The Significance of the Integrated Multicriteria ABC-XYZ Method for the Inventory Management Process

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Abstract: Inventory optimization in the supply chain is one of the most important goals in logistical business operations given the fact that optimized inventories directly impact the efficiency and profitability of the business. In the contemporary conditions of business processes, the goal of an enterprise's business operations reflects in the maximal reduction in the level of inventories, simultaneously retaining a certain level of services provided, in order for them to become and remain competitive in the market. Understanding the significance of inventories enables optimal uninterrupted business doing, for which reason exactly the ABC-XYZ method, as one of the ways to efficiently manage inventories, is used in this paper. Given the fact that there are limitations to the ABC classification, the limitation to one single criterion and the non-existence of a demand analysis at determining the needed inventories, the problem is overcome by the introduction of the XYZ classification. The merging of the mentioned classifications results in the integrated ABC-XYZ classification model, which can be used, on the basis of a multi-criteria and multi-dimensional approach, to classify inventories and make a proposal for their optimization.

Keywords: inventory management; management; ABC-XYZ analysis; analytic hierarchical process

1 Introduction

The Globalization process sets new rules of the game for enterprises daily. The most important task of the management of an enterprise is to maximize a profit, and their achievement of such a goal in the contemporary conditions of business operations, is often faced with a large number of limitations. The key question that every enterprise poses and requires an answer to, is the question of how to become better and more successful than the competition. To be competitive in the market today is not a success, but rather question of survival, which is to a large extent is dependent on the enterprise's dilemma: Which inventory level is optimal, to enable profit maximization while keeping captured capital at as low a level as possible?

Inventory management represents a very important segment of the business conducted by modern enterprises and as such, it is crucial for the success of an enterprise's business operations. For that exact reason, it requires close monitoring, as well as, constant improvement in compliance with contemporary standards. The inventory level of the products that an enterprise has should be in accordance with the market needs, i.e. with the estimation of demand for a particular period. The goal of inventory management is to find the quantity of inventories of products that is sufficient to uninterruptedly meet the market requirements and reduce the costs incurred through inventories keeping.

The first step in the determination of the expected demand is the collection and organizing of pieces of information about the previous sale and goods movement through the supply chain. Sales enterprises have in their assortments a great number of articles, so there is a need for such articles to be classified and for establishing a system in which the movement of inventories will be recorded and monitored. Then, an inventory management methodology needs to be defined.

In this work, a methodology based on the periodical review and assessment of product inventories and the anticipation of demand are presented, and a proposal is made for the activities and pace of the fulfillment of inventories derived on the basis of the ABC-XYZ classification. The paper consists of the literature overview, the methodological part and a practical example as well.

The research subject is the analysis of the inventories of the Win Win Shop d.o.o. (limited liability Company) enterprise in the retail chain in the Serbian territory. The company does business in the territories of Bosnia and Herzegovina, Montenegro and Serbia. Currently, there are 101 retail shops in Serbia. The company's assortment offers a large selection of IT equipment, AV equipment, domestic appliances, small household gadgets, video surveillance devices, watches, jewelry, kids' toys, healthcare devices and many other devices. Win Win Shop's vision is to preserve and advance its position in the market. It aspires to improve its core activity, which implies the IT sector, as well as to take the position of a leader in other business niches for the other products in the offer.

Its fundamental goal is to give customers as much as possible for the invested money, while appreciating their time and loyalty. Win Win is a partner with the most famous world brands and producers, such as: HP (laptops, computers, servers, printers, monitors, toner cartridges…), Asus (laptops, netbooks, monitors, motherboard, graphical cards…), Acer (laptops, netbooks, tablets and monitors), Del (laptops and monitors), Toshiba (laptops and monitors), Lenovo (laptops), MSI (laptops, motherboards, graphical cards…), Fujitsu (laptops), Samsung HP (laptops, tablets, mobile phones, monitors, printers, toners…), ViewSonic (monitors and tablets), and many other.

The goal is to make the most favorable offer in all the segments of business doing, excellent prices, deferred payment in installments, a big choice, a wide offer of technical goods.

In accordance with the company's goals, each retail shop needs to keep a certain quantity of inventory, depending on the situation in the market. In order to achieve high profitability, quick adaptations to changes in the market and monitoring changes in the IT sector is what the company needs, reasoning it is necessary that the quantities of inventories should be as small as possible, simultaneously retaining a wide assortment. The considerations related to a reduction in costs are reflected in a reduction in the costs of the distribution and control of the products that make weak contributions to the sales results.

2 The Methodology

The analysis of inventories by means of the ABC classification is a widely used approach. The conventional ABC classification was developed at General Electric in the 1950s. The ABC analysis has been used in inventories management since the 1950s [1]. The traditional ABC ranking of products is conducted on the basis of only one criterion, and it is most frequently the annual usage (AU). In real time business operations, there is quite often a need to take into consideration some other criteria, too, for the defining of the importance and the quantities of the needed inventories of a product, so in a very short time the classical ABC classification was replaced with the multi-criteria ABC classification (multiple criteria inventory classification (MCIC)). The methods combining the known multi-criteria decision-making techniques with the ABC ranking were developed.

One of the known approaches is the application of the analytic hierarchical process (AHP) [2], and the application of the AHP in the inventories management integrated approaches [3]. Certain authors have developed the weighted linear optimization of inventories [4, 5]. Ng suggested a model, named after the NG-model, according to which, all criteria are translated into the scalar result of each element undergoing classification [6]. The extension of the NG-model presupposes that the effects of weights should be maintained until the final solution [7].

There is also an approach to the ABC classification that uses artificial neural networks (ANN) [8] and artificial-intelligence-based classification techniques [9]. The newer models that deal with the problem issues of the ABC classification introduce fuzzy logic so as to include criteria that are nominal, those depending on the preferences and experiences of the management, those whose implementation can be simple [10]. The two-dimensional ABC-XYZ [11, 12] and the multidimensional approaches ABC-XYZ-VED [13] have also been developed.

2.1 The ABC Classification

The significance of the ABC analysis is reflected in the fact that it enables the monitoring of inventories as well as the determination of potentially useful inventories and those that do not contribute to the goals but rather are costs and are a burden for the enterprise. The ABC classification enables inventories management at several levels, in compliance with their importance. Inventories are categorized into groups according to the Pareto principle, which is based on the observation that there are a small number of elements that dominate in the achievement of the achieved results in different situations.

The Pareto principle represents the rule of 80:20, which means that 20% of the sold articles contribute 80% to the sales results. The ABC analysis in combination with the Pareto rule enables the forming of three groups of products: usually, around 20% of the products that contribute 80% to the total value belong to Group A; into Group B, the products that contribute around 15% are classified; ultimately, Group C consists of the products whose contribution is about 5%. This distribution is arbitrary, and the groups are defined in accordance with the enterprise's needs.

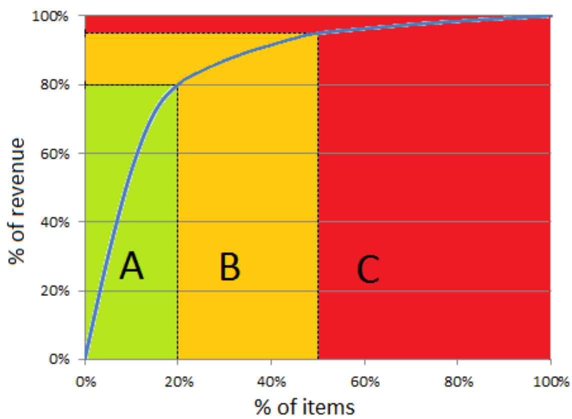

Figure 1
The example of the ABC curve

There are a few steps to follow in conducting an ABC analysis:

1) The selection of an eligible criterion. The criterion of choice usually depends on the purpose of the analysis. For example, the scrap rate is often used for quality control; the percentage (%) of a market share is used for marketing research; the annual usage is to a large extent used for inventories management.

2) The collection and checking of required data. All collected data must be accurate and the units of measure must be consistent.

3) Making the necessary calculations. When inventories management is concerned, this includes:

The calculation of the annual usage, where:

$$GV_i = c_i * x_i, \quad (1)$$

(c_i – the unit price and x_i – the volume of demand). The ranking of the elements is carried out in descending order according to the AU value. A calculation is also made of the cumulative value according to the AU, and their value in percentages.

4) The determination of the number of groups and the breakpoint for each of the groups, i.e. the rule of the classification for each group.

5) The classification of the elements into the groups on the basis of the set rule.

6) Adaptation in accordance with some other conditions [14].

The ABC method is very well-known for its simplicity, but the same is criticized for the fact that it uses only one criterion for classification. Ever since Flores and Whybark [15] suggested that more than one criterion should be perceived, this field has actively been researched in [16]. That the ABC analysis should encompass several criteria has been widely accepted.

The methodology used in this paper includes the three main steps after the identification of the relevant criteria. First, the weights of certain criteria should be determined; second, each element per each criterion should be assigned a value. If elements are measured by different units, the second step includes the repeated scaling on the scale from 0 to 1, or 0 to 100. The final step is the combining of the weight coefficients and the values of the elements per certain criteria and obtaining the total values of the weights as per each element.

This approach reveals each element of inventories per each criterion, after which different results are combined by using the weighted additive function. Many analysts use the framework provided by the Analytic Hierarchy Process (the AHP method) [17]. The AHP is used so as to compare the criteria with the aim to determine the weight coefficient of each criterion. A comparison of the pairs of a thousand elements by adhering to each criterion is an impossible task to do. Instead of that, alternatives are assessed according to each criterion by using weights. These weight coefficients are determined once and the same can be used as long as the criteria themselves or the treatment of the same by the management do not or does not, respectively, change. During the decision-making process, it will express the joint conclusion of multiple experts as to the optimal solution [18].

The result can be used in order to rank the elements according to different categories. First, the decision maker identifies all the criteria important for the given problem. Second, the criteria are arranged following a certain hierarchy.

Third, a series of the comparison of pairs transforms subjective estimations into a set of weight coefficients [2].

In the process of comparing in pairs, the value from an appropriate comparison scale from 1 to 9 is assigned as a result of the comparison of the two alternatives (or two criteria) with each other. After the matrix of the comparison in pairs is formed, the weights of the alternatives (or criteria) are calculated.

Table 1

Saaty's Evaluation Scale [19]

Degree of preference (aij)	Verbal Judgment	Description
1	Of the same significance	Two elements have identical significance with respect to the goal.
3	Weak dominance	An experience or a judgment is slightly more in favor of one element in comparison to another.
5	Strong dominance	An experience or a judgment is substantially more in favor of one element in comparison to another.
7	Demonstrated dominance	The dominance of one element is confirmed in practice.
9	Absolute dominance	The dominance of the highest degree.
2,4,6,8	Intermediate value	A compromise or a further classification is needed.

The matrix A of the dimensions nxn is formed at the level of the criteria, in which there are the elements of $a_{ii} = 1$ (the elements of the matrix on the main diagonal are units), and the elements of a_{ji} are the reciprocal values of a_{ij}, i≠j, i, j=1, 2, ..., n, Equation (2).

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ {}^{1}/_{a_{12}} & \cdots & \cdots & a_{2n} \\ \vdots & \ddots & \ddots & \vdots \\ {}^{1}/_{a_{1n}} & \cdots & \cdots & a_{nn} \end{bmatrix} \quad (2)$$

The coefficient weights for the given matrix of comparison are calculated according to the formula: $A\omega = \lambda_{max}\omega$, where λ_{max} is the biggest eigenvalue of A and ω is the eigenvector corresponding to λ_{max}. Because of the features of the *A* Matrix, it follows that $\lambda max = n$, and the difference λmax - n is used in measuring the consistency of estimations. In the case of inconsistency, the closer λmax is to n, the more consistent the estimation is.

The Consistency Index (CI) represents the measure of the deterioration of n from λ_{max}, and can be represented by the following formula:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (3)$$

By means of the Consistency Index, it is also possible to calculate the consistency ratio

$$CR = CI/RI \tag{4}$$

Where, RI is the random consistency index. The CR value should be less than 0.1, or otherwise the evaluation of the criteria is considered as inconsistent and the same should be repeated [20].

It is presumed that there are N elements, and that they should be classified into the A, B or C groups, depending on the classification according to the J criterion. Any one of the elements according to any one of the criteria is labeled with x_{ij}. There is a presumption that all the criteria are positively linked to the level of importance, i.e. the higher the value of the element per certain criterion, the bigger a chance for that element to be classified into Class A.

The proposed approach with weight coefficients is used in order to ensure that each element, as per several criteria, generates one result, called the optimal result of the element (5). The weight coefficients used for optimization are calculated as a group of coefficients whose total must equal 1 and which satisfy the conditions, Equations (6), (7) and (8) [4].

$$\max \qquad S_i = \sum_{j=1}^{J} w_{ij} * x_{ij} \tag{5}$$

$$\sum_{j=1}^{J} w_{ij} = 1, \tag{6}$$

$$w_{ij} - w_{i(j-1)} \geq 0, \quad j = 1, \dots, (J-1) \tag{7}$$

$$w_{mj} \geq 0, \;\; j = 1, \dots, J \tag{8}$$

2.2 The XYZ Classification

The quantity of products in inventories in one sales enterprise should be in compliance with demand. The XYZ is used in those sales enterprises in which demand can dramatically vary from one to another of certain products. The XYZ analysis distributes the elements into the three groups, according to the characteristics of consumption. Group X consists of the products for which there is continuous demand, characterized by very slight oscillations, for which reason it is possible to forecast demand for this group with great accuracy; into Group Y, the products sold discontinuously, with fluctuations in demand, are classified, and forecasts for this group of products are of middle-degree accuracy; Group Z encompasses the products sold from time to time, and with big differences in the volume of demand, so the forecasting of demand is very difficult and with little accuracy [21].

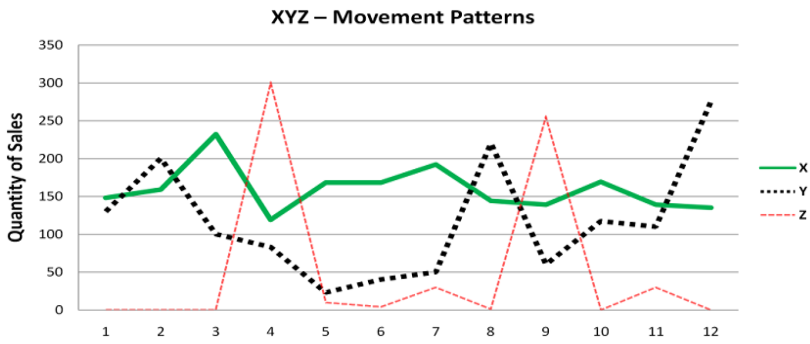

Figure 2
The demand patterns of XYZ products [21]

In the XYZ analysis, ranking is conducted according to the demand variability criterion viewed against average demand. It is needed to determine the variation coefficient, which is calculated as the ratio of the standard deviation and average sales. The variation coefficient is a relative measure of the dispersion of the probability distribution.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2} \tag{9}$$

$$CV = \frac{\sigma}{\bar{x}} \tag{10}$$

The next step is the defining of the product groups and their forming on the basis of the obtained calculations. The proposed division is: Group X from 0% to 10% for the products whose demand can accurately be estimated; Group Y from 10% to 25% for the products whose demand can relatively accurately be predicted; Group Z from 25% to ∞ for the products whose demand can be predicted with very little precision [22]. As in the case of the ABC classification, ranks are arbitrary.

2.3 The Integrated ABC-XYZ Approach

The integrated ABC-XYZ approach is used to determine the activities for each of the defined groups of articles in a paired comparison matrix.

Group A/X consists of those elements with a big share in the total value, continuous consumption and the great accuracy of the demand forecast. These products make it possible to precisely plan and order, so there is no need to keep large safety quantities of inventories.

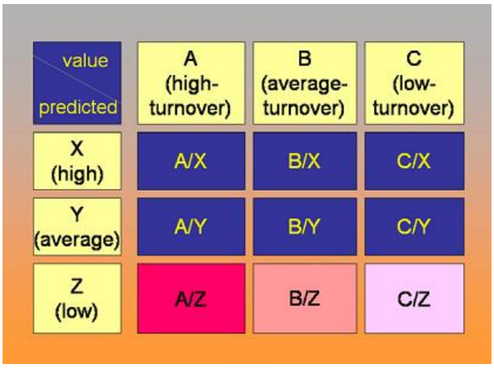

Figure 3
The combined ABC and XYZ analyses [23]

Group A/Y includes the products with a big share in the total value, but their consumption is discontinuous and the precision of their forecasting is lower. This group of products should be dedicated adequate attention when planning is concerned, so as to achieve purchase prices at the lowest cost possible.

Group A/Z consists of those products with a high share in the total value, but they are sold from time to time and demand for them can be forecasted with little accuracy. Inventories management is the most complicated within this group.

Group B/X consists of the products with a middle share in the total value, continuous consumption, demand for which is forecasted with great accuracy. When this group of products is concerned, the dynamics of purchase should be determined, simultaneously with determining the smallest inventory levels.

Group B/Y consists of the products with a middle share in the total value, discontinuous consumption and a middle-degree of accuracy for their forecasting demand.

Group C/X consists of the products with a small share in the total value, continuous consumption and the great accuracy of the forecasting of needs. These products should be ordered in accordance with the needs.

The products belonging to the groups B/Z, C/Y and C/Z have negligible impacts on an enterprise’s business operations, so, they are purchased rarely and their planning is frequently neglected or left to suppliers in combination with some other product.

In general, the categories AX, BX and AY can be said to qualify for just-in-time approaches, whereas efforts must be minimized for the items of low value with bad demand predictability, which are located in the CZ category. All the remaining material groups in between must be individually investigated.

The following table summarizes the characteristics of the nine different material classes after combining the ABC-Analysis with the XYZ-Analysis.

Table 2
Part Characteristics in the Combined ABC-XYZ-Matrix [24]

	A	**B**	**C**
X	high value, high predictability continuous demand	medium value, high predictability continuous demand	low value, high predictability continuous demand
Y	high value, medium predictability fluctuating demand	medium value, medium predictability fluctuating demand	low value, medium predictability fluctuating demand
Z	high value, low predictability irregular demand	medium value, low predictability irregular demand	low value, low predictability irregular demand

In addition to that, different inventory strategies are also possible. The matching target inventory levels are shown in Table 3.

Table 3
Part Characteristics in the Combined ABC-XYZ-Matrix [25]

	A	**B**	**C**
X	low inventory	low inventory	low inventory
Y	low inventory	medium inventory	high inventory
Z	medium inventory	medium inventory	high inventory

In the continuation of the paper, we are going to demonstrate the application of the integrated ABC-XYZ approach on a practical example.

3 Empirical Study

The research was being conducted during the period of 12 months in the course of the year 2015, and the results were being collected on a monthly basis. In order to determine the optimal quantities of the products, the analysis was carried out as per product groups. The data analyzed in the paper relate to 44 articles from within the group of IT products consisting of Laptop/Notebook computers, and they consist of the price per unit of product and the realized monthly demand.

In order to include additional criteria in the classification as well, the data were collected about the delivery time (LT) from the supplier and the criticality (C) of certain articles. The criticality criterion is qualitative and is determined on the 3-value scale: 0.1, 0.5 and 1, where 0.1 represents the article which is not critical for the total offer of the enterprise and 1 is the article which is the key one for the enterprise's offer. The collected data and their transformed values are accounted for in Table 6 below.

For the ABC classification, the following parameters are set:

- Group A consists of the elements encompassing 0-80% of the obtained total value of the elements.

- Group B consists of the elements encompassing 80-95% of the obtained total value of the elements.
- Group C consists of the elements encompassing 95-100% of the obtained total value of the elements.

For the XYZ classification, the following parameters are set [25]:

- Group X consists of the elements whose variation coefficient is less than 0.5.
- Group Y consists of the elements whose variation coefficient is between 0.5 and 1.
- Group Z consists of the elements whose variation coefficient is bigger than 1.

Table 4

The initial data and their transformed values

Item No.	Total	Price (€)	Annual usage (€)	Lead time (day)	Criticality	AU transformed	LT transformed	C transformed
1	8	810.18 €	6,481.40 €	15	0.5	0.01	1	0.44
2	42	416.58 €	17,496.50 €	15	1	0.05	1	1.00
3	53	441.58 €	23,403.92 €	15	0.5	0.07	1	0.44
4	134	333.25 €	44,655.50 €	7	1	0.14	0.2	1.00
5	18	391.58 €	7,048.50 €	7	0.5	0.01	0.2	0.44
6	7	433.25 €	3,032.75 €	7	0.5	0.00	0.2	0.44
7	69	365.75 €	25,236.75 €	5	1	0.08	0	1.00
8	28	407.58 €	11,412.10 €	5	1	0.03	0	1.00
9	59	332.32 €	19,606.68 €	5	1	0.06	0	1.00
10	33	366.65 €	12,099.45 €	5	1	0.03	0	1.00
11	68	333.25 €	22,661.00 €	5	1	0.07	0	1.00
12	25	333.25 €	8,331.25 €	5	0.1	0.02	0	0.00
13	9	879.53 €	7,915.80 €	7	1	0.02	0.2	1.00
14	5	842.50 €	4,212.50 €	7	0.5	0.00	0.2	0.44
15	4	861.02 €	3,444.07 €	7	0.5	0.00	0.2	0.44
16	67	349.92 €	23,444.42 €	5	0.1	0.07	0	0.00
17	21	346.20 €	7,270.20 €	5	0.1	0.02	0	0.00
18	37	313.80 €	11,610.60 €	5	0.1	0.03	0	0.00
19	409	566.58 €	231,732.58 €	5	1	0.78	0	1.00
20	30	374.92 €	11,247.50 €	5	0.1	0.03	0	0.00
21	23	458.25 €	10,539.75 €	5	1	0.03	0	1.00
22	12	578.61 €	6,943.30 €	7	0.5	0.01	0.2	0.44
23	7	1,203.61 €	8,425.26 €	15	0.5	0.02	1	0.44
24	6	1,374.92 €	8,249.50 €	15	0.1	0.02	1	0.00
25	6	849.92 €	5,099.50 €	15	0.1	0.01	1	0.00
26	5	1,268.43 €	6,342.13 €	15	0.1	0.01	1	0.00
27	3	1,833.24 €	5,499.73 €	15	0.5	0.01	1	0.44

28	3	2,040.82 €	6,122.45 €	15	0.5	0.01	1	0.44
29	10	541.58 €	5,415.83 €	7	0.1	0.01	0.2	0.00
30	5	722.13 €	3,610.67 €	7	0.1	0.00	0.2	0.00
31	4	1,879.62 €	7,518.47 €	7	0.1	0.02	0.2	0.00
32	12	1,374.92 €	16,499.00 €	7	0.5	0.05	0.2	0.44
33	8	1,933.25 €	15,466.00 €	7	0.5	0.04	0.2	0.44
34	5	1,366.58 €	6,832.92 €	7	0.5	0.01	0.2	0.44
35	2	1,412.42 €	2,824.83 €	7	0.1	0.00	0.2	0.00
36	155	308.25 €	47,778.75 €	5	1	0.15	0	1.00
37	186	308.25 €	57,334.50 €	5	1	0.19	0	1.00
38	823	308.25 €	253,689.75 €	5	1	0.86	0	1.00
39	144	333.25 €	47,988.00 €	5	1	0.15	0	1.00
40	118	341.58 €	40,306.83 €	5	0.5	0.13	0	0.44
41	1181	249.91 €	295,141.74 €	5	0.5	1.00	0	0.44
42	196	366.58 €	71,850.33 €	5	1	0.24	0	1.00
43	103	366.58 €	37,758.08 €	5	1	0.12	0	1.00
44	115	366.58 €	42,157.08 €	5	1	0.13	0	1.00

In order to determine the weights of the criteria, the AHP procedure was conducted, and according to it, the weight value of 0.387 was obtained for the AU criterion; the weight value of 0.169 was obtained for the Lead Time criterion, and for the Criticality criterion, that value was 0.443. The score of each article and the group it belongs to according to the carried out ABC classification are presented in Table 5 below.

Table 5
The results of the ABC classification

Item No.	Total	Price (€)	AU	LT	C	Score	Group
2	42	416.58 €	17,496.50 €	15	1	0.446	A
4	134	333.25 €	44,655.50 €	7	1	0.445	A
13	9	879.53 €	7,915.80 €	7	1	0.443	A
7	69	365.75 €	25,236.75 €	5	1	0.443	A
8	28	407.58 €	11,412.10 €	5	1	0.443	A
9	59	332.32 €	19,606.68 €	5	1	0.443	A
10	33	366.65 €	12,099.45 €	5	1	0.443	A
11	68	333.25 €	22,661.00 €	5	1	0.443	A
19	409	566.58 €	231,732.58 €	5	1	0.443	A
21	23	458.25 €	10,539.75 €	5	1	0.443	A
36	155	308.25 €	47,778.75 €	5	1	0.443	A
37	186	308.25 €	57,334.50 €	5	1	0.443	A
38	823	308.25 €	253,689.75 €	5	1	0.443	A
39	144	333.25 €	47,988.00 €	5	1	0.443	A

42	196	366.58 €	71,850.33 €	5	1	0.443	A
43	103	366.58 €	37,758.08 €	5	1	0.443	A
44	115	366.58 €	42,157.08 €	5	1	0.443	A
3	53	441.58 €	23,403.92 €	15	0.5	0.201	A
23	7	1,203.61 €	8,425.26 €	15	0.5	0.198	A
1	8	810.18 €	6,481.40 €	15	0.5	0.198	A
28	3	2,040.82 €	6,122.45 €	15	0.5	0.198	A
32	12	1,374.92 €	16,499.00 €	7	0.5	0.198	B
27	3	1,833.24 €	5,499.73 €	15	0.5	0.197	B
33	8	1,933.25 €	15,466.00 €	7	0.5	0.197	B
5	18	391.58 €	7,048.50 €	7	0.5	0.197	B
22	12	578.61 €	6,943.30 €	7	0.5	0.197	B
34	5	1,366.58 €	6,832.92 €	7	0.5	0.197	B
14	5	842.50 €	4,212.50 €	7	0.5	0.197	B
15	4	861.02 €	3,444.07 €	7	0.5	0.197	B
6	7	433.25 €	3,032.75 €	7	0.5	0.197	C
40	118	341.58 €	40,306.83 €	5	0.5	0.197	C
41	1181	249.91 €	295,141.74 €	5	0.5	0.197	C
24	6	1,374.92 €	8,249.50 €	15	0.1	0.001	C
26	5	1,268.43 €	6,342.13 €	15	0.1	0.001	C
25	6	849.92 €	5,099.50 €	15	0.1	0.001	C
31	4	1,879.62 €	7,518.47 €	7	0.1	0.000	C
29	10	541.58 €	5,415.83 €	7	0.1	0.000	C
30	5	722.13 €	3,610.67 €	7	0.1	0.000	C
12	25	333.25 €	8,331.25 €	5	0.1	0.000	C
16	67	349.92 €	23,444.42 €	5	0.1	0.000	C
17	21	346.20 €	7,270.20 €	5	0.1	0.000	C
18	37	313.80 €	11,610.60 €	5	0.1	0.000	C
20	30	374.92 €	11,247.50 €	5	0.1	0.000	C
35	2	1,412.42 €	2,824.83 €	7	0.1	0.000	C

After the multi-criteria ABC classification, the groups were formed, in which Group A contains 21 articles, which accounts for 47.73% of the total number of the analyzed articles; Group B contains 8 articles and 18.18% of the total number of the articles; and Group C consists of 15 articles and accounts for 34.1%.

While performing the XYZ analysis, the data needed are those about the monthly sales in the observed period. The arithmetic mean and the standard deviation for each one of the determined articles are calculated. Then, the variation coefficient is calculated, on the basis of which coefficient products undergo the classification into the groups X, Y and Z, according to the set parameters and the results of the classification are displayed in Table 6 below.

Table 6
The results of the XYZ classification

Item No.	Arithmetic mean	Standard deviation	Variation coefficient	Group
17	1.75	0.829	0.47	X
19	34.08	11.594	0.34	X
36	12.92	5.560	0.43	X
38	68.58	17.217	0.25	X
39	12.00	5.788	0.48	X
41	98.42	19.543	0.20	X
42	16.33	7.930	0.49	X
43	8.58	3.523	0.41	X
2	3.50	2.693	0.77	Y
4	11.17	7.548	0.68	Y
5	1.50	1.118	0.75	Y
7	5.75	5.182	0.90	Y
8	2.33	2.211	0.95	Y
9	4.92	4.406	0.90	Y
10	2.75	2.005	0.73	Y
11	5.67	4.230	0.75	Y
12	2.08	1.706	0.82	Y
21	1.92	1.498	0.78	Y
32	1.00	0.816	0.82	Y
37	15.50	8.865	0.57	Y
40	9.83	5.505	0.56	Y
44	9.58	6.251	0.65	Y
1	0.67	0.943	1.41	Z
3	4.42	4.591	1.04	Z
6	0.58	0.759	1.30	Z
13	0.75	1.090	1.45	Z
14	0.42	0.640	1.54	Z
15	0.33	0.624	1.87	Z
16	5.58	6.304	1.13	Z
18	3.08	3.328	1.08	Z
20	2.50	2.843	1.14	Z
22	1.00	1.080	1.08	Z
23	0.58	0.759	1.30	Z
24	0.50	0.645	1.29	Z
25	0.50	0.957	1.91	Z
26	0.42	0.640	1.54	Z
27	0.25	0.595	2.38	Z
28	0.25	0.433	1.73	Z

29	0.83	1.213	1.46	Z
30	0.42	0.493	1.18	Z
31	0.33	0.850	2.55	Z
33	0.67	1.929	2.89	Z
34	0.42	0.862	2.07	Z
35	0.17	0.373	2.24	Z

After the XYZ analysis, which also introduces the level of demand in the consideration of the inventories, the three groups of articles are formed: the X group – to which the articles with high and relatively stable demand belong, and in which, in this case, there are 8 articles, which accounts for 18.18% of the total number of the analyzed articles; group Y – which is characterized by the articles following a particular trend of demand, namely the 14 such articles, accounting for 31.82% of the total number of the articles; and the C group, in which demand is irregular and unpredictable, with 22 articles, accounting for 50% of the total number of the analyzed articles.

Table 7
The result of the integrated ABC-XYZ analysis is given in the table

Item No.	The score obtained through the ABC classification	Variation coefficient	ABC classification	XYZ classification
19	0.443	0.340	A	X
36	0.443	0.430	A	X
38	0.443	0.251	A	X
39	0.443	0.482	A	X
42	0.443	0.486	A	X
43	0.443	0.410	A	X
2	0.446	0.769	A	Y
4	0.445	0.676	A	Y
7	0.443	0.901	A	Y
8	0.443	0.948	A	Y
9	0.443	0.896	A	Y
10	0.443	0.729	A	Y
11	0.443	0.746	A	Y
21	0.443	0.781	A	Y
37	0.443	0.572	A	Y
44	0.443	0.652	A	Y
1	0.198	1.414	A	Z
3	0.201	1.039	A	Z
13	0.443	1.453	A	Z
23	0.198	1.301	A	Z
28	0.198	1.732	A	Z

5	0.197	0.745	B	Y
32	0.198	0.816	B	Y
14	0.197	1.536	B	Z
15	0.197	1.871	B	Z
22	0.197	1.080	B	Z
27	0.197	2.380	B	Z
33	0.197	2.894	B	Z
34	0.197	2.069	B	Z
17	0.000	0.474	C	X
41	0.197	0.199	C	X
12	0.000	0.819	C	Y
40	0.197	0.560	C	Y
6	0.197	1.301	C	Z
16	0.000	1.129	C	Z
18	0.000	1.079	C	Z
20	0.000	1.137	C	Z
24	0.001	1.291	C	Z
25	0.001	1.915	C	Z
26	0.001	1.536	C	Z
29	0.000	1.456	C	Z
30	0.000	1.183	C	Z
31	0.000	2.550	C	Z
35	0.000	2.236	C	Z

The results of the integration of the ABC and XYZ classifications accounted for in Table 6 enable the formation of the 9 groups of products, where it is possible to suggest a special inventories management strategy with respect to each group.

Table 8
The division of the articles from the aspect of the multi-criteria ABC-XYZ analysis

	A	B	C
X	19,36,38,39,42,43		41, 17
Y	2,4,7,8,9,10,11,21,37,44	32,5	40, 12
Z	13,3,23,1,28	27,33,22,34,14,15	6,24,26,25,31,29,30,16,18,20,35

The results presented in the table show that Group AX contains 6 products, which account for 13.63% of the total number of the analyzed articles; Group AY consists of 10 products, accounting for 22.72%; these two groups of products represent those products that are dedicated greatest attention to from the logistical point of view. There is constant and predictable demand for these products, and they have a high share in the total financial result of the enterprise. There is a need for the constant monitoring of these articles and for the establishment of such a system of purchase that will be continual, monitoring demand according to quantities.

The articles from the AZ group, namely the 5 articles found in the group, are those with a high yield because their unit price is high but demand for them appears from time to time. A proposal is made with respect to these articles that they should have minimal inventories depending on demand. The BY articles require the keeping for safety inventories. The BZ, CY and CZ groups require the least attention, so they can also be analyzed. Some articles can be declared as unneeded and they can be exempt from making further orders, whereas when the other articles are concerned, it is possible to form group orders so as to reduce the costs of purchase, simultaneously forming certain inventories in order to fulfill the requirements of demand.

Conclusion

Our contemporary, competitive environment calls for efficiency in the circulation of goods from the supplier to the consumer, for all the segments of the supply chain. In order to achieve the targeted level of service towards consumers, it is necessary that inventories should be managed in a satisfactory and effective manner. In the search for a balance between these two contradictory goals, managers draw on various techniques, which, unfortunately, are often experiential.

Supply chain management is a process of an efficient integration of producer and supplier; and storeroom and buyer, in such a manner that produced goods are distributed in optimal quantities to reduce the costs of business operations, while simultaneously satisfying the buyer.

Inventories play an exceptionally big role in retail business enterprises. Losses from inventories, accounting for up to 1% of retail sales, are assessed as good, while in numerous retail shops the same can account for over 3% of sales. According to some research studies, leading enterprises in the retail field lose from 10% to 25% of their profits due to the inappropriate management of their inventories.

Today, inventory management is one of the most important tasks an enterprise is faced with, on a daily basis. The main goal of inventory management is to minimize the volume and the time of the engagement of working capital in inventories. Consequently, if inventories are treated in a poor manner, interruptions in production are possible, as well as, the loss of inventories due to being stored for too long. In order to avoid that loss, there are numerous systems and methods for inventory management, the ABC analysis being one of the most popular.

There are, however, limitations to the ABC analysis, which are overcome by introducing the XYZ analysis. The XYZ can be said to be a secondary analysis of inventories, which enables the following step in the inventories analysis – the application of the demand variability criterion in comparison with the average level of demand. A symbiosis of the two analyses results in the integrated model for the ABC-XYZ for the classification and optimization of inventories. The purpose of the application of this method is the establishment of the optimal inventory level, which is one of the key conditions for cost reductions within an enterprise.

The presented inventory analysis system, focused on Laptop/Notebook computers, is indicative of the practical application of the ABC-XYZ analysis. As we can see, the products that should be paid greater attention to, as well as, those that should be paid lesser attention to, in the purchase operation, have been identified. Moreover, we have also determined which products are not necessary in the product mix.

Given the fact that there are few significant possibilities for reducing costs in an Enterprise, the optimization of inventories represents one of the key ways for an Enterprise to be more profitable. The application of the ABC-XYZ analysis would improve the decision-making process in an enterprise, with respect to its inventories domain, which consequently contributes to a reduction in costs and assures, a better competitive position for an Enterprise.

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