VARIOUS METHODS FOR ABC ANALYSIS OF INVENTORY IN MS EXCEL WITH EXAMPLES

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ABSTRACT. The technologies in IT industry play an important part in all areas of business and education in the contemporary world. It is hard to imagine most of the activities going smoothly without computers and software. The purpose of this paper is to present an idea for inventory ABC analysis. A sample dataset is used. A classification of inventory by empirical and graphical method in MS Excel is carried out. The application of ABC analysis in inventory management leads to a differentiation of inventories into three groups—the most essential, the least essential for the activities of the organization and all between them. Depending on the level of importance of the inventories, different approaches for their management are recommended. This leads to the need to optimize logistic costs. The proposed approach can be used in the educational processes for students and also for real practical applications in inventory management in logistics.

1. Introduction. Inventory management is a combination of complex processes and activities which are important elements in the logistical system of each organisation in the contemporary economy.

According to some authors the meaning of inventory is in the following: "Stocks are supplies of goods and materials that are held by an organisation. They are formed whenever the organisation's inputs or outputs are not used at the time they become available. An Inventory (nomenclature) is a list of things held in stock" [6].

Inventories are found in every logistics system as they represent the static state of material flow and they are major management objects in logistics. This determines their importance and is the main reason for the continuous theoretical and practical interest in the problems related to their management. There are different concepts and methods for inventory management.

However, the first step in inventory management is to classify their nomenclature and to group them and for each of these a set of management models and methods is recommended. The classical methods for classifying the inventories' nomenclature are the well-known ABC analysis method and XYZ analysis method [1, 4, 5] and some of their more recent modifications which are known in the literature, such as FSN, VED, HML, SDE analysis methods, etc. [7, 8, 9, 10].

The application of ABC analysis is a laborious process, especially in the presence of a volumetric inventory. With the help of information technology, this method can be applied without serious difficulty. The benefits of this analysis are as follows: "An ABC analysis puts items into categories that show the amount of effort worth spending on inventory control" [6]. The application of ABC analysis in inventory management and identifying the most important and the least important inventories leads to optimising the costs of their management.

In this report the author aims to present an opportunity to perform an ABC analysis of inventories' nomenclature using MS Excel. The proposed method can be used both in the students teaching process and in the actual inventory management in logistics.

2. Essence of ABC analysis and methods of classification of inventory nomenclature. The ABC method of analysis is based on the well-known in the economy Pareto rule or 80/20 rule. According to the 80/20 rule, 20% of the elements composing a phenomenon determine 80% of its occurrence. With regard to stock inventories, the 80/20 rule can be interpreted in the following ways: 20% of the maintained inventories are related to 80% of the total cost of purchasing all types of inventories; 20% of

the maintained inventories are related to 80% of the total management costs of all types of inventories, etc.

The ABC method is a way of analysing and controlling the status of inventories, which is boiled down to the distribution of the nomenclature of all stock inventories into three groups A, B and C on the basis of some formal algorithm.

The first stage of the application of this method involves the choice of a classification criterion. The classification criterion should be chosen in accordance with the objectives of inventory management and may be: total value of inventories of each kind; total costs associated with each type of inventory; profitability of each type of inventory, etc.

The second stage of the implementation of the ABC method is connected with the ordering of the nomenclature of stock inventories in descending order according to the selected classification criterion. For that purpose, it is necessary to determine the importance of each item in the inventory nomenclature according to the chosen classification criterion. For example, if a classification of the total value of inventories is made, the monetary total value of inventories should be determined from each item of the nomenclature corresponding to the average level of inventories of that type, etc.

In the third stage, the nomenclature of all inventories is divided into three groups A, B and C, and subsequently, for each of the groups of inventories appropriate management methods are set out, which are inspected in detail in the specialized literature. In Group A, inventories are of the highest significance and importance to the organization, group B refers to inventories of intermediate importance, and group C refers to inventories that are the least important to the organization.

In the literature there are three basic methods for classification of the stock nomenclature—empirical method, graphical method and differential method [2, 3].

Empirical method. It is the easiest one to use and is expressed in the following. In Group A, the first 20% of the descending order of inventory is regarded. Group B accounts for the next 30% of the descending order of inventory nomenclature. Group C refers to the last 50% of the descending order of inventory.

Graphical method. In this method, after the stock inventory nomenclature is arranged in descending order according to the chosen criterion, the relative indexes q_i (as %) are calculated—the relative share of

the ith type in the total value of all stock inventories according to the selected criterion (i = 1, 2, ..., N, where N is the number of inventories in the nomenclature).

It is calculated by the formula

$$q_i = \frac{c_i}{\sum_{i=1}^{N} c_i} \times 100, \tag{1}$$

where c_i denotes the ith inventory type according to the selected classification criterion.

The quantities q_i are summed up in increasing order and a summary part of the total value of the inventory in percentage $\sum q_i$ is obtained, according to the chosen criterion. In the graphical method, the obtained quantities are plotted on the ordinate axis of the coordinate system, and the indexes 1, 2, ..., N are plotted on the abscissa. The points with coordinates $(i; \sum q_i)$ of the coordinate system merge lightly with the cumulative curve $OO'D$ (point $O(0;0)$, $D(N; \sum q_N)$, $\sum q_N = 100\%$), which is generally concave. Then a tangent l_1 is constructed to the curve $OO'D$, which is parallel to OD. The abscissa of the tangent point O' shows the boundary between groups A and B, and the ordinate of this point shows the total part of the inventories of Group A according to the chosen classification criterion.

In order to continue dividing the stock inventory nomenclature into groups, it is necessary to connect the points O' and D with a straight line, and then construct a tangent l_2 to the curve $OO'D$, parallel to $O'D$. The abscissa of the tangent point O'' shows the boundary between groups B and C, and the ordinate of this point shows the total part of inventories of groups A and B according to the chosen classification criterion.

Differential approach—this approach is realised in the following manner:

The total value of the stock inventories from all types is determined according to the criteria chosen for classification $\sum C_i$.

The average value of one type of the stock inventory is calculated by the formula:

$$p = \frac{\sum C_i}{N}, \tag{2}$$

where N is the total number of different types of inventories.

All types of stock inventories, for which the value of the classification criterion is at least 6 times bigger than p, are associated with group A.
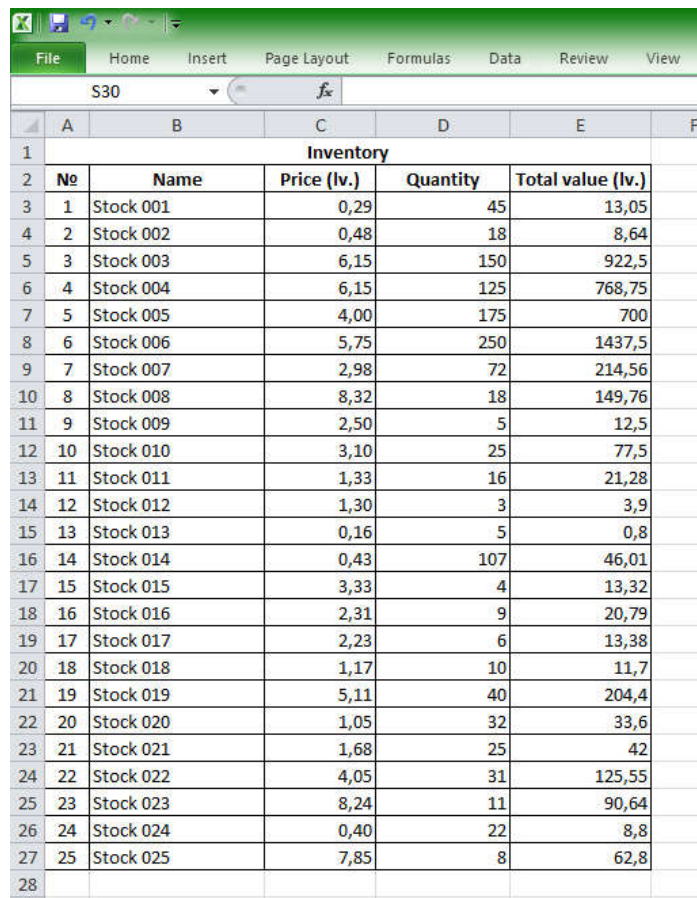
All types of stock inventories, for which the value of the classification criterion is maximum $0.5p$, are associated with group C.

All other stock inventories are associated with group B.

The basic positive point of this approach is its simplicity and also the fact that there is no need to arrange the nomenclature of the stock inventories in descending order of the total value of the classification criterion.

3. Executing ABC analysis in MS Excel. The classification of the inventory's nomenclature by empirical, graphical and differential method in the MS Excel will be presented on the basis of sample data. A 25-item nomenclature has been intentionally chosen in order to be able to visualize the results of each stage.

Let's assume that information for the unit price and average inventory level of each type is available (Fig. 1). The total value of the inventories of each item in the nomenclature is defined as a product of price and quantity.
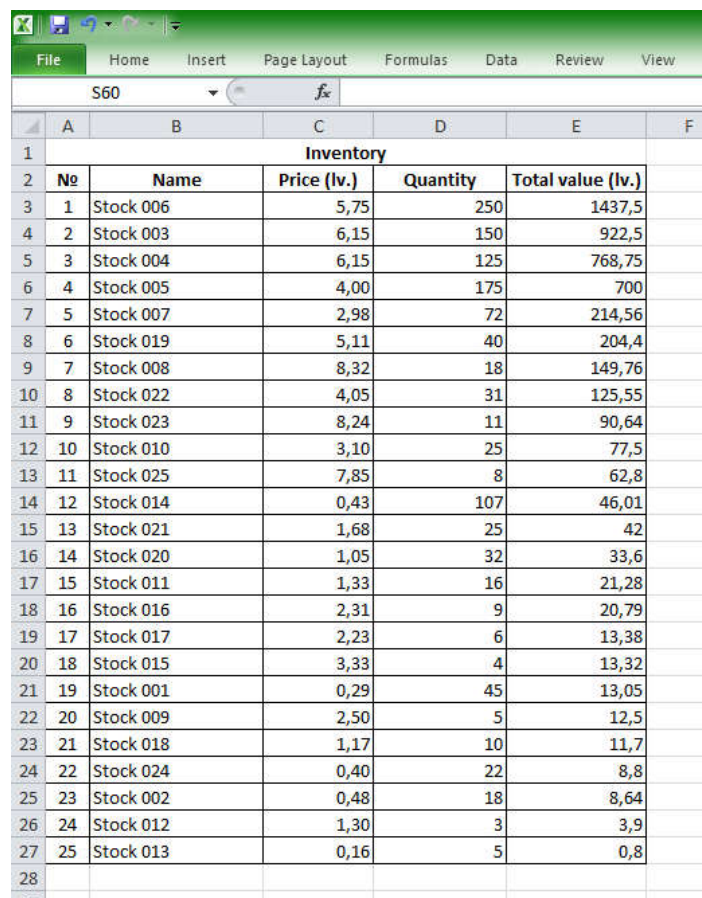
№	Name	Price (lv.)	Quantity	Total value (lv.)
1	Stock 001	0,29	45	13,05
2	Stock 002	0,48	18	8,64
3	Stock 003	6,15	150	922,5
4	Stock 004	6,15	125	768,75
5	Stock 005	4,00	175	700
6	Stock 006	5,75	250	1437,5
7	Stock 007	2,98	72	214,56
8	Stock 008	8,32	18	149,76
9	Stock 009	2,50	5	12,5
10	Stock 010	3,10	25	77,5
11	Stock 011	1,33	16	21,28
12	Stock 012	1,30	3	3,9
13	Stock 013	0,16	5	0,8
14	Stock 014	0,43	107	46,01
15	Stock 015	3,33	4	13,32
16	Stock 016	2,31	9	20,79
17	Stock 017	2,23	6	13,38
18	Stock 018	1,17	10	11,7
19	Stock 019	5,11	40	204,4
20	Stock 020	1,05	32	33,6
21	Stock 021	1,68	25	42
22	Stock 022	4,05	31	125,55
23	Stock 023	8,24	11	90,64
24	Stock 024	0,40	22	8,8
25	Stock 025	7,85	8	62,8

Fig. 1. Inventory's nomenclature

As a classification criterion, we choose the total value of inventories of each type, i.e. the most important for the organization will be the inventories with the biggest investment, and the least important ones will be those that need the least financial resources.

The next step is to rearrange the inventory nomenclature in descending order by their total value. With MS Excel this is a simple procedure. The Sort function from the Data menu is used, and for the sort criterion (Sort by) Total Inventory is pointed. Sorting from the largest to smallest item must be set. One particular point here is that the entire table (zone B2:E27) must be marked in order not to lose the link between the inventory name and its total value (Fig. 1).
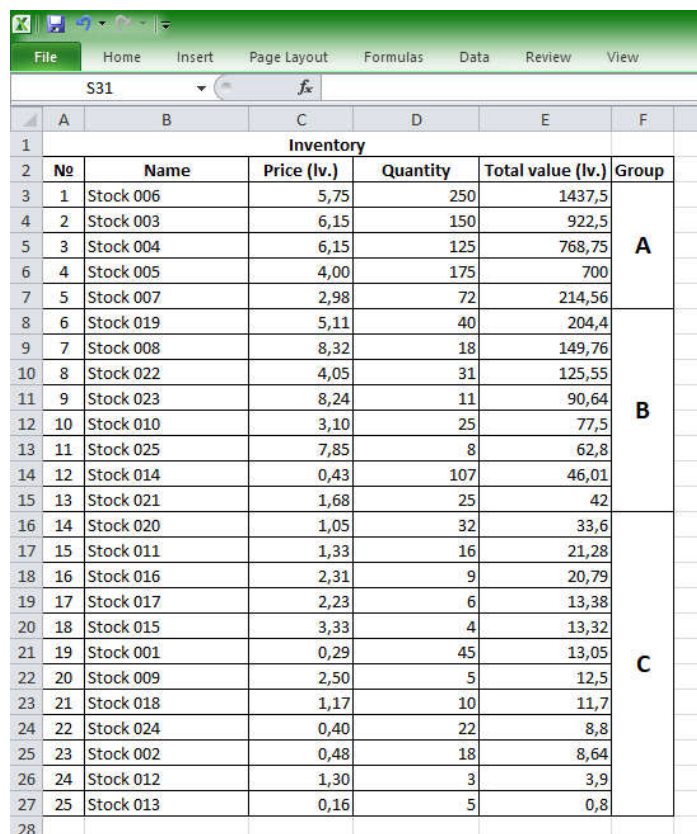
№	Name	Price (lv.)	Quantity	Total value (lv.)
1	Stock 006	5,75	250	1437,5
2	Stock 003	6,15	150	922,5
3	Stock 004	6,15	125	768,75
4	Stock 005	4,00	175	700
5	Stock 007	2,98	72	214,56
6	Stock 019	5,11	40	204,4
7	Stock 008	8,32	18	149,76
8	Stock 022	4,05	31	125,55
9	Stock 023	8,24	11	90,64
10	Stock 010	3,10	25	77,5
11	Stock 025	7,85	8	62,8
12	Stock 014	0,43	107	46,01
13	Stock 021	1,68	25	42
14	Stock 020	1,05	32	33,6
15	Stock 011	1,33	16	21,28
16	Stock 016	2,31	9	20,79
17	Stock 017	2,23	6	13,38
18	Stock 015	3,33	4	13,32
19	Stock 001	0,29	45	13,05
20	Stock 009	2,50	5	12,5
21	Stock 018	1,17	10	11,7
22	Stock 024	0,40	22	8,8
23	Stock 002	0,48	18	8,64
24	Stock 012	1,30	3	3,9
25	Stock 013	0,16	5	0,8

Fig. 2. Inventories' nomenclature in descending order of total value

After ordering the inventories' nomenclature in descending order by total value, it becomes as following (Fig. 2).

The next step is to apply the empirical method of classifying inventories on the ordered nomenclature. According to it, the first 20% of the inventories, or 20% of 25 = 5, i.e. the top 5 items in the rearranged nomenclature fall into Group A. In group B, the next 30% or 30% of 25 = 7.5, rounded to an integer is 8, i.e. the next 8 elements of the nomenclature. The remaining inventories from item 14 to item 25 belong to group C (Fig. 3).

№	Name	Price (lv.)	Quantity	Total value (lv.)	Group
1	Stock 006	5,75	250	1437,5	
2	Stock 003	6,15	150	922,5	
3	Stock 004	6,15	125	768,75	A
4	Stock 005	4,00	175	700	
5	Stock 007	2,98	72	214,56	
6	Stock 019	5,11	40	204,4	
7	Stock 008	8,32	18	149,76	
8	Stock 022	4,05	31	125,55	
9	Stock 023	8,24	11	90,64	B
10	Stock 010	3,10	25	77,5	
11	Stock 025	7,85	8	62,8	
12	Stock 014	0,43	107	46,01	
13	Stock 021	1,68	25	42	
14	Stock 020	1,05	32	33,6	
15	Stock 011	1,33	16	21,28	
16	Stock 016	2,31	9	20,79	
17	Stock 017	2,23	6	13,38	
18	Stock 015	3,33	4	13,32	
19	Stock 001	0,29	45	13,05	C
20	Stock 009	2,50	5	12,5	
21	Stock 018	1,17	10	11,7	
22	Stock 024	0,40	22	8,8	
23	Stock 002	0,48	18	8,64	
24	Stock 012	1,30	3	3,9	
25	Stock 013	0,16	5	0,8	

Fig. 3. Inventories' nomenclature classified by empirical method

Next we will show how the graphical method of classifying the inventory's nomenclature can be applied. This approach is slightly more laborious and involves some additional calculations (Fig. 4).

Firstly, the total value of all stocks is determined as the sum of the total values of the particular items in the nomenclature. The formula "= SUM (E3:E27)" entered in cell E28 was used. This value is used to calculate the relative proportion of each element in the nomenclature using formula (1). For this purpose, the column G in the table in MS Excel was used. In the cells from G3 to G27 by copying are entered the following formulas "=E3*100/\$E\$28", "=E4*100/\$E\$28", ..., "=E27*100/\$E\$28".

№	Name	Price (lv.)	Quantity	Total value (lv.)	Relative share (%)	Total relative share (%)
	Inventory					
1	Stock 006	5,75	250	1437,5	28,73	28,73
2	Stock 003	6,15	150	922,5	18,44	47,16
3	Stock 004	6,15	125	768,75	15,36	62,53
4	Stock 005	4,00	175	700	13,99	76,52
5	Stock 007	2,98	72	214,56	4,29	80,81
6	Stock 019	5,11	40	204,4	4,08	84,89
7	Stock 008	8,32	18	149,76	2,99	87,88
8	Stock 022	4,05	31	125,55	2,51	90,39
9	Stock 023	8,24	11	90,64	1,81	92,20
10	Stock 010	3,10	25	77,5	1,55	93,75
11	Stock 025	7,85	8	62,8	1,26	95,01
12	Stock 014	0,43	107	46,01	0,92	95,93
13	Stock 021	1,68	25	42	0,84	96,77
14	Stock 020	1,05	32	33,6	0,67	97,44
15	Stock 011	1,33	16	21,28	0,43	97,86
16	Stock 016	2,31	9	20,79	0,42	98,28
17	Stock 017	2,23	6	13,38	0,27	98,55
18	Stock 015	3,33	4	13,32	0,27	98,81
19	Stock 001	0,29	45	13,05	0,26	99,07
20	Stock 009	2,50	5	12,5	0,25	99,32
21	Stock 018	1,17	10	11,7	0,23	99,56
22	Stock 024	0,40	22	8,8	0,18	99,73
23	Stock 002	0,48	18	8,64	0,17	99,91
24	Stock 012	1,30	3	3,9	0,08	99,98
25	Stock 013	0,16	5	0,8	0,02	100,00
SUM				5003,73		

Fig. 4. Calculations in which is necessary to apply the graphical method for classifying the inventory's nomenclature

The next step is to calculate the total relative shares of stocks in the nomenclature and use column H. The relative share of the first element of the nomenclature must be entered in box H3 and therefore the formula "= G3" is

used. The sum of the relative shares of inventories from the first to the current position must be entered in each subsequent cell of this column. Therefore, the formulas "=SUM($G$3:G4)", "=SUM($G$3:G5)", ..., "=SUM($G$3:G27)" are entered in cells H4 to H27.

Column H values are used to construct the cumulative curve. In MS Excel, it is also easy to do this by entering a graph, such as Line or Scatter (Fig. 5).

After the cumulative curve has been constructed, two tangent lines to the curve should be constructed in succession based on the algorithm described above, showing where the boundary between the groups of inventories are.

Building a plan related to the graphical method can be accomplished without much difficulty using the Line drawing tool included in Shapes from the Insert menu.
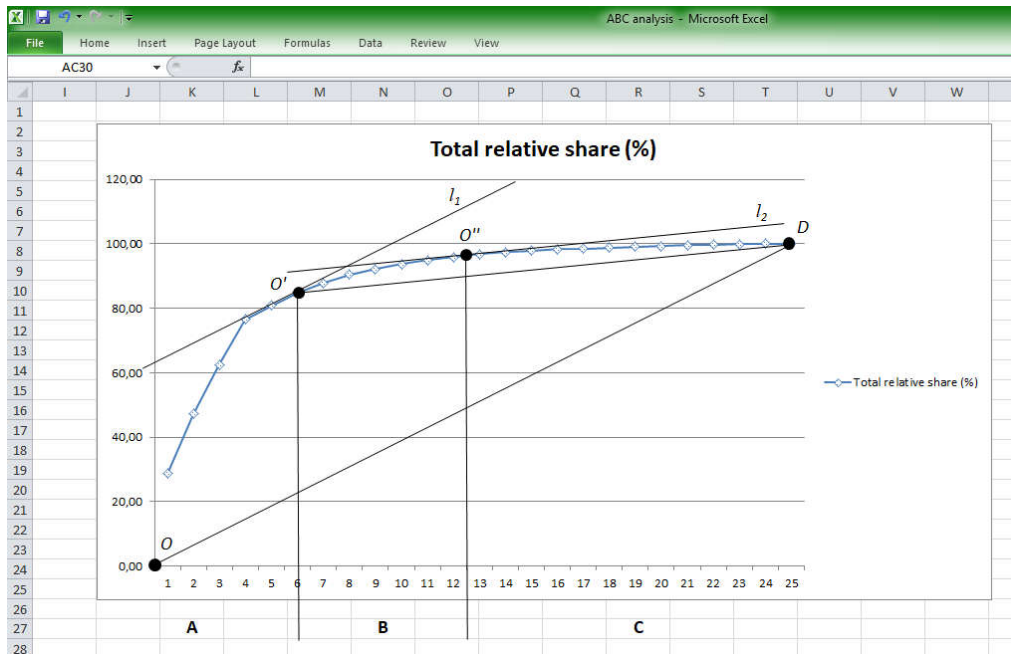

Fig. 5. Graphical method for classifying inventory's nomenclature

The following result is obtained when working with the suggested sample data for inventory's nomenclature and drawing the plan according to the described graphical method: Group A must include the inventories which

are in the first 6 positions of the rearranged nomenclature; Group B must include inventories in positions 7 to 12; Group C should include inventories from 13th to 25th position.
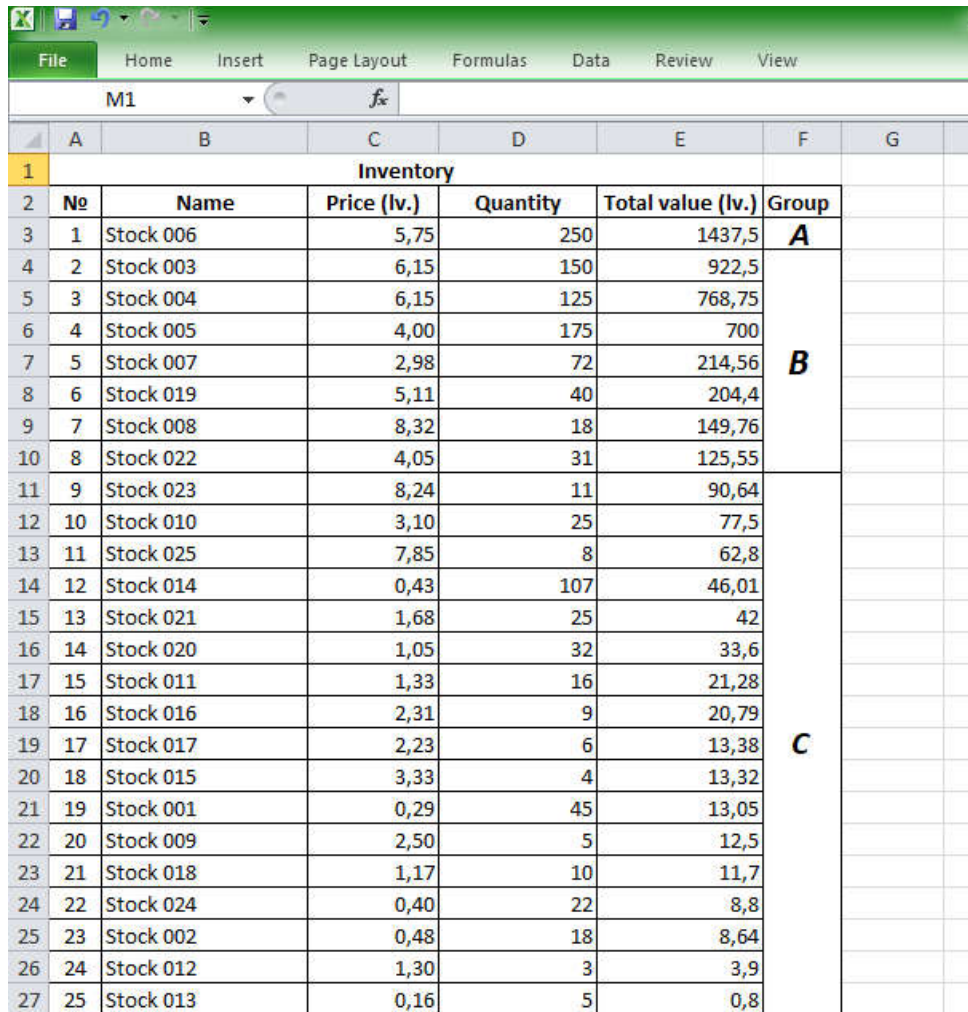
Next, we will demonstrate the application of the differential approach for classifying the nomenclature of the inventories and its division into groups A, B and C, according to total value of the inventories and their significance for the organization. That is why we determine the average value for each position of the nomenclature of the inventories, using formula (2). In MS Excel this can be done by the function AVERAGE, applied to the area in the table, which includes the values of the different positions of nomenclatures of the inventories, i.e. in cell E28 the input should be "=AVERAGE(E3:E27)". Thus, the average value $p = 200.15$ of one type of stock inventory is determined. Then the values $6p = 1200.90$ and $0.5p = 100.07$ are calculated (Fig. 6).

17	15	Stock 011	1,33	10	21,28
18	16	Stock 016	2,31	9	20,79
19	17	Stock 017	2,23	6	13,38
20	18	Stock 015	3,33	4	13,32
21	19	Stock 001	0,29	45	13,05
22	20	Stock 009	2,50	5	12,5
23	21	Stock 018	1,17	10	11,7
24	22	Stock 024	0,40	22	8,8
25	23	Stock 002	0,48	18	8,64
26	24	Stock 012	1,30	3	3,9
27	25	Stock 013	0,16	5	0,8
28				$p =$	200,15
29				$6p =$	1200,90
30				$0,5p =$	100,07
31					

Fig. 6. Differential method for classifying inventory's nomenclature

It can be specified that according to the differential approach with group A only the inventory on the first position should be associated, with group B the inventories on positions from 2 to 8 are associated and group C will include all the other inventories, on positions from 9 to 25 (Fig. 7).

When implementing the ABC analysis method in practice it is a matter of manager's decision which method for determining of the groups A, B and C will be used. Usually the results are similar but not always identical and up to now there are no clear instructions which is the one to be preferred for application.

№	Name	Price (lv.)	Quantity	Total value (lv.)	Group
				Inventory	
	Name	**Price (lv.)**	**Quantity**	**Total value (lv.)**	**Group**
1	Stock 006	5,75	250	1437,5	A
2	Stock 003	6,15	150	922,5	
3	Stock 004	6,15	125	768,75	
4	Stock 005	4,00	175	700	
5	Stock 007	2,98	72	214,56	B
6	Stock 019	5,11	40	204,4	
7	Stock 008	8,32	18	149,76	
8	Stock 022	4,05	31	125,55	
9	Stock 023	8,24	11	90,64	
10	Stock 010	3,10	25	77,5	
11	Stock 025	7,85	8	62,8	
12	Stock 014	0,43	107	46,01	
13	Stock 021	1,68	25	42	
14	Stock 020	1,05	32	33,6	
15	Stock 011	1,33	16	21,28	
16	Stock 016	2,31	9	20,79	
17	Stock 017	2,23	6	13,38	C
18	Stock 015	3,33	4	13,32	
19	Stock 001	0,29	45	13,05	
20	Stock 009	2,50	5	12,5	
21	Stock 018	1,17	10	11,7	
22	Stock 024	0,40	22	8,8	
23	Stock 002	0,48	18	8,64	
24	Stock 012	1,30	3	3,9	
25	Stock 013	0,16	5	0,8	

Fig. 7. Inventories' nomenclature classified by differential method

With the exemplary nomenclature that we considered and classified into groups A, B and C, we have different results by the three different methods. For a better comparison these results are shown in Fig. 8. Based on this and considering other factors, which have impact on the inventory management, the managers should make an analysis and choose the optimal option for classifying the nomenclature of the inventories, in terms of minimizing the total costs of inventory management.

№	Name	Total value (lv.)	Empirical method Group	Graphical method	Differential method Group
1	Stock 006	1437,5			A
2	Stock 003	922,5			
3	Stock 004	768,75	A	A	
4	Stock 005	700			
5	Stock 007	214,56			B
6	Stock 019	204,4			
7	Stock 008	149,76			
8	Stock 022	125,55			
9	Stock 023	90,64	B	B	
10	Stock 010	77,5			
11	Stock 025	62,8			
12	Stock 014	46,01			
13	Stock 021	42			
14	Stock 020	33,6			
15	Stock 011	21,28			
16	Stock 016	20,79			
17	Stock 017	13,38			C
18	Stock 015	13,32			
19	Stock 001	13,05	C	C	
20	Stock 009	12,5			
21	Stock 018	11,7			
22	Stock 024	8,8			
23	Stock 002	8,64			
24	Stock 012	3,9			
25	Stock 013	0,8			

Fig. 8. A comparison between the results of the classification
of the nomenclatures of the inventories by the three methods

Some difficulties may occur when applying the graphical method if the volume of the inventory's nomenclature is relatively bigger. In this case an approximated function of the cumulative curve may be used which is obtained for example by the "least squares method". Then, without needing a graph, we may determine the coordinates of the points which mark the boundaries between the three groups inventories, using some calculus skills (straight line in plane and derivatives of function of one variable). This can also be

performed by using MS Excel which will reduce the volume of the calculation procedures and will give quite accurate results.

4. Conclusion. The approaches proposed for ABC analysis of the inventories in the logistical system by MS Excel is definitely reducing the number of the calculation procedures. They are easy and applicatory tools and can be used by a wide range of consumers, having in mind how popular MS Excel is. Their application in education is also profitable because it makes the method clear and comprehensible. They are immediately applicable in practice when working with real data and bigger nomenclatures.

The approach proposed in the paper is another confirmation of the necessity of applying the technologies in IT industry in all the areas of business and education in the contemporary society.

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