DE GRUYTER OPEN

Folia Oeconomica Stetinensia
DOI: 10.1515/foli-2017-0022

WYDZIAŁ NAUK EKONOMICZNYCH I ZARZĄDZANIA
UNIWERSYTET SZCZECIŃSKI

DECISION SUPPORT METHODS FOR SUPPLY PROCESSES IN THE FLORAL INDUSTRY

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Received 5 July 2017, Accepted 8 October 2017

Abstract

The aim of this paper was to show the application of the ABC and AHP (multi-criteria method for hierarchical analysis of decision processes) as an important part of decision making in supply processes which are realized in the floral industry. The ABC analysis was performed in order to classify the product mix from the perspective of the demand values. This in consequence enabled us to identify the most important products which were then used as a variant in the AHP method.

Keywords: multi-criteria decision making, decision making support, ABC method, AHP method

JEL classification: C38, C44, L81

Introduction

Decision making is an intrinsic part of human life. Its importance exhibits itself not only during economic activities but also in daily life. Each company is realizing tasks and setting goals as a result of decisions made during various management processes. Those decisions affect not only the quality of management but also its performance on the market as well as the company surroundings. Effective management makes making complex decisions a very frequent process. When a decision maker has a huge number of possible decision variants, which are being assessed and based on multiple criteria a lack of a methodical approach and may lead to a decision that has consequences.

Supply processes in the floral industry result in decision problems that concern product mix for a given period (usually a week). In this paper, we analyse a decision situation in a selected company representing the floral industry. Here the decision maker has to choose from a significant number of decision variants and the choice will represent his/her preferences which on the other hand are based on the forecasted/expected demand during the upcoming week. Quota observed in supply processes result directly from those observed during the sales process. In this paper we briefly characterize selected methods of supporting the decision making processes. The main objective was to use two approaches, namely: the ABC analysis and AHP method and to check their applicability in the decision processes made in the floral industry. For our research we have used sales data covering the period 2008–2014 concerning cut flowers. The classification performed by means of the ABC method was done during International Women's Day, March 8th. The ABC method was used to identify the products (cut flowers) which are of the greatest importance from the perspective of sold volume. The conducted analysis and identified products were then used as variants in the AHP method. This made it possible to depict the considered problem in a hierarchical structure. In the research we distinguished the main goal, criteria and variants.

The decision problem, which will be solved by means of the proposed model, can be formulated by means of the following question: which product/group of products will have the greatest importance during International Women's Day. At the end we presented the results of our analysis and verified the usefulness of the applied methods.

1. Characteristics of the selected methods

1.1. ABC analysis

The ABC method which is a type of the Pareto-Lorenz analysis is commonly used in logistics. This method facilitates supply processes by classifying a given product mix accordingly to its value (Kardas, 2013). The ABC classification provides us with a static image which represents the position of a given product within individual periods. The main assumption which lies behind this method is such that: the period used for calculations must be the same for all products as well as they must be quantified by means of the same characteristics and counted in the same units (Szymczak, 2011).

The ABC method was developed to sort various products which create enterprise stock. Products can be ordered accordingly to the: demand, production of sales in a given period. Thanks to the ABC analysis it is easier to find the balance between the stocks and demand (Krzyżaniak, 2005). The classical ABC analysis is the most commonly used method to classify products in two categories of different importance from the perspective of the company. Accordingly to its name products are divided into three categories which represent respectively: A – 80%, B – 15% and C – 5% of product volume/value (Figure 1).

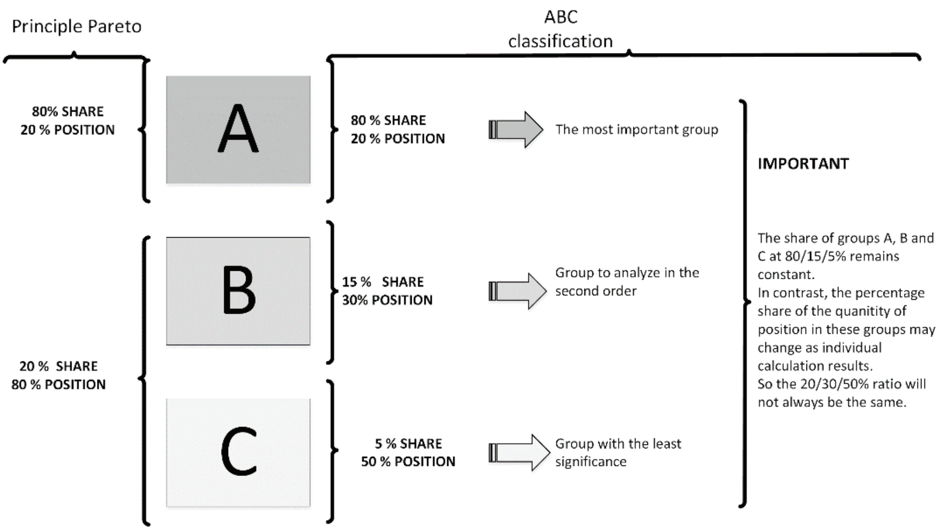

Figure 1. ABC classification into three groups

Source: own elaboration based on (Analiza ABC XYZ | staworzynski.com, 2017).

The ABC method is a single criteria analysis, thereby it is impossible to consider more than one criterion simultaneously. However, one can perform the same analysis several times and each time select as a criteria with a different characteristic. At the end the results can be combined and various weights can be attributed to the individual criteria. This method is usually performed and based on the following criteria (Kaczor, Lorenc, 2012):

– sales volume of sales revenue,
– how often is the product taken from the stock,
– what is the average batch of the product taken from the stock,
– weight and volume.

The ABC analysis can be divided into the following stages (Radziejowska, Mastej, 2001):

1. Product value estimation.
2. Sorting product values from the highest to the lowest.
3. Determining the total value of sales.
4. Estimating the percentage share of a given product in the total sales value.
5. Calculating the index of a cumulative percentage share.

The procedure used in the ABC classification can be summarized as follows (Radziejowska, Mastej, 2001; Szymczak, 2011):

– calculating the total value of given product sales based on the following formula (1):

$$W_j = \sum_{i=1}^{n} x_{ij}, \quad j = 1, \ldots, N \tag{1}$$

where:

x_{ij} – the volume of sold products j in period i,
N – number of products,
n – number of observations (here weeks);

– percentage share of given product sales in all sales (2):

$$r_{ij} = \frac{x_{ij}}{W_j} \times 100\% \tag{2}$$

where:

r_{ij} – the percentage share of product j in period i,
x_{ij} – the volume of sold products j in period i,
W_j – total value of sold product i,

– the cumulative index of percentage share (3) (4):

$$\text{for } i = 1 \text{ and } j = 1, \ldots, N \text{ is } q_{1j} = x_{1j} \tag{3}$$

$$\text{for } i = 2, \ldots, n \text{ and } j = 1, \ldots, N \text{ is } q_{ij} = q_{i-1,j} + x_{ij}\, x_{1j} \tag{4}$$

where:

x_{ij} – the volume of sold products j in period i,

q_{ij} – cumulative index of percentage share of j product in period i,

– estimating the values of α and β parameters, for example. α = 80 and β = 95, which are then used to create A, B and C categories.

1.2. Analytic Hierarchy Process – AHP Method

The Analytic Hierarchy Method (pol. Metoda Procesu Analizy Hierarchicznej) is one of the multi criteria analysis tools. It was developed by Thomas L. Saaty from Pittsburgh University at the end of the 20th century (Saaty, 1980). The AHP method is a technique used to estimate the "marks" by applying a dimensionless scale for a measurable or immeasurable criterion. One of the main aspects of this method is a qualitative assessment, where variants are analysed as a part of a comparative or diagnostic appraisal. The AHP method is realized in four stages (Drake, 1998):

1. Selection of a hierarchically sorted analysis criteria.
2. Selecting the weight of individual criteria by a pairs comparison using Saaty's scale.
3. Assessing how analysed solutions meet the individual criteria by comparing them by means of Saaty's scale.
4. Calculating the final assessment of individual solutions. This is estimated as a sum of quotient: weights attributed to individual criteria and the degree to which a given condition is fulfilled by the analysed solution.

An example of a simple hierarchical structure is presented in Figure 2.

Verbal and quantitative assessment used in the AHP method is presented in Table 1.

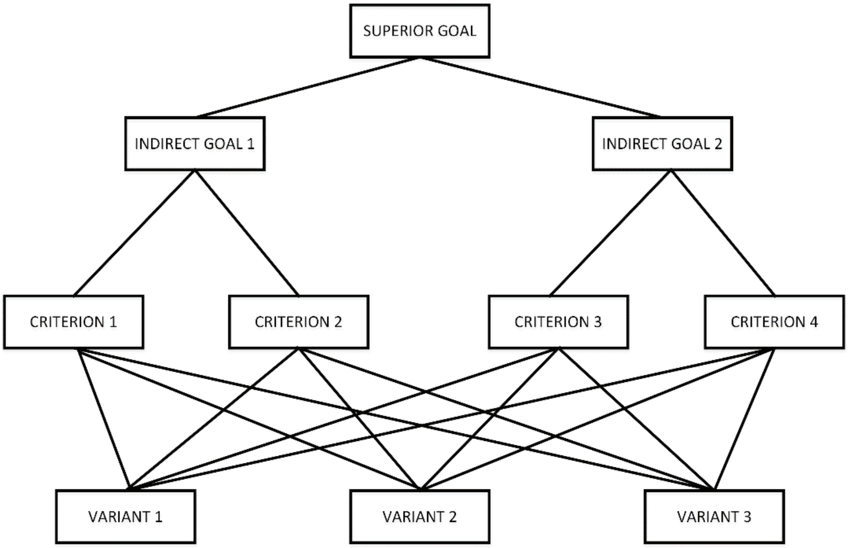

Figure 2. Hierarchical decision structure

Source: own elaboration based on Downarowicz, Krause, Sikorski, Stachowski (2000).

Table 1. Verbal and quantitative assessment in the AHP method

Quantitative assessment	Verbal assessment
1	equal (importance)
2	weak or slight dominance
3	moderate dominance
4	moderate plus
5	strong dominance
6	strong plus
7	very strong or demonstrated dominance
8	very, very strong
9	extreme dominance

Source: source own elaboration based on Saaty (1994).

Whilst analysing the decision problem by means of the AHP method it is very important to maintain coherence in criteria assessment, which translates into the possibility of changing their weights. In order to verify whether the assessments of each criteria are coherent the value of the calculated index CR should not be greater than 0.1 (Saaty, 1994). The consistency ratio (CR) is calculated and based on the following formula (5):

$$CR = \frac{CI}{r} < 0.1 \tag{5}$$

where:

CI – consistency index,

r – index of random coherences.

The value of index representing the coherence of comparison matrices (CI) is estimated and based on the following formula (6):

$$CI = \frac{\lambda_{\max} - n}{r(n-1)} < 0.1 \quad (6)$$

where:

λ_{max} – incoherence index,

n – number of criteria (rows in the matrix),

r – index of random coherences.

The incoherence index λ_{max} for individual criteria is calculated as a sum of selected criteria weights and assessments. The index of random coherences r depends on the number of considered criteria. Table 2 summarizes its values.

Table 2. The value of the r index for a selected number of criteria

n	1	2	3	4	5	6	7	8	9	10
r	0.00	0.00	0.52	0.89	1.12	1.25	1.35	1.40	1.45	1.49

Source: own elaboration based on Miszczyński (2007).

By the same token, it is possible to determine the coherence of the decision variants preferences for each criterion. As n one takes the number of decision variants (not the number of criteria). A synthesis of the criteria importance and alternatives preferences for each criteria is performed by multiplying the weight of a given criterion by the assessment value for a given decision variant. As a result one obtains ranking of variants. Such a list is a measure for each decision variant (Zdanowicz, 2006).

2. Methods and results

As an input data we have used sales data from a company which is running its business in the Lesser Poland voivodeship and representing the floral industry. Data concerned cut flowers (roses) sales with a division into their colour and length. Analysis was performed for data covering a period which included International Women's Day. The considered product (flowers) is measured in pieces (Kutyba, Mikulik, 2016).

The ABC method was used to classify the product mix. The products were sorted and classified by the volume of sales in a given period. As a result the product mix has been divided in three groups: A, B and C. Analysis was performed for each year separately (2008–2014). The considered weeks were characterized by a certain volume of sales during Women's Day. The analysis considered 12 various colours and 9 lengths of roses. The first step of the analysis was to sort the product mix from the largest to the smallest values of sales. The next step was to calculate the picking up sums of the following items. In the last but not least stage the share of individual items (roses) was calculated. The last step, the product mix, was assigned to one of three groups: A, B and C. The results are presented in Figure 3 (Kutyba, Mikulik 2016).

		Year									Year						
No.	Type	2008	2009	2010	2011	2012	2013	2014	No.	Type	2008	2009	2010	2011	2012	2013	2014
1	10_A	A	A	A	A	A	A	A	45	60_J	A	A	A	A	A	A	A
2	30_B	C	C	C	C	C	C	C	46	60_K	B	B	B	B	B	B	C
3	30_C	B	B	C	C	C	C	C	47	60_L	A	A	A	A	A	A	A
4	30_D	C	C	C	C	A	C	C	48	70_A	C	C	C	C	C	C	C
5	30_E	C	C	C	C	C	C	C	49	70_B	C	C	B	C	B	B	C
6	30_G	C	B	B	C	C	C	C	50	70_C	A	A	B	A	B	A	A
7	30_H	C	C	C	B	C	C	C	51	70_D	B	B	C	C	C	A	C
8	30_I	B	C	C	C	C	C	C	52	70_E	B	C	C	C	C	C	C
9	30_J	C	C	C	C	B	C	C	53	70_E	B	C	C	C	C	C	C
10	30_K	C	C	C	C	C	C	C	54	70_G	A	B	B	C	C	C	C
11	30_L	B	B	C	C	A	C	C	55	70_H	B	B	B	B	B	A	B
12	40_A	C	C	C	C	C	C	C	56	70_I	B	C	A	A	C	A	B
13	40_B	C	B	C	C	B	C	C	57	70_J	A	A	A	A	A	A	A
14	40_C	A	A	A	B	B	C	C	58	70_K	C	C	C	C	C	B	C
15	40_D	B	B	B	A	A	A	A	59	70_L	B	A	C	B	B	A	B
16	40_E	C	C	C	C	C	C	C	60	80_B	C	C	C	C	C	C	C
17	40_E	C	C	C	B	B	B	B	61	80_C	A	A	B	B	C	A	C
18	40_G	A	A	A	B	C	C	C	62	80_D	C	C	C	C	C	C	C
19	40_H	B	C	C	B	C	C	A	63	80_E	C	C	C	C	C	C	C
20	40_I	A	B	C	B	B	C	A	64	80_E	C	C	C	C	C	C	C
21	40_J	B	A	A	A	A	C	B	65	80_G	C	C	C	C	C	C	C
22	40_K	C	C	C	B	B	C	C	66	80_H	C	B	C	C	C	A	C
23	40_L	A	A	A	A	A	B	B	67	80_I	C	C	A	B	C	B	C
24	50_A	C	C	C	C	C	B	C	68	80_J	A	A	B	A	A	A	A
25	50_B	C	C	C	A	A	B	B	69	80_K	C	C	C	C	C	C	C
26	50_C	A	A	A	A	A	B	B	70	80_L	B	B	C	C	C	B	C
27	50_D	A	A	B	A	A	A	A	71	90_B	C	C	C	C	C	C	C
28	50_E	C	C	C	C	C	C	C	72	90_C	C	C	B	C	C	C	C
29	50_E	C	C	C	B	B	B	B	73	90_D	C	C	C	C	C	C	C
30	50_G	A	A	A	B	C	C	C	74	90_E	C	C	C	C	C	C	C
31	50_H	B	C	B	A	B	A	A	75	90_E	C	C	C	C	C	C	C
32	50_I	A	A	A	A	A	B	A	76	90_H	C	C	C	C	C	B	C
33	50_J	A	A	A	A	A	A	A	77	90_I	C	C	C	C	C	B	C
34	50_K	B	B	B	A	B	B	B	78	90_J	B	B	C	C	C	A	B
35	50_L	A	A	A	A	A	B	B	79	90_K	C	C	C	C	C	C	C
36	60_A	C	C	C	C	C	A	C	80	90_L	C	C	C	C	C	C	C
37	60_B	C	C	B	B	A	B	B	81	100_C	C	C	C	C	C	C	C
38	60_C	A	A	A	A	A	A	A	82	100_E	C	C	C	C	C	C	C
39	60_D	A	A	B	C	B	A	A	83	100_E	C	C	C	C	C	C	C
40	60_E	C	C	C	C	C	C	C	84	100_H	C	C	C	C	C	C	C
41	60_E	C	C	C	B	B	B	C	85	100_I	C	C	C	C	C	C	C
42	60_G	A	A	A	C	C	C	C	86	100_J	C	C	C	C	C	A	C
43	60_H	B	B	A	A	A	A	A	87	100_K	C	C	C	C	C	C	C
44	60_I	A	A	A	A	B	A	A	88	100_L	C	C	C	C	C	C	C

Figyre 3. Results of the ABC analysis performed and based on the years 2008–2014

Source: own elaboration.

To the A group belong all products where the cumulative percentage share is smaller than 80%. In the B group one can find products where the share is less than 95% of the product mix value. The remaining products are in the C group.

By analysing the results one can notice that flowers: 10_A, 50_J, 60_C, 60_J, 60_L, 70_J are a product mix which in each considered year formed the A group. The remaining product mix has changed its classification. The product mix which constituted to the A group in the years 2008–2014 was used as an input data to the AHP method. In order to present the application of the AHP method and to show which flower type is the most important one from the perspective of supply processes during a week with International Women's Day we analysed the product mix which considered six types of flowers: 10_A, 50_J, 60_C, 60_J, 60_L,70_J. As sub-criteria (indirect goals) we used the following parameters:

K1 – maximal sales,

K2 – minimal standard deviation,

K3 – maximal coefficient of the linear trend.

Table 3. Input data to the AHP analysis

Criterion	Product					
	10_A	50_J	60_C	60_J	60_L	70_J
K1	4,880	7,400	1,700	8,780	1,900	4,440
K2	1,538	2,299	624	2,757	635	1,544
K3	–46	–136	–81	278	–78	387

Source: own elaboration.

In Table 3 we juxtaposed individual types of flower and the corresponding weights of their criteria. The decomposition of the considered problem in the form of a hierarchical tree is presented in Figure 5.

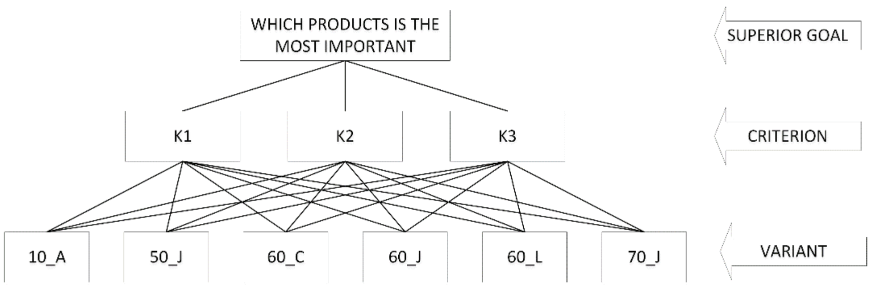

Figure 5. The structure of the decision process of selecting rose type for a double level hierarchy

Source: own elaboration based on Downarowicz et al. (2000).

The assessment of preferences was performed for all pairs of variants separately from the perspective of each criterion. Whereas, the assessment of preferences was performed by means of the expert method using Saaty's metric. The results of the assessment along with: the values of weights (priorities), a ranking of criteria as well as the results of the matrix coherence analysis are given in Table 4.

Table 4. Criteria preference considering the superior goal

Criterion	K1	K2	K3	Weight	Ranking
K1	1.00	7.00	5.00	0.74	1
K2	0.14	1.00	0.50	0.09	3
K3	0.20	2.00	1.00	0.17	2
r = 0.52; λ_{max} = 3.02; CI = 0.02; CR = 0.05					

Source: own elaboration.

Considering the significant variability of the considered criteria their values have been normalized to a range from 1 to 9. For each criteria the normalization was performed and based on formula (7):

$$V' = \frac{(V - \min)}{\max - \min} \times (new\_\max - new\_\min) + new\_\min \tag{7}$$

where:

V' – normalized value,

V – values considered for normalization,

min, max – minimal and maximal observed value of those considered for normalization,

*new*_max, *new*_min – range for the new subset.

Based on the normalized matrix the assessments were assigned and based on Saaty's scale. The assessment matrix for criterion K2 was transposed considering the fact that the lowest value is the most desired one. The assessment matrix along with weights, a ranking for product mix type for individual criteria and the results of the former analysis are given in following tables: 5, 6 and 7.

Table 5. Product mix preferences considering the maximal sales (K1)

	10_A	50_J	60_C	60_J	60_L	70_J	Weight	Ranking
10_A	1.00	0.50	5.00	0.50	4.00	2.00	0.18	3
50_J	2.00	1.00	7.00	0.50	6.00	2.00	0.26	2
60_C	0.20	0.14	1.00	0.11	0.50	0.25	0.03	6
60_J	2.00	2.00	9.00	1.00	7.00	2.00	0.35	1
60_L	0.25	0.17	2.00	0.14	1.00	0.33	0.05	5
70_J	0.50	0.50	4.00	0.50	3.00	1.00	0.13	4
r = 1.25; λ_{max} = 6.13; CI = 0.022; CR = 0.017								

Source: own elaboration.

Table 6. Product mix preferences considering the minimal standard deviation (K2)

	10_A	50_J	60_C	60_J	60_L	70_J	Weight	Ranking
10_A	1.00	2.00	0.25	2.00	0.25	1.00	0.091	3
50_J	0.50	1.00	0.14	2.00	0.14	0.50	0.055	5
60_C	4.00	7.00	1.00	9.00	1.00	4.00	0.364	1
60_J	0.50	0.50	0.11	1.00	0.13	0.50	0.041	6
60_L	4.00	7.00	1.00	8.00	1.00	4.00	0.357	2
70_J	1.00	2.00	0.25	2.00	0.25	1.00	0.091	4
r = 1.25; λ_{max} = 6.05; CI = 0.008; CR = 0.006								

Source: own elaboration.

Table 7. Product mix preferences considering the maximal coefficient of linear trend

	10_A	50_J	60_C	60_J	60_L	70_J	Weight	Ranking
10_A	1.00	2.00	2.00	0.33	2.00	0.25	0.115	3
50_J	0.50	1.00	0.50	0.14	0.50	0.11	0.043	6
60_C	0.50	2.00	1.00	0.25	1.00	0.20	0.074	5
60_J	3.00	7.00	4.00	1.00	4.00	0.50	0.284	2
60_L	0.50	2.00	1.00	0.25	1.00	0.25	0.077	4
70_J	4.00	9.00	5.00	2.00	4.00	1.00	0.406	1
r = 1.25; λ_{max} = 6.12; CI = 0.019; CR = 0.015								

Source: own elaboration.

The obtained values of the incoherence coefficient and the incoherence index confirm that the condition of assessments coherence in pairs in the comparison matrix for criteria and decision variants is met. In the following table (8) we juxtaposed the final results which were obtained thanks to multiplying the criteria weights and the product mix preferences weights. The investigated product mix has been sorted from the most to the least important.

Table 8. Product mix ranking results

	K1	K2	K3	Weight	Ranking
10_A	0.135	0.009	0.019	0.16	4
50_J	0.190	0.005	0.007	0.20	2
60_C	0.024	0.034	0.012	0.07	6
60_J	0.255	0.004	0.048	0.31	1
60_L	0.036	0.034	0.013	0.08	5
70_J	0.098	0.009	0.068	0.17	3

Source: own elaboration**.**

Conclusions

The multitude of techniques and methods, which are used by analytics during the modelling of various processes, makes it possible to precisely describe the investigated situations. Additionally, it also gives an opportunity to predict decisions made, especially those connected to high risk resulting from innovative operations.

The aim of this paper was to present a methodology of solving decision problems based on the ABC analysis and multicriteria AHP method. The results of the conducted calculations was finding the solution which satisfied the decision maker. The classification performed by the means of the ABC method was done during International Women's Day. The ABC method was used to identify the products (cut flowers) which are of the greatest importance from the perspective of sold volume. By analysing the results one can notice that flowers: 10_A, 50_J, 60_C, 60_J, 60_L, 70_J are a product mix which in each considered year formed the A group. The remaining product mix has changed its classification. The conducted analysis and identified products were then used as variants in the AHP method (Table 3). This made it possible to depict the considered problem in a hierarchical structure.

The presented results analysis in the AHP method we see that considering the price criteria the most satisfying variant is choosing the product mix: 60_J and 50_J since their sales are the biggest. Roses type 60_L and 60_C are of lesser significance since their sales are not very impressive (Table 8). The presented methods can be used to support the decision process in the supply department. Simultaneously, the classical ABC and the AHP method are elastic and can be used to various classes of analysed objects, also considering their idiosyncratic characteristics. Using the AHP method can give following benefits (Szymaczek, 2008):

– one can look at the decision problem from a different perspective by soring criteria and variants as a part of hierarchy,

– it reduces a multicriteria problem to a group of simple comparisons,
– it gives an opportunity to simultaneously analyse countable and uncountable criteria along with obtaining an aggregated assessment of variants,
– it eliminates the risk of prejudices and manipulation on the decision,
– it gives a rationale for the decision made,
– it gives an opportunity to conduct a sensitivity analysis.

On the other hand, the AHP method has some limitations mainly resulting from the analysis of non-measurable and non-mathematical data. The interpretation and evaluation of such data relies on a subject matter expert. In order to eliminate this limitation only mathematical data (K1, K2, K3) is presented in this article in Section 2.

The knowledge of methods such as the ABC and AHP may be useful for decision makers on various organizational levels. Starting from the purchase centre, through investments and ending at strategic level. The presented methods can be used in making decisions and creating product mixes in the supply area in the floral industry.

References

Analiza ABC XYZ | staworzynski.com (2017). Retrieved from: http://staworzynski.com/?pl_analiza-abc-xyz,258 (10.04.2017).

Downarowicz, O., Krause, J., Sikorski, M., Stachowski, W. (2000). Application of AHP method for evaluation and safety control of a complex technical system. In: O. Downarowicz (ed.), *Wybrane metody ergonomi i nauki o eksploatacji*. Gdańsk: Gdańsk University of Technology.

Drake, P.R. (1998). Using the Analytic Hierarchy Process in Engineering Education. *International Journal of Engineering Education*, *3* (14).

Kaczor, G., Lorenc, A. (2012). Increasing the efficiency of order picking process by optimizing the placement of pro ducts in stock including the frequency of picking product and weight of the product. *Logistyka*, *6*.

Kardas, E. (2013). The analysis of stock using ABC and XYZ methods in construction. *Logistyka*, *6*.

Krzyżaniak, S. (2005). *Podstawy zarządzania zapasami w przykładach*. Poznań: The Institute of Logistics and Warehousing.

Kutyba, A., Mikulik, J. (2016). Inventory control, Logistics in the flower trade. *Napędy i Sterowanie*, *7/8*.

Miszczyński, M. (2007). *Wielokryteriowa optymalizacja dyskretna. Wybrane metody*. Łódź: University of Lodz.

Radziejowska, G., Mastej, P. (2001). *Logistyka w przedsiębiorstwie: przewodnik do ćwiczeń. Cz. 1*. Gliwice: Wydawnictwo Politechniki Śląskiej.

Saaty, T.L. (1980). *The analytic hierarchy process.* New York: McGraw-Hill.

Saaty, T.L. (1994). *Fundamentals of Decisions Making and Priority and Theory with the Analytical Hierarchy Process*. Pittsburgh: RWS Publications.

Szymaczek, M. (2008). *AHP pomoże podjąć decyzję*. Akademia Wiedzy BCC. Retrieved from: http://www.bcc.com.pl/akademia-lepszego-biznesu/ahp-pomoze-podjac-decyzje.html (12.04.2017).

Szymczak, M. (2011). *Decyzje logistyczne z Excelem*. Warszawa: Difin.

Zdanowicz, R. (2006). Dobór oprogramowania do modelowania i symulacji procesów wytwarzania. *Pomiary Automatyka i Robotyka*, *1*.