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Multiple Criteria Evaluation of transportation performance for selected agribusiness companies

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Abstract

This paper presents the analysis of transportation activities carried out in different agribusiness entities and resulting in the overall ranking of transportation units operating in the considered agribusiness companies. It is assumed that all these units utilize their own fleet and thus arrange transportation services, by themselves, as the company's internal activities. The data for analysis is obtained from the survey research carried out on a sample of transportation units operating in 10 agribusiness companies. The authors define a consistent family of criteria that allows to evaluate transportation activity in an agribusiness industry, including both universal merits and industry specific transportation features. The evaluation matrix is constructed and the ranking of 10 transportation units is generated. It is based on a subjective model of preferences defined by the decision maker (DM) - the management teams of the analyzed agribusiness companies. The defined model of preferences includes the interests of different stakeholders, such as: customers, employees (in particular drivers) and the society. In the computational phase a multiple criteria ranking procedure called Analytic Hierarchy Process (AHP) method is applied. A series of computational experiments is carried out. As a result a company featured by the most desirable transportation performance is selected.

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Key words: transportation; agribusiness company; multiple criteria decision making.

1. Introduction

The major objective of the modern supply chain in the food industry is to satisfy the customers' needs, which essentially means to deliver high quality food products (being in an appropriate condition), in right quantities and at a right time to the right final consumer at the right (minimum) costs and at the minimum capital investment (Ballou, 2004). This definition proves that general logistics principles, called "7 right rule" apply also in the

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agribusiness sector (Klepacki, 2008). The role of logistics in agribusiness is crucial because of the specific character of the industry, which is characterized by low level of susceptibility for transportation and warehousing of many agricultural products, including: milk, meat, fruits and vegetables (Ajiboye et al., 2009).

Transportation is a fundamental part of the food supply chain and plays in it a very important role. The quality of food products strongly depends on their transportation conditions and proper organization of transportation activity. Due to limited shelf life of agricultural raw materials and articles and their high sensitivity to external conditions they must be properly handled during all transportation processes. A lack of controlled atmosphere and refrigeration equipment in transportation leads to the spoilage of the transported products. A well-organized food transportation should encompass the integration and coordination of various activities of participating organizations, such as purchasing, manufacturing and distributing (Allen et al., 2004). Consequently, any consideration of improving food transportation processes has to be seen in the context of optimizing the total supply chain, a process often referred to as "from farm to fork".

The differences in organization of transportation between sub-sectors are highly correlated with the variation of demand for products and their deliveries in these sub-sectors. In such sectors as fruits, vegetables and grains processing transportation is seasonal but it has regular and frequent character in dairy, meat and bakery enterprises (Wicki et al. 2011). Thus, in the sub-sectors with the seasonal demand (grains, fruits and vegetables processing) the third party transportation is more common. Moreover, transportation in various agribusiness sub-sectors is carried out with the application of different categories of fleet, e.g. road tankers, refrigerated trucks or life-stock trucks (Baran, 2012, Rokicki, 2011).

Transportation processes in agribusiness need to be both efficient and effective, which means they must be responsive to the requirements and expectations of different groups of stakeholders, i.e.: management boards/owners of enterprises, customers, employees and the society. Transporting goods efficiently, effectively, and profitably to each consumer allows consumers to maximize their utilities (or desires). In addition, proper organization of the transportation processes may undoubtedly improve the competitiveness among the agribusiness companies by optimization of costs, as well as offering a higher level of customer service. In consequence managers and owners of agribusiness companies can offer lower consumer prices and expand markets. Due to high share of transportation costs in the final food price and the increasing level of food spoilage in the transportation processes, the owners/managers of agribusiness companies need a comprehensive evaluation of transportation performance of their enterprises and extensive benchmarking analysis of their transportation activities compared with those of their competitors.

Many approaches to the evaluation of companies' performance are reported in the literature, including among others: extensive economic – financial analysis, based on the application of a set of financial ratios (Hsu and Liu, 2008, Wang, 2003), the concept of the Balanced Scorecard proposed by Kaplan and Norton (2001), which focuses on the analysis of 5 major components of the company, i.e.: financial, customer, internal process, learning and growth; Data Envelopment Analysis - DEA (Cooper et al., 2007), which results in generating the company's efficiency index; the Multiple Criteria Analysis (MCA) (Salucci and Delle Site, 2010), which provides a comprehensive, multiple – dimensional evaluation of the company. The above mentioned concepts and methodologies are applied to the evaluation of both the whole, large organizations as well as their smaller components and organizational units.

Most of the research publications concerning the evaluation of agribusiness companies report on the application of financial ratios and DEA method (Alene et al. 2006, Bayarsaihan et al. 1997, Latruffe et.al. 2005). None of these studies evaluate the transportation activities in agribusiness companies using MCA. The major purpose of this article consists in evaluating transportation performance of transportation units operating in agribusiness companies using Multiple Criteria Analysis. Therefore, it is expected that this study will give new insights for carrying out the MCA in agribusiness companies.

The paper is composed of five sections. The first one presents the introduction to the problem and a short literature survey. In the second section the methodology of MCDM/A is presented and the AHP method is described. Section 3 is focused on the formulation of the decision problem. In section 4 the results of computational experiments carried out with the application of the AHP method are reported. Last section includes concluding remarks. The paper is completed by a list of references.

2. The Methodology of Multiple Criteria Decision Making

2.1. Overall characteristics of MCDM/A

Multiple Criteria Decision Making/Aiding (MCDM/A) is a field which originates in Operations Research (OR) (Hillier, Lieberman, 2001), the area that conducts comprehensive "research on operations" and provides a variety of quantitative tools and methods that help the Decision Maker (DM) to make rational decisions. The nature of MCDM/A, as a field of study, is similar to the profile and overall approach applied in Operations Research. Similarly to OR, MCDM/A attempts to equip the DM in a set of tools and methods that help him or her to solve complex decision problems. At the same time, MCDM/A, as opposed to OR, focuses its efforts on solving multiple criteria decision problems, that is such complex decision situations in which the DM, while evaluating a set of actions/ solutions/ variants must take into account several – often contradictory – points of view (Vincke, 1992).

By definition MCDM/A is a field which aims at giving the DM different tools, methods and algorithms that enable him/her to advance in solving the above mentioned multiple criteria decision problems. These problems are such situations in which, having defined a set of actions/variants/solutions ***A*** and a consistent family of criteria ***F*** the DM tends to (Vincke, 1992):

- determine the best subset of actions/variants/solutions in ***A*** according to ***F*** (choice or optimization problem),
- divide ***A*** into subsets representing specific classes of actions/variants/solutions, according to concrete classification rules (sorting problem),
- rank actions/variants/solutions in ***A*** from the best to the worst, according to ***F*** (ranking problem).

Based on the above quoted definition one can easily determine major components that exist in each formulation of the multiple criteria decision problem, i.e. a set of objects/actions/alternatives/variants/solutions ***A*** and a consistent family of criteria ***F***. In the above mentioned examples ***A*** is composed of: a set of assignments / allocations of drivers and transportation tasks to vehicles; a set of vehicles under technical evaluation and a set of transportation service providers, respectively. The consistent / coherent family of criteria *F* is a set of criterion functions ***f***, defined on ***A*** and designed to evaluate all components of the set ***A*** in a comprehensive and consistent manner. Each criterion ***f*** in ***F*** represents subjective preferences of the DM with respect to a concrete aspect / dimension of the decision problem, such as: cost, quality, reliability, efficiency, timeliness, etc. Thus, all the criteria in ***F*** compose a set of characteristics that exhaust the spectrum of issues associated with the considered decision problem and correspond to the DM's expressed interests and expectations. The consistent family of criteria should be characterized by the following features: exhaustiveness of evaluation, cohesiveness, non redundancy (Roy, 1990a, Vincke, 1992, Zak,1999, 2011):

The multiple criteria decision making/aiding methods, used in the solution procedure of the multiple criteria decision problems, can be classified according to several criteria, including: the objective of the decision process in which the method is applied (Roy, 1990a, Zak, 1999) the moment of the definition of the DM's preferences (Zak, 1995) and the manner of the preference aggregation (Roy, 1990a, Vincke, 1992). With respect to the first division criterion three categories of methods, corresponding to the three major categories of multiple criteria decision problems, are identified:

- multiple criteria choice (optimization) methods;
- multiple criteria sorting methods;
- multiple criteria ranking methods.

The second classification criterion allows to distinguish:

methods with an a'priori defined preferences e.g. Electre methods (Roy, 1990a, Roy, 1990b), Promethee I and II (Brans et al, 1984), UTA (Jacquet-Lagreze, Siskos, 1982), Mappac (Matarazzo, 1991), Oreste (Pastijn, Leysen, 1989),

- methods with an a'posteriori defined preferences e.g. PSA method (Czyzak, Jaszkiewicz, 1995),
- interactive methods e.g. GDF (Geoffrion et al, 1972), SWT (Haimes, Hall, 1975), Steuer Procedure (Steuer, 1977), STEM (Benayoun et al, 1971), VIG (Korhonen, Laakso, 1986), LBS (Jaszkiewicz, Slowinski, 1999).

According to the third classification criterion one can define:

- the methods of American inspiration, based on the utility function e.g. AHP (Saaty, 1980), UTA (Jacquet-Lagreze, Siskos, 1982),
- the methods of the European/French origin, based on the outranking relation e.g. Electre methods (Roy, 1990b), Promethee I and II (Brans et al, 1984).

In this research the decision problem is defined as a multiple criteria ranking problem and a multiple criteria ranking method, called AHP (Satty, 1980) is applied to solve it. The method utilizes an a'priori procedure for defining the DM's preferences and the aggregation method based on the utility function.

2.2. The AHP method

The AHP (Analytic Hierarchy Process) method (Satty, 1980) is a multiple objective ranking procedure focused on the hierarchical analysis of the decision problem. The method is based on the multiattribute utility theory (Keeney, Raiffa, 1993) and allows to rank a finite set of variants $\boldsymbol{A}$ from the best to the worst. Through the definition of the overall objective, evaluation criteria, subcriteria and variants the method constructs the hierarchy of the decision problem.

On each level of the hierarchy, based on the pair-wise comparisons of criteria, subcriteria and variants, the DM's preferential information is defined in the form of relative weights $\boldsymbol{w_r}$ (Saaty, 1980). Each weight represents the quantified strength of the compared element against another, on the standard "1 – to – 9" measurement scale, in which: 1 corresponds to the elements that are equally preferred; 3 and 5 denominate – weakly and strongly preferred element, respectively, while 7 and 9 represent strongly and absolutely preferred element, respectively. The intermediate judgments like: 2, 4, 6, 8 can be also used. All weights have a compensatory character, i.e.: the value characterizing the less important element (1/2, 1/5, 1/9) is the inverse of the value characterizing the more important element in the compared pair (2, 5, 9).

The algorithm of the AHP method focuses on finding a solution for a, so called, eigenvalue problem (Saaty, 1980) on each level of the hierarchy. As a result a set of vectors containing normalized, absolute values of weights $\boldsymbol{w_a}$ for criteria, subcriteria and variants is generated. The sum of the elements of the vector is 1 (100%). The absolute weights $\boldsymbol{w_a}$ are aggregated by an additive utility function. The utility of each variant $\boldsymbol{i} - \boldsymbol{U_i}$ is calculated as a sum of products of absolute weights $\boldsymbol{w_a}$ on the path in the hierarchy tree (from the overall goal, through criteria and subcriteria) the variant is associated with. The utility $\boldsymbol{U_i}$ represents the contribution of variant $\boldsymbol{i}$ in reaching an overall goal and constitutes its aggregated evaluation that defines its position in the final ranking. The final result of the AHP method algorithm is the ranking of variants from the best to the worst based on the decreasing values of their overall evaluations.

The important element of the AHP algorithm is the investigation of the consistency level of matrices of relative weights $\boldsymbol{w_r}$ on each level of hierarchy. Through the calculation of a, so called, consistency index $\boldsymbol{CI}$ one can measure how consistent is the preferential information given by the DM. If the value of $\boldsymbol{CI}$ is close to 0 the preferential information given by the DM is considered to be almost perfect. The acceptable level of $\boldsymbol{CI}$ is below 0.1.

3. Definition of the decision problem

The decision problem (DP) considered in this paper is formulated as a multiple criteria ranking problem. It consists in evaluating and ranking a set of 10 transportation units (variants) operating in their parent Polish agribusiness companies which focus their activities on processing agricultural and food products. The analysis was conducted for transportation units operating in agribusiness enterprises for the year 2012. The considered agribusiness enterprises are characterized by the following features:

- average level of employment between 50 and 250 employees;
- total annual revenues ranging from EUR 6,000,000 to 40,000,000;
- the enterprise possessed an organizational branch/department performing transportation activities and had its own fleet of vehicles.

The surveyed sample consisted of 10 transportation units (variants from V1 to V10) which are operating in Polish agribusiness companies. It is assumed that all these variants utilize their own fleet and thus arrange transportation services, by themselves, as the company's internal activities. The units deliver food products to customers from different market, size and location. The variants operate in different agribusiness sub-sectors, such as milk, grains, fruits and vegetables processing. As a result analyzed variants utilize different categories and kinds of fleet e.g. road tankers, refrigerated trucks.

The objective of the multiple criteria analysis of transportation units operating in agribusiness companies is to evaluate them from different perspectives. The multiple criteria evaluation of transportation units is envisaged by the authors of the paper as an extensive benchmarking analysis, resulting in the recognition of the most efficient transportation unit characterized by the best transportation performance in the analyzed sample.

The decision maker (DM) in the analyzed decision making process is represented by the top management of the analyzed agribusiness companies. The top management of the agribusiness companies expect benchmarking comparison of the efficiency, reliability, quality of transportation performance of transportation units and they are interested in ranking transportation units from the best to the worst.

The analysts in the decision process are the authors of the paper. They provide methodological guidelines and advise in different phases of the decision process. The important role of the analysts is clearly demonstrated in this paper in the phases of: defining a consistent family of criteria and using the MCDM/A method matching the character and specific features of the considered DP.

In accordance with the definition of the consistent family of criteria, mentioned in section 2, it is composed of several measures that completely, consistently and non-redundantly evaluate transportation activity of the studied transportation units operating in agribusiness companies. While defining a family of criteria the authors made efforts to include characteristics of economical, technical, safety, environmental and organizational/social character as well as the interests, requirements and expectations of different groups of stakeholders, i.e.: management board/owners of enterprises, customers, employees (in particular drivers) and the society (i.e.: roads users). As can be seen, some of the criteria are universal, i.e. refer to the expectations of all mentioned entities. Others are related to interests of individual intervening parties. With regard to the nature of the discussed problem, most of the criteria are related to the interest of the management board/owners of the evaluated agribusiness companies.

The proposed criteria and subcriteria are as follows:

- **Transportation costs (C1) -** this criterion is composed of two subcriteria:
  - Fleet utilization costs [thousand PLN/100,000 km], which is the basic economic measure determining the overall, average unit utilization expenses of each vehicle in the fleet. It includes such components as: fuel costs and vehicle maintenance costs. This sub-criterion is minimized and it is particularly important for the management/owners of the enterprise. In addition, another party – i.e. drivers may be indirectly interested, in this sub-criterion due to widely promoted policy of awarding drivers for "economical" driving, which correlates their personal interests with fleet utilization costs.
  - Tonne-kilometre costs [PLN/tkm] - this minimized sub-criterion is critical for the management and owners of the enterprise. It guarantees the achievement of the maximum profit while performing a given transportation task. The cost of tkm varies depending on the technical condition of the vehicles as well as capacity and horse power of their engines.
- **Delivery time (C2)** [h/100km] - this minimized criterion is very important for customers. It is defined as an average time of delivering orders to strategic customers located within 100 km radius from the company's headquarter (depot). This criterion depends on the distance of a given enterprise from its key customers and the average technical speed of the vehicles available in the fleet.

- **Fleet modernity (C3)** [years] - this criterion is defined as an arithmetic average of the age of all vehicles used in the company. The age of a vehicle is defined as the period between its manufacturing and the moment of this analysis. It is expressed in time units (years) and it is minimized. The criterion of fleet modernity is important for both management / owners of the enterprise and drivers. The reduction of the average age of the fleet leads to building good image of the company, decreasing fleet utilization costs, increasing comfort of driving and reducing the probability of unexpected breakdowns of vehicles (very painful for drivers).
- **Transportation reliability (C4) -** this criterion is composed of two subcriteria:
  - Timeliness of deliveries, expressed in [%], that specifies the level of orders fulfilled punctually (on time). It is defined as a ratio of the number of deliveries fulfilled by the service provider within time limits (dates, hours), specified by the customer to the total number of orders received in the considered period of time.
  - Fulfillment of deliveries, expressed in [%], which measures the level of completed orders (deliveries). It is defined as a ratio of the number of deliveries fulfilled by the service provider and the total number of orders received in the considered period of time.

  These subcriteria are maximized and both play on important role to customers who expect complete and on-time fulfilment of their deliveries.
- **Transportation Quality (C5) -** this criterion includes two subcriteria:
  - Failure-free transportation (deliveries), which measurers the share [%] of deliveries carried out without any mechanical defects and damages to the delivered goods. It is defined as the ratio of the number of deliveries fulfilled without any damages to the total number of orders fulfilled in the considered period of time.
  - Share of deliveries of unspoiled goods [%], that indicates the level of fulfilled orders in which food products have been delivered 100% unspoiled. This criterion is defined as a ratio of the number of deliveries featured by the zero level of food spoilage to the total number of orders fulfilled in the considered period of time.

Taking into account high transportation sensitivity of agricultural and food products, this criterion is especially important for the customer, who is interested in maintaining proper conditions of transportation and the resulting high quality of delivered goods. Since customers require, in a natural way, deliveries of undamaged and unspoiled food products these two subcriteria represent their interests. To some extent they are also important to the management and owners of the service providers (agribusiness companies) as the indicators supporting their reputation and image. They also stimulate high quality transportation standards resulting in the elimination (or at least substantial reduction) of conventional penalties imposed on service providers for delivering damaged and spoiled goods (products).

- **Safety (C6)** - this criterion includes two subcriteria which are of particular importance to the drivers as well as other road users. In the indirect manner they also satisfy the interests of the management/owners of the company.
  - Road safety, which corresponds to the share of deliveries without accidents [%]. This subcriterion is maximized. It is defined as a ratio of the number of deliveries fulfilled without accidents to the total number of orders fulfilled in the considered period of time.
  - Situational safety which is defined as a share of deliveries without any assault and theft [%]. This subcriterion is maximized. It is computed as the ratio of the number of deliveries carried out without any assault, theft to the total number of deliveries fulfilled in the considered period of time.
- **Environmental friendliness (C7)** [pts] - this maximized criterion measures the average standard of exhaust gas emissions of vehicles of the considered fleets. The criterion is expressed in terms in points allocated for average standard of exhaust gas emissions of vehicles e. g. 4 pts for EURO 4. Higher value of this criterion indicates that the company possesses a larger number of vehicles satisfying enhanced European emission standards (EURO 4 and EURO 5). This criterion is important for management of the analyzed agribusiness companies and society.

- **Fleet utilization (C8)** [%] is a criterion that measures the fitness between the size and character of the transported goods and the capacity of the available fleet. As a maximized magnitude it is important for both the management of the enterprise and the customers. High value of this criterion corresponds to appropriate fleet management and translates into increased efficiency of transportation operations.

As a result of the criteria and variant definition and based on data collected in the about mentioned sample of agribusiness companies the evaluation matrix presented in table 1 has been constructed.

Table 1. The evaluation matrix for performing MCA of transportation activities of transportation units (variants) in 10 agribusiness companies

Criteria	Subcriteria	Variants									
		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
Transportation Costs (C1)	Fleet Utilization Costs [thousand PLN/100,000 km]	101.0	88.60	79.90	98.00	83.30	85.00	84.10	104.0	86.40	99.00
	Tonne-Kilometre Costs [PLN/tkm]	0.52	0.38	0.48	0.54	0.39	0.51	0.56	0.53	0.41	0.56
Delivery Time (C2) [h/100km]		1,80	1.60	1.65	1.84	1.82	1.76	1.77	1.99	1.71	1.86
Fleet Modernity (C3) [years]		12,53	8.00	7.43	11.57	8.00	10.53	10.00	12.23	9.00	10.00
Transportation Reliability (C4)	Timeliness of Deliveries [%]	99.0	95.0	97.0	99.0	95.0	95.0	98.0	98.0	95.0	97.0
	Fulfilment of Deliveries [%]	99.5	90.0	99.8	99.0	95.0	99.7	100.0	99.0	100.0	98.0
Transportation Quality (C5)	Failure-free Transportation [%]	99.5	90.0	99.84	99.0	95.0	99.68	99.96	99.0	100.0	98.0
	Share of Deliveries of Unspoiled goods [%]	99.5	99.0	99.99	100.0	99.97	100.0	100.0	100.0	100.0	100.0
Safety (C6)	Road Safety [%]	99	98	100	98	98	100	100	100	99	100
	Situational Safety [%]	99	100	99	100	100	99	98	100	98	100
Environmental Friendliness (C7) [pts]		4,41	3.67	4.43	4.57	4.33	4.00	3.67	4.00	4.50	4.00
Fleet Utilization (C8) [%]		68	86	90	72	83	68	73	69	86	71

4. Computational experiments and their results

Computational experiments have been carried out with the application of AHP method implemented in the specialized software called MakeItRational. In the first stage the hierarchical structure of the decision problem has been defined, including the definition of the overall goal, criteria, subcriteria and variants (see description in section 3). In the next step the model of the DM's preferences has been constructed. This has included the definition of the importance of individual criteria and subcriteria and the recognition of the DM's sensitivity to changes of their values. The manner of assigning criteria and subcriteria weights of importance according to the AHP procedure mentioned in section 2. On the basis of pair-wise comparisons between criteria and sub-criteria the relative weights w_r , ranging between 1/9 to 9 have been generated.

Table 2. Relative weights w_r for criteria generated by the AHP method

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1	2	6	4	2	4	9	5
C2	1/2	1	5	3	1	3	7	4
C3	1/6	1/5	1	1/3	1/4	1/3	3	1/2
C4	1/4	1/3	3	1	1/2	1	5	2
C5	1/2	1	4	2	1	2	7	4
C6	1/4	1/3	3	1	1/2	1	5	2
C7	1/9	1/7	1/3	1/5	1/7	1/5	1	1/3
C8	1/5	1/4	2	1/2	1/4	1/3	3	1

The results of calculations of relative weights w_r for criteria, applied in the evaluation of transportation units of the agribusiness companies, have been presented in table 2. This matrix is characterized by pair-wise coherence. In addition, all terms on the diagonal of the matrix $w_{r11}, w_{r22},..., w_{r88}$ are equal to 1. It can be seen that criterion 1(Transportation Costs) is more important than all others (relative weights are higher than 1), while criterion 7 (Environmental Friendliness) is the least important (relative weights are lower than 1).

In the next step the eigenvalue problem has been solved, which resulted in the generation of normalized absolute weights w_a on all levels of the hierarchy i.e. for criteria, subcriteria and variants in the form of weight vectors all, above mentioned components of the hierarchy. As can be observed in table 3, the most important criterion - with the highest value of weights (w_a = 0.3112) is criterion 1 – C1, i.e. Transportation Costs. The next places are held by: criterion 2 – C2 (Delivery Time) and criterion 5 – C5 (Transportation Quality). Criteria 7 (C7) - Environmental Friendliness and 3 (C3) - Fleet Modernity belong to the least important characteristics. Their absolute weights are 0.0221 and 0.0409, respectively, which is presented in table 3.

Table 3. Absolute weights w_a of criteria and subcriteria generated in the AHP method

No	Criteria/ Subcriteria	Absolute Weight	No	Criteria/ Subcriteria	Absolute Weight
C1	Transportation costs	31.12	C5	Transportation Quality	17.75
C1.1	Fleet Utilization Costs	15.56	C5.1	Failure-free Transportation	8.88
C1.2	Tonne-Kilometre Costs	15.56	C5.2	Share of Deliveries of Unspoiled Goods	8.88
C2	Delivery time	20.53	C6	Safety	9.36
C3	Fleet Modernity	4.09	C6.1	Road Safety	4.68
C4	Transportation Reliability	9.36	C6.2	Situational Safety	4.68
C4.1	Timeliness of deliveries	4.68	C7	Environmental Friendliness	2.21
C4.2	Fulfilment of Deliveries	4.68	C8	Fleet Utilization	5.56

Further analysis lead to mutual comparisons of variants for all individual criteria and subcriteria. The relative weights of individual variants specify the relative position of a given variant (transportation unit of the agribusiness companies) in relation to its competitors (other transportation units), evaluated by the given sub-criterion. The values of the relative weights also reflect the direction of preference of this criterion. Similarly to previous computations a vector containing normalized, absolute values of weights for variants has been generated.

In the next step for each matrix on 3 hierarchical levels, i.e.: criteria, subcriteria and variants, consistency indexes *CI* have been computed. In all matrices the values of the consistency indexes *CI* have not exceeded 0.1, which proved that the acquired preferential information has been appropriately defined. This allowed the authors to continue the computational experiment.

The final stage consisted in aggregating the absolute weights w_a of the elements of the hierarchy tree by means of an additive utility function. As a result the utility of each variant U_i, has been calculated. Figure 1 presents the final ranking of variants (transportation units operating in agribusiness companies) from the best to the worst based on their decreasing utilities. Thus, transportation unit with the highest utility is placed at the top of the ranking, while the transportation unit with the lowest utility is placed at the bottom. The utility of each variant also provides information on its participation in achieving the overall goal of the analysis.

The utility of each variants U_i also provides information on the relative "distance" between variants. The considered case shows that variant 3 - V3 has advantage over the remaining variants (utility 0.1395). Further along the line are variants V9, V2 and V5, respectively. The differences between these three variants are relatively insignificant. On the end of the ranking is variant 8 – V8, whose utility is 0.0653.

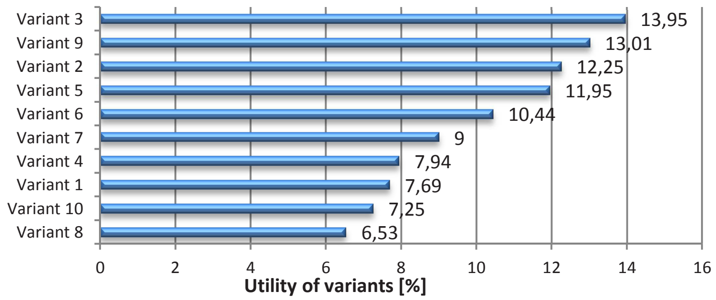

Fig. 1. Final ranking of 10 transportation units of the agribusiness companies generated by AHP method

5. Conclusions

The paper presents the application of the MCDM/A methodology to the evaluation of transportation units of the Polish agribusiness companies, resulting in the assessment of their transportation competence / performance. The decision problem is formulated as a multiple criteria ranking problem. All variants (transportation units of the agribusiness companies) are evaluated by a consistent family of criteria and finally ranked from the best to the worst with the application of the selected MCDM/A ranking method, i.e.: AHP method. The authors of the paper present all the phases of the solution procedure of the multiple criteria decision problem. They put special emphasis on the definition of the consistent family of criteria which allows for comprehensive evaluation of transportation units of the agribusiness companies, recognition of the major groups of interests and modeling of their preferences (especially the DM's preferences) and generating the final ranking of the considered variants.

From the methodological point of view the proposed approach for ranking and benchmarking of transportation units has a universal character and can be applied in a variety of agribusiness companies. It is composed of the following stages: recognition of the DM and major stakeholders; analysis of variants (transportation units); definition of the consistent family of criteria and constructions of the evaluation matrix; definition of DM's model of preferences; computational experiments leading to the final ranking.

From the practical point of view the results of this analysis can be summarized as follows:

- the best transportation unit is variant V3, which owes the top position in the ranking to the very good performance on key criteria, including Transportation Costs and Delivery Time. Parameters of transportation activity in this transportation unit may constitute a benchmark for other evaluated entities.
- the worst transportation unit is variant V8 located at the bottom of the ranking. The result of the low position of this variant in the ranking is poor performance on all considered criteria.

Further studies can be carried out in the following directions:

- the application of different MCDM/A methods to the ranking of transportation units of the agribusiness companies and comparison of generated results. From a methodological point of view it is interesting to verify whether different MCDM/A methods generate similar rankings.
- detailed analysis of the winning variant V3 as a benchmark for other evaluated transportation units. This research should result in developing a set of universal features characterizing a model transportation unit for the agribusiness company.

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