurement value criterion of the Electrolux product group

Rank	Code	Product Name	UM	Procurement Value	Share of APV	Ranking	Cumulative	Group
1	6975525	MIXER WITH BOWL ELECTROLUX ESM3300	PCS	7253	5.40 %	10.12%	10.12%	A
2	6381389	HAND BLENDER ELECTROLUX E4HB1-6GG	PCS	3151	2.35 %	7.13%	17.25%	A
3	6970129	IRON ELECTROLUX E6SI1-2MN	PCS	2433	1.81 %	5.40%	22.65%	A
4	6620355	BLENDER ELECTROLUX E4TB1-6ST	PCS	3923	2.92 %	3.92%	26.58%	A
5	6574497	MIXER ELECTROLUX EHM3300	PCS	1829	1.36 %	3.27%	29.85%	A
...	...	...	...	...	...	...	...	...
10	6742049	MIXER ELECTROLUX EHM3310	PCS	1223	0.91 %	2.17%	42.89%	B
11	6455286	GRILL ETG340 ELECTROLUX	PCS	2289	1.71 %	2.08%	44.97%	B
12	6545996	HANDHELD BATTERY-POWERED VACUUM CLEANER ZB5003SW ELEC	PCS	1487	1.11 %	1.98%	46.95%	B
...	...	...	...	...	...	...	...	...
41	6574510	BUILT-IN OVEN EOB2100COX ELECTROLUX	PCS	1044	0.78 %	0.78%	82.99%	C
42	6424226	BUILT-IN HOB EIT60428C ELECTROLUX	PCS	1593	1.19 %	0.74%	83.72%	C
43	6970208	WASHING	PCS	2797	2.08	0.72%	84.44%	C

		MACHING			%			

Table 8: ABC analysis for the unit price criterion of the Electrolux product group

Rank	Code	Product Name	UM	Unit Price	Share of UP	Ranking	Cumulative	Group
1	6975525	MIXER WITH BOWL ELECTROLUX ESM3300	PCS	65.936	0.24 %	3.86%	3.86%	A
2	6381389	HAND BLENDER ELECTROLUX E4HB1-6GG	PCS	51.648	0.18 %	3.43%	7.29%	A
3	6970129	IRON ELECTROLUX E6SI1-2MN	PCS	45.914	0.16 %	3.32%	10.61%	A
4	6620355	BLENDER ELECTROLUX E4TB1-6ST	PCS	74.444	0.27 %	2.97%	13.58%	A
5	6574497	MIXER ELECTROLUX EHM3300	PCS	36.584	0.13 %	2.93%	16.51%	A
...	...	...	...	...	...	...	...	...
15	6975520	KETTLE EEWA3330 ELECTROLUX	PCS	38.833	0.14 %	2.21%	41.54%	B
16	6742045	KETTLE EEWA3300 ELECTROLUX	PCS	38.475	0.14 %	2.09%	43.63%	B
17	6975515	VACUUM CLEANER ELECTROLUX EEG42EB	PCS	78.251	0.28 %	2.09%	45.72%	B
...	...	...	...	...	...	...	...	...
39	6620358	BUILT-IN HOB EIS6134 ELECTROLUX	PCS	579.638	2.07 %	1.11%	81.71%	C
40	6574514	BUILT-IN HOB EHF6342XOKELECTROLUX	PCS	320.653	1.14 %	1.05%	82.77%	C
41	6574510	BUILT-IN OVEN EOB2100COX ELECTROLUX	PCS	260.875	0.93 %	1.05%	83.82%	C

6. ABC-FUCOM as sensitivity analysis

In this section, the ABC-FUCOM model is applied. It is calculated first the weighting coefficients using the FUCOM method (Durmić, 2019). The values of the weighting coefficients for all three criteria are presented in Table 9.

Table 9: Values of weighting coefficients

Criteria	C1	C2	C3
WCj (k)	0.222	0.510	0.268

After calculating and obtaining the values of the weighting coefficients, the next step is to multiply the obtained weighting coefficients by the shares for each product individually. The calculation is shown in Table 10.

Table 10: Weighted percentage values of criteria

Rank	Code	MCDM-Q	MCDM-APV	MCDM-UP
1	6975525	2.54%	1.45%	0.12%
2	6381389	1.41%	0.63%	0.09%
3	6970129	1.22%	0.49%	0.08%
4	6620355	1.20%	0.78%	0.14%
5	6574497	1.16%	0.37%	0.07%
...	...	...	...	...
89	6574517	0.02%	0.15%	1.37%
90	6455287	0.02%	0.01%	0.12%
91	6424222	0.02%	0.06%	0.57%
92	6381426	0.02%	0.12%	1.06%
93	6203332	0.02%	0.14%	1.24%

After weighting the criteria, the next step is to obtain the final percentage values for each product by summing MCDM-Q, MCDM-APV, and MCDM-UP. Then, the final percentage values are sorted from highest to lowest, and their cumulative values are the following step we undertake. All calculations are presented in Table 11. The final task in this section is to conduct the ABC analysis, i.e., classifying products into groups A, B, and C. The classification is performed based on the previously calculated cumulative values. Products classified into groups A, B, and C are also shown in Table 11.

Table 11: Percentage values, cumulative values and product ranking

Rank	Code	Final	Cumulative	Group
1	6975525	4.37%	4.37%	A
2	6381389	4.11%	8.48%	A
3	6970129	3.33%	11.81%	A
4	6620355	2.32%	14.13%	A
5	6574497	2.32%	16.46%	A
		...	...	...

20	6970217	1.54%	44.33%	B
21	6975524	1.54%	45.87%	B
22	6970363	1.53%	47.40%	B
23	6972292	1.50%	48.90%	B
24	6971813	1.50%	50.39%	B
		...	...	...
89	6574517	0.10%	99.77%	C
90	6455287	0.08%	99.85%	C
91	6424222	0.06%	99.91%	C
92	6381426	0.05%	99.97%	C
93	6203332	0.03%	100.00%	C
		100.00%		

Table 11 shows which products are classified into each group. Group A consists of 19 products, which require the most attention due to their highest values. Group B includes 31 products, while Group C consists of 43 products, which are those with the lowest values. From this, we can conclude that most of the products are in the same groups (A, B, C) in the ABC-SWAR and ABC-FUCOM models.

7. Conclusion

The paper presents an ABC analysis integrated with the SWARA method to ensure that the product ranking results at Mepromex company are as reliable as possible. The results of the ABC analysis combined with the SWARA method show that Group A consists of 17 products, which are the most important and require the most attention. Group B consists of 31 products of less importance, and Group C consists of 45 products with the lowest values. Product P1 (mixer with bowl esm3300) has the highest percentage share of 5.09%, while the product with the lowest percentage share is P77 (cleaner m3dcr200) with 0.04%. After applying and calculating the ABC-SWARA model, a single-criterion ABC analysis was performed for each specified criterion (quantity, procurement value, unit price). The results are as follows: observing the tables, it can be seen that product P1 (mixer with bowl Electrolux esm3300) appears in both analyses (single-criterion ABC and MCDM ABC analysis) in Group A. After conducting the analyses, the results show that there is no product in Group B in both analyses, while products P41-P93 are in Group C in both analyses. Some of these include P41 (built-in oven eob2100cox), P50 (vacuum cleaner bag e201sm), and P93 (built-in OVEN KOCEH70X). Sensitivity analysis was performed using the ABC-FUCOM model, and it can be seen that the products are grouped almost identically to those in SWARA-ABC. Two products changed ranks in all three groups.

In this paper, the ABC analysis contributed to the classification of products based on their importance. The significance of the ABC analysis in combination with MCDM methods is of particular importance due to the complexity among various factors, allowing us to classify products more precisely using the ABC-SWARA model. Additionally, for comparative analysis, it is important to conduct a single-criterion ABC analysis to gain a broader perspective on product ranking. Sensitivity analysis was performed using the ABC-FUCOM model.

This paper indicates that ABC analysis can be applied in various sectors and can significantly contribute to inventory management and decision-making processes. The paper aims to provide support analysis to managers of a company in order to make more reliable decisions and give more attention to the most important products. Managers strive to control various processes, from purchasing, sales to the warehouse by applying various methods to increase the economy and productivity of the business. A model such as SWARA-ABC is of great importance because it includes various components and gives a clear picture of the state of inventory.

In future research, it is possible to use this model to other products in this company to provide a complete analysis and manage inventory in such a company. However, there may be problems with data collection in such companies, given that most of the goods in the shopping mall are of a seasonal nature, and the types of goods and suppliers change in a short period.

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