ECONOMICS
& Sociology

Wątróbski, J., Jankowski, J., Ziemba, P. (2016), Multistage Performance Modelling in Digital Marketing Management, *Economics and Sociology*, Vol. 9, No 2, pp. 101-125. **DOI: 10.14254/2071-789X.2016/9-2/7**

Jarosław Wątróbski,
West Pomeranian University of Technology in Szczecin,
Szczecin, Poland,
E-mail: jwatrobski@wi.zut.edu.pl

Jarosław Jankowski,
Wrocław University of Technology,
Wrocław, Poland,
E-mail: jjankowski@wi.zut.edu.pl

Paweł Ziemba,
The Jacob of Paradyż University of Applied Science in Gorzów Wielkopolski,
Gorzów Wielkopolski, Poland,
E-mail: pziemba@pwsz.pl

Received: January, 2016
1st Revision: March, 2016
Accepted: May, 2016

DOI: 10.14254/2071-789X.2016/9-2/7

MULTISTAGE PERFORMANCE MODELLING IN DIGITAL MARKETING MANAGEMENT

ABSTRACT. Effective online marketing management requires developing new research methods supporting campaign performance evaluation. The paper presents a multistage approach with performance modelling based on Dynamic Multi Criteria Decision Analysis. The crisp and fuzzy versions of the TOPSIS method were used in the process of dynamic modelling. The evaluation was performed in terms of marketing management, taking into account several conflicting criteria (user experience and intensity of advertising content). Real data from advertising servers were used during the evaluation and example decision processes were performed.

JEL Classification: C44

Keywords: TOPSIS, Dynamic MCDA, online environment.

Introduction

Interactive media, apart from one-to-one communication, allow for detailed tracking of the performance of online campaigns and improving it with the use of dedicated technologies (Hoffman and Novak, 1995). Several interdisciplinary research directions can be observed with the main goal of increasing outcomes from online advertising and identification of new challenges (Guha *et al.*, 2010). Campaign execution is usually based on media plans, which are prepared at strategical level with conventional planning methods (Cannon, 2001) or dedicated models dealing with a multi-objective approach in the online environment (Hengbo and Yanfeng, 2012; Du and Xu, 2012). While campaign planning takes place periodically, the online advertising systems require tuning and optimization in real time. In the online environment, methods based on multivariate testing or stochastic models or contextual selection (Tang *et al.*, 2013) are used. Apart from optimization, improvement is performed with the use of behavioral targeting systems (Yan *et al.*, 2009), retargeting customers with revealed interest in specific products (Lambrecht and Tucker, 2013) or real time bidding systems (Yuan *et al.*, 2013). Intensive online advertising can affect websites and makes information seeking more difficult and causes an increased cognitive load, frustration and other negative emotions (Brajnik and Gabrielli, 2010). Due to factors related to cognitive avoidance, the dropping performance of online advertising is observed over time (Kelly *et al.*, 2010). With connected characteristics related to audience, changes of the performance over the time, campaign planning requires the use of past data with the ability of taking into an account uncertain information. Earlier approaches based on stochastic or fuzzy models use same importance for data from past periods and from recent results.

Due to searching for a more realistic approach, the presented research is based on the use of past data with a forgetting function and weighted importance of data from past periods. The work is presented as follows: after the literature review and the problem statement, the conceptual framework of a multistage performance modelling is presented. In the next stage, the proposed framework is used in an empirical study for dynamic evaluation of data from experimental advertising campaign. Finally, conclusions are presented.

1. Literature Review

Interactive media created the ability to measure different results from online marketing campaigns and use them in the decision process related to planning at both strategy and tactical levels. New metrics are used in this field for media planning for the evaluation of online campaigns and are based on the direct response and interactions or longer term influence on brand awareness (Novak and Hoffman, 1996; Pavlou and Stewart, 2000) with an essential quantitative approach to media planning (Hoffman and Novak, 2000). New approaches dedicated to online media use its specifics, but conventional media planning based on earlier approaches is still applicable in that area (Cannon, 2001). The basis for online campaign execution within the portal selling advertising space is the scheduling at different slots the use of different creations. Estimations of potential audiences and the ability to serve advertisements use the analysis based on the planned behaviors and site pre-visit intentions (Wu, 2007). At the operational level other areas deal with the real time campaign optimization and searching for the best method of resource exploitation with the use of stochastic models (Chakrabarti *et al.*, 2009). Even when a banner selection is performed at the operational level and the selection is used with the different parameter scheduling, the execution is based on plans from a strategical level (Amiri and Menon, 2003). Scheduling is used within advertising server applications to select specific content as an answer to a request coming from a web browser.

One of the first applications of optimization models in this field was based on the search behaviors of the user which allows for optimization of the advertising content delivery (Langheinrich *et al.*, 1999). Optimization task was defined as a linear programming problem with a limited number of served advertisements in a given period. An extension of the concept was the solution for a distribution of emissions as a result of a two-stage optimization (Chickering and Heckerman, 2000). The proposed approach identified the likelihood of diversion from the emission of advertising in the analysis of data. The optimal emissions plan allows the parametrization of the advertising server to obtain the maximum number of interactions in a given period of time. Another extension allowed to avoid exposition to a narrow target group with the use of entropy maximization (Tomlin, 2000). The results showed that a nonlinear approach can be used as a component of other models and used for advertising inventory management. The model proposed in (Langheinrich *et al.*, 1999) was extended towards the estimation of click-through rates and computing the probabilities of impressions based. Other approaches use tracking of user sessions and maximization of clicks probability with the solution based on Bayesian models and generated ranking of advertisements with assigned probabilities (Gupta *et al.*, 2011). In other solutions, selection of the advertising content is based on the user profiles collected during the website browsing process (Giuffrida *et al.*, 2011). Another work is related to adjusting the pricing strategies for online advertising using the most popular CPM (cost per mile) and CPC (cost per click) models. Another approach is based on multi-objective model whose main goal is to construct pricing strategies and maximize the revenue of the web portal and minimize the cost for the advertiser (Hengbo and Yanfeng, 2012).

Advertising units used within campaigns often explore techniques based on persuasion, call-to-action messages, colors, animations and different layouts or changing the structure of advertisements in the real time using data about consumer behavior (Urban *et al.*, 2014; Zorn *et al.*, 2012; Yoo and Kim, 2005). The attempts of increasing the performance of online marketing are connected with growing intensity of online actions and negative feedback from target users (Zha and Wu, 2014). Web users are more and more overloaded by different information. Only part of content takes attention because of the limited ability to process information (Lang, 2000). Attempts to acquire attention from users are connected with the use of the high visibility components (Turatto and Galfano, 2000). Intensive usage of video, audio and animations within advertising content is negatively affecting user experience (Rosenkrans, 2009). Overall evaluation of results of the campaign can be reduced because of limited cognitive capacity when negative affective response with irritation and annoyance (Yoo *et al.*, 2004). Overload with information on the web is resulting engaging in selective online perception and only a limited number of messages is processed while others are ignored (Jankowski *et al.*, 2011). Interests of researchers and entrepreneurs resulted in different experiments and ways of measuring the intrusiveness.

In our approach, we propose the integration of performance measure together with the evaluation of intensity of advertising content. The proposed approach delivers compromise solutions within an uncertain environment and with forgetting parameters that include both objectives to evaluate the results from different perspectives and the different usage of past data. The method presented in this paper shows a new approach to perform a more detailed analysis to gain more information about past behaviors with a multi-criteria approach. The results are based not only on compromise solutions obtained during interactive process based on references but on modeling data from a real environment as well.

2. Methodological Background

2.1 Preparing of the input data

The issues considered in the article are oriented towards performance modeling in the online environment. For the research, data from experimental advertising campaigns performed in the real environment were employed. Data collected during experimental campaigns in periods t_1, t_2, ..., t_{10} were used for generating a solution for planning an advertising campaign in the period t with an included ability to define forgetting levels for data from earlier periods. Empirical research was conducted in three stages. The first stage includes the design of variants of advertising objects with different levels of intensity. In the second stage online testing campaign was conducted in the real environment. In the third one the content was evaluated in terms of perceived influence of a user. Collected data from each experiment were used to compute parameters for a model.

A field experiment was conducted in ten time periods t_1, t_2, ..., t_{10} with the average length of one day each. For each period and for each advertisement data related to the number of ad impressions and click through ratio based on the number of clicks were collected. In *Table 1* the number of impressions for each campaign based on the available audience for each period is shown. The number of impressions are affecting possible results and high variability is showing difficulties with the use of deterministic parameters for the model. Online experiment delivered data related to a number of registered interactions in a form of clicks. Using these data click trough ratio representing a number of clicks in relation to the number of impressions for each period was computed for each ad unit (AU) within each campaign C. The obtained results are shown in *Table 1*.

Table 1. Data taken into consideration in the research for the first advertiser

Variant	Conversion rate (max)											Intensity (min)	Profits (max)
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Mean		
A1.1	0,000	0,000	0,018	0,000	0,000	0,001	0,001	0,001	0,002	0,003	0,003	0,003	0,000
A1.2	0,000	0,000	0,011	0,046	0,000	0,001	0,002	0,001	0,003	0,002	0,006	0,258	0,001
A1.3	0,000	0,001	0,021	0,082	0,000	0,002	0,003	0,002	0,006	0,005	0,012	0,184	0,002
A1.4	0,000	0,001	0,012	0,000	0,000	0,001	0,001	0,000	0,002	0,004	0,002	0,847	0,001
A1.5	0,000	0,000	0,025	0,000	0,000	0,001	0,001	0,002	0,003	0,004	0,004	0,703	0,001
A1.6	0,000	0,000	0,021	0,047	0,000	0,002	0,003	0,002	0,002	0,004	0,008	0,839	0,003
A1.7	0,000	0,000	0,015	0,070	0,000	0,001	0,002	0,001	0,005	0,004	0,010	0,439	0,004
A1.8	0,000	0,001	0,014	0,016	0,000	0,001	0,001	0,002	0,003	0,002	0,004	0,579	0,002
A1.9	0,000	0,001	0,025	0,016	0,000	0,001	0,001	0,002	0,003	0,002	0,005	0,500	0,003
A1.10	0,000	0,001	0,014	0,094	0,000	0,001	0,001	0,002	0,007	0,005	0,012	0,648	0,007

Changes in a response within analyzed periods were observed and can be a result of different timing, a temporal growth of interest in an advertised product. Earlier research showed that the response changes over the time.

2.2 Research methodology

The article presents an attempt to construct an MCDA based performance model taking into consideration dynamic aspects of a decision process (Morselli, 2015). In a typical problems related to decisions in a fast changing environment the dynamics of the domain of decision-making is observed. The visible preference changes are reflected in diversity and changes of evaluation of decision variants (Endress and Gear, 2015). Other components of the decision process are unchanging – both sets of decision variants and their evaluation criteria are constant and coherent.

The methodology of the research, proposed in the article, uses the term of Dynamic Multicriteria Decision Analyses (DMCDA) (Campanella and Ribeiro, 2011). The MCDA methods itself have been popular and have been widely used in many scientific disciplines for many years (Balcerzak and Pietrzak, 2016a; Olczyk, 2014; Jantoń-Drozdowska and Majewska, 2015; Jantoń-Drozdowska and Majewska, 2016; Łyszczarz, 2016). To put it simply, the use of individual MCDA methods is directed to:

- decision support in the environment of many criteria with the assistance of the decision-maker, analyst and field experts,
- the generation of rational ("good", not optimal) recommendation, since it is assumed that input data of individual models constitute non-dominated solutions in the Pareto terms (Roy, 1991).

Assumptions and guidelines for using individual MCDA methods as well as the shape of the support process available in the works (Guitouni and Martel, 1998; Roy, 2005) have limitations of the base methodology. An example are assumptions (see Roy, 2005) about the consistent shape of the criteria evaluation family, and, as a consequence, the stability of evaluating preferences the decision-maker or an assumption about the unchanging form of other elements of a modelled domain (a constant set of decision variants which feed the decision support model only once and valid competences of experts/evaluators). As it can be easily seen that meeting these assumptions in practice may be difficult and an example of such a changeable environment of decision-making can be interactive media.

When analyzing the literature, one can point out articles in which authors suggest adapting the MCDA methodology for the needs of modelling of selected dynamic elements of a decision process. For instance, Po-Lung Yu and Yen-Chu Chen in the paper (Yu and Chen, 2010) introduced a comprehensive theory of dynamic multiple criteria decision analysis. The authors generalized the problem itself and extended the elements of the decision problem by introducing the notions of habitual domains, and competence set analysis. Nevertheless, most articles in the field are focused on developing the classic MCDA model only for selected aspects of dynamic decision making (Balcerzak, 2009; Pietrzak and Balcerzak, 2016a; 2016b). They refer to the issues of changes in the MCDA domain, that is changing sets of decision variants or evaluation criteria, or they extend the classic MCDA paradigm by additional elements of the support process, such as changeable spaces (Jassbi *et al.*, 2014; Hashemkhani Zolfani *et al.*, 2016). The synthesis of these approaches can be found in, among other things in the papers (Kornbluth, 1992; Agrell and Wikner, 1996).

2.3 Selection of an MCDA method

An essential aspect leading to the use of the potential of MCDA methods in performance modeling in the online environment is a proper selection on the basis of characteristics (Wątróbski and Jankowski, 2015; Wątróbski and Jankowski, 2016a) and abilities (Wątróbski and Jankowski, 2016b) offered by individual methods. *Table 2* depicts basic features of the most popular MCDA methods.

Table 2. Characteristics of selected MCDA methods

MCDA method	Characteristics																Abilities					Reference
	Binary relations				Criteria compen-sation effect			Preferential information					Problematics									
	I - Indifference	P - Preference	R - Incomparability	S - Outranking	Non-compensatory	Partially compensatory	Fully compensatory	Ordinal	Cardinal	Deterministic	Non-deterministic	Fuzzy	α - Choice	β - Sorting	γ - Ranking	δ - Description	Quantitative weights of criteria	Pairwise comparisons matrices	Indifference and preference thresholds	Performance of variants on quantitative scale	Full comparability of variants	
AHP	T	T				T			T	T	T		T		T		T	T		T	T	(Saaty, 1994)
ANP	T	T				T			T	T	T		T		T		T	T		T	T	(Saaty and Vargas, 2006)
ELECTRE I			T	T		T		T	T	T			T				T					(Roy, 1968)
ELECTRE II			T	T		T		T	T	T			T		T		T					(Roy and Bertier, 1973)
ELECTRE III			T	T		T		T	T	T			T		T		T		T	T		(Roy, 1978; Leyva-Lopez and Fernandez-Gonzales, 2003)
ELECTRE IS			T	T		T		T	T	T			T				T		T	T		(Roy and Skalka, 1984)
ELECTRE IV			T	T		T		T	T	T			T		T				T			(Roy and Hugonnard, 1982)

MCDA method	Characteristics																Abilities					Reference
	Binary relations				Criteria compen-sation effect			Preferential information					Problematics									
	I - Indifference	P - Preference	R - Incomparability	S - Outranking	Non-compensatory	Partially compensatory	Fully compensatory	Ordinal	Cardinal	Deterministic	Non-deterministic	Fuzzy	α - Choice	β - Sorting	γ - Ranking	δ - Description	Quantitative weights of criteria	Pairwise comparisons matrices	Indifference and preference thresholds	Performance of variants on quantitative scale	Full comparability of variants	
ELECTRE TRI			T	T		T		T	T	T				T			T		T	T		(Bouyssou and Roy, 1993)
Fuzzy AHP	T	T				T			T	T	T	T	T		T		T	T		T	T	(Mikhailov and Tsvetinov, 2004)
Fuzzy ANP	T	T				T			T	T	T	T	T		T		T	T		T	T	(Promentilla et al., 2008)
Fuzzy PROMETHEE I	T	T	T			T		T	T	T	T	T	T		T		T		T	T		(Wang,Chen L. Y. and Chen, Y. H., 2008; Motlagh et al., 2016)
Fuzzy PROMETHEE II	T	T				T		T	T	T	T	T	T		T		T		T	T	T	(Wang,Chen L. Y. and Chen, Y. H., 2008; Motlagh et al., 2016)
Fuzzy TOPSIS	T	T					T		T	T	T	T	T		T		T			T	T	Chen,Lin and Huang, 2006)
Lexicogra-phic method	T	T			T			T	T	T			T									(Fishburn, 1974)
MAUT	T	T				T			T	T	T		T		T		T			T	T	(Keeney and Raiffa, 1976)
NAIADE I			T	T		T		T	T	T	T	T	T		T		T			T		(Munda, 1995)
NAIADE II				T		T		T	T	T	T	T	T		T		T			T	T	(Munda, 1995)
PROMETHEE I + GAIA	T	T	T			T		T	T	T			T		T	T	T		T	T		(Brans et al., 1984; Mareschal and Brans, 1988; Brans and Mareschal, 2005)
PROMETHEE II + GAIA	T	T				T		T	T	T			T		T	T	T		T	T	T	(Brans,Mareschal and Vincke, 1984; Mareschal and Brans 1988; Brans and Mareschal 2005)
SAW	T	T					T		T	T			T		T		T			T	T	(MacCrimmon, 1968)
TOPSIS	T	T					T		T	T			T		T		T			T	T	(Hwang and Yoon, 1981; Shih et al., 2007)

In multicriteria decision analysis the decision-maker's preferences are expressed by means of binary relations. When comparing decision variants, the following relations can take place: indifference of compared variants (ai I aj), preference of one variant towards another one (ai P aj), incomparability between variants (ai R aj) and grouped relations, such as outranking (ai S aj) joining indifference and preference (Roy, 1991). Individual relations in the methods of "European school of decision-making" are usually based on thresholds: p (preference threshold), q (indifference threshold) and v (veto threshold). It should be stressed that the use of the incomparability relation in the MCDA method prevents the full comparability of variants (Roy, 1991).

A so-called criterion compensation effect can have a significant influence on solutions received by means of individual MCDA methods. The compensation is that a low evaluation of a variant with regard to one of criteria can be compensated with a high evaluation with regard to another criterion (De Montis *et al.*, 2000). Guitouni and Martel (Guitouni and Martel, 1998) distinguish three levels of compensation: (1) full compensation, which takes place when good productivity of a variant with regard to one of criteria can be easily balanced by means of poor productivity with regard to another criterion, e.g. SAW; (2) non-compensation, when some criteria are so important that they cannot be compensated in any other way, e.g. lexicographic method; (3) partial compensation – compensation between criteria is acceptable only in a limited range.

Preference information used in MCDA methods is closely related to a measuring scale and data on which a given method can operate. Input data can be qualitative or quantitative and, consequently, they can be expressed on an ordinal or cardinal scale (Roy, 2005). The nature of the data refers to whether they are reliable or not (Ozturk *et al.*, 2005). Reliable data, also referred to as deterministic, are expressed in a sharp form, whereas unreliable data (non-deterministic) are represented by a discrete or continuous distribution (Guitouni and Martel, 1998). Moreover, some methods make it possible to express unreliable data in a fuzzy form (Ozturk *et al.*, 2005). It ought to be emphasized that some MCDA methods allow aggregating preferential information coming from many decision-makers.

Every decision problem can be attributed to the problematics the decision problem deals with. The problematics result from the aim which is expected from the decision process (Ishizaka and Nemery, 2013). In the problematics of description (P.δ), preparing a description of potential actions and the identification of a criterion or a family of criteria pose a problem. In the problematics of choice (P.α), supporting the decision-maker is concentrated on selecting a small number of "good" variants. The problematics of sorting (P.β) is concentrated on attributing a variant to one of classes available. Finally, in the problematics of ranking (P.γ), a ranking of decision variants according to defined criteria is prepared (Roy, 1996).

The MCDA method, which is used in performance modeling in the online environment, should especially take into consideration indifference and preference relations, which will make it possible to differentiate the performance. Moreover, it should not allow an incomparability relation to appear, since it is essential that the performance ranking is total. Taking into account acceptable compensation criteria, it is reasonable to compensation of low-marked criteria by high-marked ones seems to be legitimate. Measuring data, on which the method will work, can be determined as reliable, since these are objective measures expressed in quantitative scale.

The problematics considered by individual MCDA methods is of importance, because a method ought to consider, first of all, the problematics of a ranking. It allows putting websites in order according to their synthesized quality, expressed on a quantitative scale. The analysis of characteristics and abilities of individual MCDA methods with relation to the requirements discussed points out to the fact that the TOPSIS method along with its fuzzy development, can be used in evaluating websites.

3. Methodological framework

Presented in this paper methodology is based on deterministic and fuzzy versions of the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. Modelled aspects of dynamics of the evaluation process cover the changeability of partial evaluations of decision variants in time (performance tables and global performance of variants – see (Chen *et al.*, 2010)) as well as the analysis of the influence of this changeability on the final score of the decision process. The research procedure is based on classical assumptions introduced by Guitoni and Roy (see (Guitouni and Martel, 1998; Roy, 2005)) and consists of five stages: (I) the structuring of the decision making situation, (II) the preferences articulation and modelling, (III) the aggregation of these preferences, (IV) the exploitation of this aggregation, (V) the recommendation. It is presented in *Figure 1*.

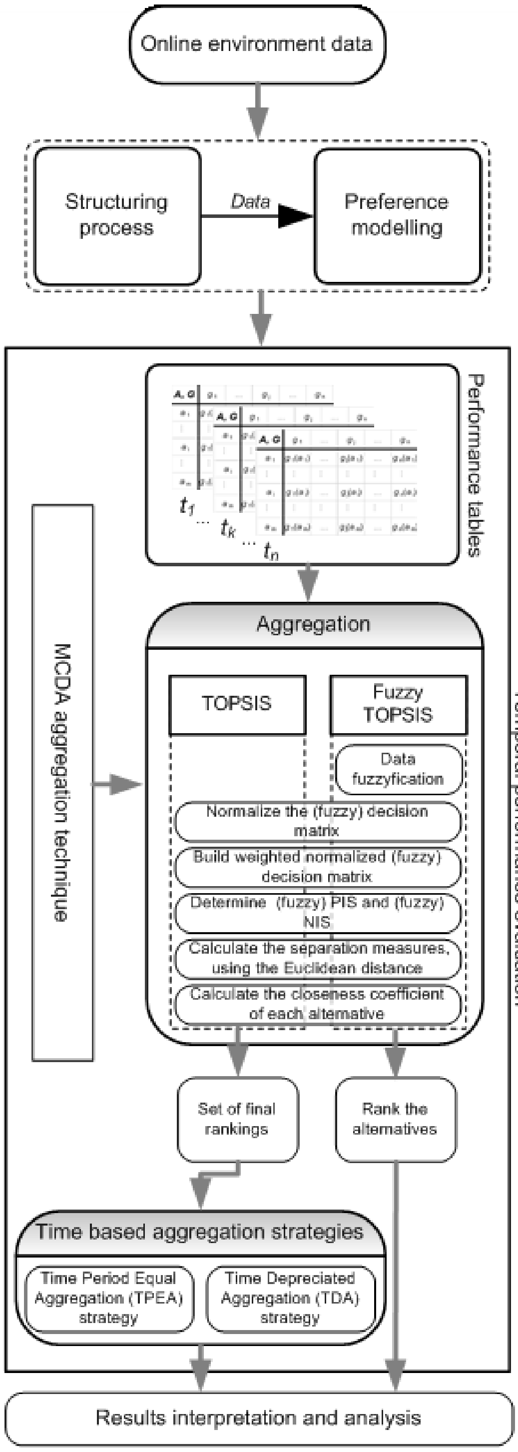

Fig.1. Dynamic MCDA-based framework of performance modeling in the online environment

Preference modelling and source data aggregation was realized with the use of the TOPSIS method in the classic and fuzzy forms. The reason for this is the necessity of detailed considering of data from different periods of time in the model as well as the necessity of conducting a broader analysis and interpretation of obtained and aggregated values. As for computational algorithms used in the TOPSIS method, it is worth reminding that the construction of final rankings is carried out by means of measuring Euclidean spaces of individual decision variants from reference points (Negative Ideal Solution – NIS and Positive Ideal Solution – PIS) (Balcerzak, 2016). The algorithms themselves are presented in detail in the papers (Opricovic and Tzeng, 2004; Behzadian *et al.*, 2012; Balcerzak and Pietrzak, 2016b) for the crisp version and in (Chen, 2000; Chen *et al.*, 2006) for the fuzzy one. Moreover, what needs further explanation are only aggregation strategies which were additionally introduced in the paper.

As a result of the analysis of input data in the presented framework two 2 time-based aggregation strategies were assumed:

- The first strategy (Time Period Equal Aggregation – TPEA) assumed an even influence of each performance table on the final result of performance evaluation. In other words, the utility force of variants in all periods of time t_k is equal.
- The second strategy (Time Depreciated Aggregation – TDA) according to which the latest data are more preferred than the older ones. However, the research was conducted for three different functions of forgetting force.

It is worth noting that in the case of one decision problem, the selection of an aggregation strategy ought to be realized according to the characteristics of the decision problem and subsequent model problems can constitute (Chen *et al.*, 2010): Time Appreciated Aggregation or Time Period Mostly Appreciated Aggregation.

In the end, the final utility of decision variants in time based aggregation strategies was calculated according to the formula:

$$V\left(a^i\right) = \sum_{k=1}^{n} CC_{ik} * p_k\left(t\right) \tag{1}$$

where:

$p(t_k)$ – force of a k-th period of time t,

CC_{ik} – utility of an i-th variant in k-th period,

$V(a^i)$ – overall utility of an i-the variant on the basis of n periods.

4. Results

The research was conducted on the basis of the following data:

- a conversion rate,
- intensity of an advertising content,
- publisher's profit.

The Conversion Rate is a basic tool for measuring the effectiveness of an advertisement, which is expressed as a ratio of the number of the user's desired interactions to the number of situations, in which they could potentially be realized (Jankowski *et al.*, 2016). In the case of an online advertisement, the desired interaction can be, for instance, the user's "click" in an interactive advertisement object, for example, a banner, and the number of situations is determined by the number of pop-ups of this advertisement. In the conducted analyses, a coefficient CR was determined *a posteriori* on the basis of real data. The intensity of an advertising content was determined in subjective research by users of the website in which the advertisement was placed. The publisher's profit was calculated as the product of the number of interactions and the costs incurred by the advertiser, at the same time, the costs are dependent on the intensity of the advertisement. The data discussed were gathered for 50 decision variants which were advertisements of 10 advertisers characterized by different intensity and which were displayed with a different frequency.

In the research, 10 periods of time, following in succession, were taken into account, in which different conversion coefficients were obtained. The data concerning the intensity of the advertising medium and the publisher's profit were constant for each of the ten periods. The data are presented in *Table 1* and *Appendix*. It should be noted that in certain periods of time not all advertising variants were displayed. In *Table 1* and *Appendix* such advertising variants obtained the conversion rate of 0 for selected periods.

4.1 Data aggregation using TOPSIS method

The gathered data were used in the Multicriteria Aggregation Procedure (MCAP) of TOPSIS in the crisp form, therefore, 10 separate variant rankings based on their overall utility. The preference direction for the criteria of the conversion rate and profit was a maximum, whereas for the criterion of advertisement intensity was a minimum. Moreover, it was assumed that all the criteria had equal weights. The usefulness of variants for subsequent periods of time and their positions in the rankings are presented in *Table 3* and *Appendix*.

Table 3. Utility and positions of variants in rankings in individual periods of time

Rank		1	2	3	4	5	6	7	8	9	10
Period 1	Variant	A5.10	A5.4	A5.6	A1.10	A2.10	A1.7	A1.3	A2.1	A4.1	A3.8
	CCi	0,717	0,626	0,618	0,411	0,316	0,299	0,263	0,26	0,254	0,254
Period 2	Variant	A5.2	A1.10	A5.10	A5.7	A5.5	A1.9	A2.5	A1.8	A1.3	A2.10
	CCi	0,616	0,541	0,482	0,434	0,403	0,381	0,356	0,34	0,335	0,309
Period 3	Variant	A1.10	A2.10	A2.9	A1.7	A1.9	A1.3	A2.1	A2.7	A2.2	A1.6
	CCi	0,67	0,613	0,574	0,551	0,529	0,529	0,521	0,514	0,467	0,451
Period 4	Variant	A1.10	A1.7	A2.10	A1.3	A2.3	A2.1	A4.1	A4.7	A5.10	A4.8
	CCi	0,764	0,61	0,579	0,558	0,539	0,523	0,496	0,487	0,475	0,474
Period 5	Variant	A3.8	A3.6	A3.10	A3.4	A3.1	A1.10	A3.2	A3.3	A2.10	A3.7
	CCi	0,688	0,565	0,484	0,47	0,435	0,432	0,43	0,361	0,334	0,327
Period 6	Variant	A1.10	A1.7	A2.10	A1.3	A3.8	A2.3	A5.10	A1.6	A3.1	A3.6
	CCi	0,673	0,543	0,542	0,495	0,485	0,48	0,448	0,428	0,419	0,415
Period 7	Variant	A1.10	A1.7	A1.3	A2.10	A3.9	A1.6	A5.10	A4.6	A4.7	A2.9
	CCi	0,603	0,585	0,516	0,498	0,446	0,437	0,436	0,436	0,411	0,41
Period 8	Variant	A1.10	A2.10	A3.2	A3.6	A2.3	A1.7	A1.3	A1.9	A3.8	A3.1
	CCi	0,626	0,537	0,512	0,481	0,474	0,467	0,467	0,466	0,462	0,436
Period 9	Variant	A1.10	A1.7	A3.10	A1.3	A5.4	A2.10	A3.8	A4.7	A3.3	A5.10
	CCi	0,696	0,518	0,506	0,477	0,464	0,457	0,442	0,431	0,431	0,422
Period 10	Variant	A5.10	A1.10	A5.4	A3.8	A5.5	A2.10	A3.2	A1.7	A4.3	A1.3
	CCi	0,662	0,542	0,525	0,453	0,443	0,422	0,418	0,402	0,379	0,369

When analyzing the similarity of variant usability rankings for individual periods of time, one can tell that in such a dynamic environment the Internet is, an Internet advertisement in particular, users' preferences can be subject to constant and significant changes. This is reflected when comparing top ten variants in the ranking for Periods 8 and 9. That is in the top ten places of the ranking of Period 9, there are only 5 variants from the top ten places of the Period 8 ranking. Furthermore, one can notice a significant fall of a variant A3.6, which in Period 4 took the fourth position and in Period 9 was on the 36th position.

4.2 Time based aggregation strategies

In the next step of the research, the rankings obtained for subsequent periods of time were aggregated in a global ranking in accordance with formula (1). Two aggregation strategies were applied here, i.e. a time period equal aggregation (TPEA), and a time depreciated aggregation (TDA) (Chen *et al.*, 2010). Three particular TDA approaches were applied. They differ in variant utility weights for individual periods of time. For TDA_1, a force p_k={0.1, 0.15, 0.20, ..., 0.55} was assumed, for TDA_2 p_k={0.1, 0.2, 0.3, ..., 1}, for TDA_3 p_k={0.1, 0.3, 0.5, ..., 1.9} . Global utility rankings are displayed in *Table 4*.

Table 4. Utility and positions of variants in general rankings

Rank		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TDA_1	Var.	A1.10	A1.7	A2.10	A5.10	A3.8	A1.3	A2.3	A3.10	A2.1	A4.7	A3.1	A2.9	A4.8	A3.2	A1.9	A5.1	A3.3
	$V(a^i)$	0,610	0,476	0,473	0,466	0,443	0,442	0,387	0,369	0,369	0,364	0,364	0,359	0,353	0,352	0,350	0,346	0,344
TDA_2	Var.	A1.10	A1.7	A2.10	A5.10	A3.8	A1.3	A2.3	A3.10	A2.1	A4.7	A3.1	A2.9	A3.2	A4.8	A1.9	A5.1	A3.3
	$V(a^i)$	0,612	0,479	0,475	0,465	0,449	0,444	0,389	0,373	0,369	0,367	0,367	0,360	0,358	0,356	0,350	0,348	0,348
TDA_3	Var.	A1.10	A1.7	A2.10	A5.10	A3.8	A1.3	A2.3	A3.10	A3.1	A4.7	A2.1	A3.2	A2.9	A4.8	A3.3	A1.9	A5.1
	$V(a^i)$	0,614	0,481	0,477	0,464	0,452	0,446	0,389	0,377	0,369	0,369	0,369	0,361	0,360	0,358	0,351	0,350	0,350
TPEA	Var.	A1.10	A5.10	A2.10	A1.7	A1.3	A3.8	A2.3	A2.1	A2.9	A1.9	A4.7	A3.1	A3.10	A4.8	A4.1	A5.1	A5.4
	$V(a^i)$	0,596	0,473	0,461	0,458	0,429	0,416	0,381	0,368	0,358	0,349	0,348	0,346	0,342	0,337	0,332	0,332	0,330
Rank		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
TDA_1	Var.	A5.4	A4.1	A1.6	A4.9	A4.3	A5.3	A3.7	A1.1	A3.6	A5.2	A5.9	A3.9	A5.7	A2.7	A1.2	A2.2	A4.10
	$V(a^i)$	0,343	0,341	0,333	0,330	0,328	0,323	0,320	0,317	0,308	0,298	0,296	0,296	0,289	0,288	0,284	0,277	0,275
TDA_2	Var.	A5.4	A4.1	A1.6	A4.9	A4.3	A5.3	A3.7	A1.1	A3.6	A3.9	A5.9	A5.2	A5.7	A2.7	A1.2	A4.10	A2.2
	$V(a^i)$	0,346	0,342	0,335	0,333	0,331	0,326	0,324	0,317	0,313	0,300	0,298	0,297	0,290	0,288	0,285	0,279	0,276
TDA_3	Var.	A5.4	A4.1	A1.6	A4.9	A4.3	A5.3	A3.7	A1.1	A3.6	A3.9	A5.9	A5.2	A5.7	A2.7	A1.2	A4.10	A2.2
	$V(a^i)$	0,347	0,343	0,336	0,334	0,334	0,328	0,326	0,318	0,316	0,303	0,300	0,296	0,290	0,287	0,286	0,281	0,276
TPEA	Var.	A1.6	A3.3	A3.2	A4.9	A1.1	A4.3	A5.3	A5.2	A3.7	A2.7	A5.7	A3.6	A2.5	A5.9	A2.2	A1.2	A3.9
	$V(a^i)$	0,322	0,321	0,319	0,315	0,312	0,308	0,307	0,304	0,300	0,290	0,288	0,284	0,284	0,283	0,281	0,278	0,270
Rank		35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
TDA_1	Var.	A2.5	A4.5	A1.8	A3.4	A4.6	A4.2	A5.5	A5.8	A5.6	A3.5	A2.4	A2.8	A1.5	A2.6	A4.4	A1.4	
	$V(a^i)$	0,274	0,267	0,263	0,260	0,258	0,256	0,252	0,245	0,243	0,242	0,208	0,200	0,196	0,144	0,135	0,089	
TDA_2	Var.	A2.5	A4.5	A3.4	A1.8	A4.6	A4.2	A5.5	A3.5	A5.8	A5.6	A2.4	A2.8	A1.5	A2.6	A4.4	A1.4	
	$V(a^i)$	0,273	0,270	0,265	0,263	0,263	0,258	0,255	0,248	0,248	0,239	0,209	0,200	0,196	0,145	0,135	0,087	
TDA_3	Var.	A4.5	A2.5	A3.4	A4.6	A1.8	A4.2	A5.5	A3.5	A5.8	A5.6	A2.4	A2.8	A1.5	A2.6	A4.4	A1.4	
	$V(a^i)$	0,272	0,272	0,268	0,266	0,263	0,259	0,257	0,253	0,250	0,237	0,210	0,200	0,197	0,146	0,136	0,087	
TPEA	Var.	A5.6	A1.8	A4.10	A4.5	A4.2	A5.5	A4.6	A3.4	A5.8	A3.5	A2.4	A2.8	A1.5	A2.6	A4.4	A1.4	
	$V(a^i)$	0,265	0,264	0,255	0,253	0,246	0,235	0,234	0,233	0,229	0,206	0,200	0,199	0,194	0,139	0,129	0,096	

As far as rankings TDA_1, TDA_2 and TDA_3 are concerned, it can be easily noticed that variants in eight top positions in each of them are the same. The differences start from position nine. Moreover, it should be emphasized that these are local differences and they can be grouped in eight areas of the ranking. These are changes between positions: 9 and 11, 12-14, 15-17, 27 and 29, 33-34, 35-36, 37-39, 42-44. It demonstrates that even the lowest differences, from among these accepted, between the forces of the ranking allow achieving a stable group of variants in the global ranking. However, increasing linear differences between the forces of individual rankings results in changes only on further positions.

The comparison of TPEA and TDA rankings indicates that positions 1, 3, 7, 14 (TDA_{2-3}), 16 (TDA_{1-2}), 21, 43 (TDA_{2-3}), 44 (TDA_1), 45-50 in these rankings are identical. Furthermore, in the case of seven positions in the TPEA and TDA rankings, there only are at most changes by two positions, for instance, a variant A1.7 in the TDA ranking takes the second position, whereas in the TPEA ranking in is on the fourth position. One can notice that among top seven positions in the rankings there are three variants, which are advertisements of the first advertiser, which are characterized by different intensity of an advertising content and a different level of the profit offered. Among the leaders, there are also advertising variants of the second advertiser and one variant both for the third advertiser and the fifth one. The most profitable variant from among top variants is A1.10. However, a variant 5.10, even though it is characterized by the highest intensity, offers a slightly lower profit in comparison to A1.10 as well as A2.10.

4.3 Variability analysis

In the next step, the variability analysis of utility of variants and rankings in time was conducted. It was carried out on the basis of utility values CC_i and the position in rankings obtained for the subsequent periods of time (*Table 3*). In *Figures 2* and *3* the variability analysis of utility of variants and rankings in time was presented in a graphic form, respectively for obtained values CC_i and positions in the rankings. The analysis of *Figures 2* and *3* points out that a variant A1.10, which almost in all central periods of time outperforms other variants, is characterized by the highest stability of utility level. An exception is Period P5, in which, at the expense of other ones, a variant A3.8 improved its utility. Even though a variant A5.10 dominated in comparison to other variants, in no strategy of time aggregation it was sufficient for the variant to globally outperform a variant A1.10. Nevertheless, in the TPEA strategy it was sufficient to outdo variants A1.7 and A2.10, which according to the TDA strategy dominated over A5.10. The analysis of *Figure 2* indicates similarity of variants A1.3, A1.7 and A2.10.

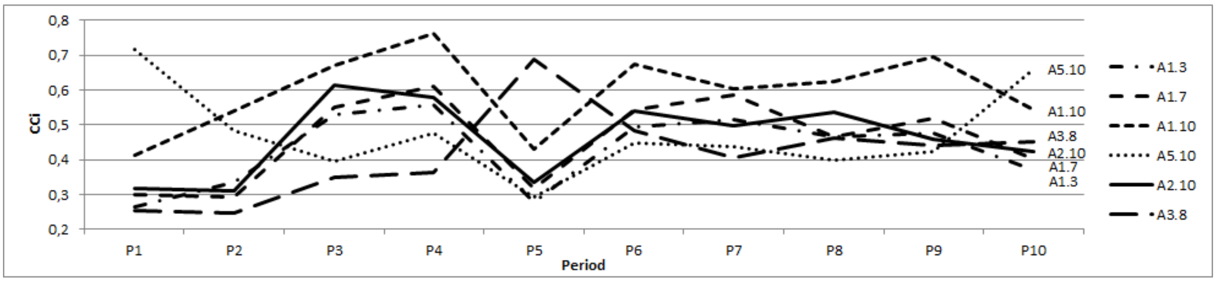

Fig. 2. Changeability analysis of variant utility in time for 6 leading variants

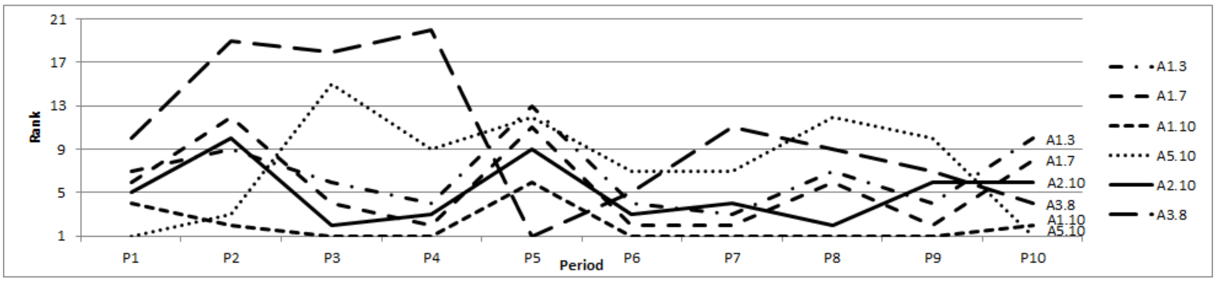

Fig. 3. Changeability analysis of positions in rankings in time for 6 leading variants

4.4 Fuzzy TOPSIS aggregation and result analysis

The aforementioned results were obtained for the TOPSIS method which operates on crisp data, however, the data gathered made it possible to construct trapezoid fuzzy values, which include range values of capacity of variants with regard to subsequent criteria. The fuzzy values for the conversion rate were constructed by determining the minimal and maximum values of the conversion rate from among the values obtained in subsequent periods of time. The minimal and maximum values constituted respectively the left and right end of the bottom base of a trapezium. Next, a mean value and a standard deviation of the ten periods of time were determined. By subtracting od adding the value of the standard deviation to the mean half, the top base of the trapezium was calculated. By analogy, fuzzy values for the intensity of the advertising medium were constructed. However, the data here were the opinions of the people who watched the advertisement, not a period of time. The fuzzy values for the profit were calculated on the basis of the obtained conversion rates with a relevant profit coefficient.

For aggregating the fuzzy data, the Fuzzy TOPSIS method, was used. Here, trapezoid fuzzy numbers for the values of individual variants with regard to each of the three criteria. Moreover, equal fuzzy values of weights of criteria amounting to $\tilde{\imath}=(5, 6, 7, 8)$ were assumed. The criterial values of variants and the result of their aggregation with the use of the Fuzzy TOPSIS method are depicted in *Table 5* and *Appendix*.

Table 5. Fuzzy data and the Fuzzy TOPSIS ranking

Variant	Conversion rate (max)				Intensity (min)				Profits (max)				CC_i	Rank
	a_1	a_2	a_3	a_4	a_1	a_2	a_3	a_4	a_1	a_2	a_3	a_4		
A1.10	0,000	0,003	0,026	0,094	0,333	0,491	0,787	0,926	0,000	0,002	0,014	0,052	0,561	1
A1.7	0,000	0,002	0,020	0,070	0,333	0,386	0,516	0,593	0,000	0,001	0,008	0,028	0,498	2
A2.3	0,000	0,003	0,023	0,083	0,111	0,146	0,257	0,333	0,000	0,001	0,005	0,017	0,487	3
A1.3	0,000	0,002	0,024	0,082	0,148	0,166	0,240	0,296	0,000	0,000	0,005	0,016	0,485	4
A2.10	0,000	0,001	0,015	0,052	0,222	0,347	0,643	0,815	0,000	0,001	0,009	0,028	0,479	5
A2.5	0,000	0,003	0,018	0,067	0,593	0,668	0,816	0,889	0,000	0,001	0,005	0,020	0,477	6
A4.8	0,000	0,003	0,015	0,056	0,370	0,463	0,648	0,741	0,000	0,001	0,007	0,025	0,477	7
A4.7	0,000	0,003	0,015	0,058	0,259	0,339	0,505	0,593	0,000	0,001	0,006	0,023	0,474	8
A5.10	0,000	0,000	0,013	0,041	0,259	0,466	0,836	1,000	0,000	0,000	0,007	0,022	0,453	9
A4.9	0,000	0,002	0,012	0,043	0,222	0,413	0,746	0,889	0,000	0,001	0,006	0,022	0,452	10

Furthermore, an example of fuzzy trapezoid criterial values of variants A1.10 and A1.7 are presented in *Figure 4*.

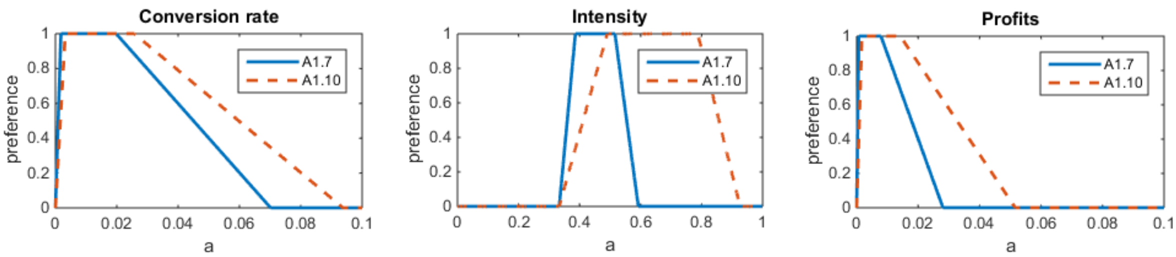

Fig. 4. Fuzzy values of variants A1.7 and A1.10 for criteria: Conversion rate, Intensity, Profits

It can be easily noticed that the obtained ranking is somewhat different from the global rankings obtained on the basis of subsequent periods of time. The top position is taken by the variant A1.10, whereas A1.7, similarly to the TDA rankings, is in the second position. On the next positions there are shifts, both with regard to the TDA and the TPEA rankings. Advertising variants of the fourth advertiser improved their positions and lower in the ranking are variants of the third advertiser. The comparison of the obtained TPEA, TDA and fuzzy rankings are also displayed in *Tables 6* and *7* where are presented correlation coefficients between the values CC_i (*Table 6*) and positions in the rankings (*Table 7*) obtained by individual decision variants.

Table 6. Correlations between coefficients CCi of variants obtained with the use of TPEA, TDA and fuzzy

	TDA_2	TDA_3	TPEA	Fuzzy
TDA_1	0,9997	0,9993	0,9918	0,5325
TDA_2		0,9999	0,9887	0,5285
TDA_3			0,9864	0,5259
TPEA				0,5494

Table 7. Correlations between the positions of variants in the TPEA, TDA and fuzzy rankings

	TDA_2	TDA_3	TPEA	Fuzzy
TDA_1	0,9990	0,9979	0,9835	0,4318
TDA_2		0,9990	0,9792	0,4227
TDA_3			0,9749	0,4175
TPEA				0,4432

The values of the correlations confirm the high similarity of TPEA and TDA rankings. Also, there is a significant correlation between these rankings and the ranking obtained with the use of the Fuzzy TOPSIS method. However, as it was observed before, the Fuzzy TOPSIS ranking differs significantly from the two other ones. It is related to the fact that the number of data considered in trapezoid fuzzy numbers is smaller than in the global aggregation based on subsequent periods of time. A fuzzy number contains information about four values of the conversion rate of a given variant, while the aggregation of evaluations of subsequent periods of time was based on ten number values of the conversion rate. It is quite the opposite in the case of the criteria of intensity and profit, where in subsequent periods of time an averaged value of these criteria was used, while fuzzy numbers contain four values. Moreover, a computational device used in the TOPSIS method in a discrete version is somewhat different from the one used in a fuzzy version. In general, Fuzzy TOPSIS takes into account the uncertainty of evaluations, therefore it allows determining a ranking for uncertain data. As a result, such a ranking is more "conservative" than the TOPSIS ranking obtained on the basis of crisp data, which are assumed to be certain.

Conclusions

The article discusses the problem of dynamic performance modelling in online media marketing management. The analysis of the interactive environment has revealed the complexity of the problem. Identified conflicting criteria were the basis for selectin the multiple criteria method of aggregation of the collected source data. Including the time factor in the performance evaluation process made it possible to encompass the whole considered problem in a broader and multi-stage manner.

The conducted research has confirmed the utility of the TOPSIS method in the considered class of decision problems.

The results indicate significant dynamics of obtained solutions in the field of digital marketing. Therefore, it is necessary to continuously evaluate the advertisement efficiency with relation to its other aspects, such as invasiveness or profits for the owner's website or costs incurred by the advertiser.

In the methodological aspect, the use of the proposed extended dynamic version of the TOPSIS method has revealed broader possibilities of the input data analysis as well as the interpretation of the obtained aggregated data. More importantly, such an approach, which takes into consideration individual data aggregation in all periods of time in which the data were gathered, has depicted greater practical abilities than a one-time construction of a model based on the same data in the fuzzy form.

During the research, areas of possible improvement or broadening of the present research have been noticed. A comparison of the obtained results with TAA, as well as an attempt to identify a function or, to put it simply, a period of time with the most essential data for a model and, in consequence, using a TPMAA aggregation strategy seem to be an interesting idea. However, it is related to a broadening of the considered model domain and including other criteria related to, for example, the present audience or the evaluation of relevance and attractiveness of content included in a given medium.

Acknowledgement

This work was partially supported by the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 316097 [ENGINE].

References

Agrell, P. J., Wikner, J. (1996), An MCDM framework for dynamic systems, *International Journal of Production Economics*, Vol. 45, No. 1, pp. 279-292.

Amiri, A., Menon, S. (2003), Efficient Scheduling of Internet Banner Advertisements, *ACM Transactions on Internet Technology*, Vol. 3, No. 4, pp. 334-346.

Balcerzak, A. P. (2016), Multiple-criteria Evaluation of Quality of Human Capital in the European Union Countries, *Economics & Sociology*, Vol. 9, No. 2, pp. 11-26.

Balcerzak, A. P. (2009), Effectiveness of the Institutional System Related to the Potential of the Knowledge Based Economy, *Ekonomista*, Vol. 6, pp. 711-739.

Balcerzak, A. P., Pietrzak, M. B. (2016a), Human Development and Quality of Institutions in Highly Developed Countries, In: M. H. Bilgin, H. Danis, E. Demir, and U. Can (eds.), *Financial Environment and Business Development. Proceedings of the 16th Eurasia Business and Economics Society*, Springer International Publishing.

Balcerzak, A. P. Pietrzak, M. P. (2016b), Application of TOPSIS Method for Analysis of Sustainable Development in European Union Countries, In: T. Loster & T. Pavelka (eds.), *The 10th International Days of Statistics and Economics*, Conference Proceedings, September 8-10, 2016, Prague.

Behzadian, M., Otaghsara, S. K., Yazdani, M., Ignatius, J. (2012), A state-of the-art survey of TOPSIS applications, *Expert Systems with Applications*, Vol. 39, No.17, pp. 13051-13069.

Bouyssou, D., Roy, B. (1993), *Aide Multicritere a la decision: Methodes et Cas*, Paris, Economica.

Brajnik, G., Gabrielli, S. (2010), A Review of Online Advertising Effects on the User Experience, *International Journal Of Human – Computer Interaction*, Vol. 26, No. 10, pp. 971-997.

Brans, J. P., Mareschal, B. (2005), Promethee Methods, In: *Multiple Criteria Decision Analysis. State of the Art Surveys*, J. Figueira, S. Greco, M. Ehrgott (ed.), Boston: Springer, 2005, pp. 163-195.

Brans, J. P., Mareschal, B., Vincke, P. (1984), Promethee: A new family of outranking methods in multicriteria analysis, *Operational Research OR'84*, pp. 408-421.

Cannon, H. M. (2001), Addressing New Media With Conventional Media Planning, *Journal of Interactive Advertising*, Vol. 1, No. 2, pp. 28-42.

Chakrabarti, D., Kumar, R., Radlinski, F., Upfal, E. (2009), Mortal multi-armed bandits, In: *Advances in Neural Information Processing Systems*, pp. 273-280.

Campanella, G., Ribeiro, R. A. (2011), A framework for dynamic multiple-criteria decision making, *Decision Support Systems*, Vol. 52, No. 1, pp. 52-60.

Chen, C. T. (2000), Extensions of the TOPSIS for group decision-making under fuzzy environment, *Fuzzy Sets and Systems*, Vol. 114, No. 1, pp. 1-9.

Chen, C. T., Lin, C. T., Huang, S. F. (2006), A fuzzy approach for supplier evaluation and selection in supply chain management, *International Journal of Production Economics*, Vol. 102, No. 2, pp. 289-301.

Chen, Y., Li, K. W., He, S. (2010), *Dynamic multiple criteria decision analysis with application in emergency management assessment*, Systems Man and Cybernetics (SMC), 2010 IEEE International Conference, IEEE, pp. 3513-3517.

Chickering, D., Heckerman, D. (2000), *Targeted advertising with inventory management*, Minneapolis, ACM Special Interest Group on E-Commerce (EC00).

De Montis, A., De Toro, P., Droste-Franke, B., Omann, I., Stagl, S. (2000), *Criteria for quality assessment of MCDA methods*, Vienna, Proc. 3rd Biennial Conference of the European Society for Ecological Economics, ESEE.

Du, H., Xu, Y. (2012), Research on Multi-Objective Optimization Decision Model of Web Advertising – Takes Recruitment Advertisement as an Example, *International Journal of Advancements in Computing Technology*, Vol. 4, No. 10, pp. 329-336.

Endress, T., Gear, T. (2015), Stock Prices: Are Intuitive or Deliberate Persons Better Forecasters? *Economics & Sociology*, Vol. 8, No. 4, pp. 43-50.

Fishburn, P. C. (1974), Exceptional Paper – Lexicographic Orders, Utilities and Decision Rules: A Survey, *Management Science*, Vol. 20, No. 11, pp. 1442-1471.

Giuffrida, G., Reforgiato, D., Tribulato, G., Zarba, C. (2011), *A banner recommendation system based on web navigation history*, IEEE Symposium on Computational Intelligence and Data Mining, pp. 291-296.

Guha, S., Cheng, B., Francis, P. (2010), *Challenges in measuring online advertising systems*, Proceedings of the 10th ACM SIGCOMM conference on Internet measurement, ACM, pp. 81-87.

Guitouni, A., Martel, J. M. (1998), Tentative guidelines to help choosing an appropriate MCDA method, *European Journal of Operational Research*, Vol. 109, No. 2, pp. 501-521.

Gupta, N., Khurana, U., Lee, T., Nawathe, S. (2011), *Optimizing Display Advertisements Based on Historic User Trails*, ACM SIGIR 2011 Workshop: Internet Advertizing.

Hashemkhani Zolfani, S., Maknoon, R., Zavadskas, E.K. (2016), An introduction to Prospective Multiple Attribute Decision Making, *Technological and Economic Development of Economy*, Vol. 22, No. 2, pp. 309-326.

Hoffman, D. L., Novak, T. P. (1995), *Marketing in Hipermedia Computer-Mediated Environment: Conceptual Foundations*, Nashville, Vanderbilt University.

Hoffman, D. L., Novak, T. P. (2000), When Exposure-Based Advertising Stops Making Sense (And What CDNOW Did about It). URL: http://www2000.ogsm.vanderbilt.edu/papers/CDNOW.jan2001.htm.

Hwang, C. L., Yoon, K. (1981), *Multiple Attribute Decision Making: Methods and Applications*, Berlin, Springer.

Ishizaka, A., Nemery, P. (2013), *Multi-Criteria Decision Analysis: Methods and Software,* Chichester, Wiley.

Jankowski, J., Watrobski, J., Piwowarski, M. (2011), *Fuzzy Modeling of Digital Products Pricing in the Virtual Marketplace*, Proceedings of 6th International Conference on Hybrid Artificial Intelligent Systems, Springer, Heidelberg, pp. 338-346.

Jankowski, J., Ziemba, P., Wątróbski, J., Kazienko, P. (2016), *Towards the Tradeoff Between Online Marketing Resources Exploitation and the User Experience with the Use of Eye Tracking. In: Intelligent Information and Database Systems*, Berlin Heidelberg, Springer, pp. 330-343.

Jantoń-Drozdowska, E., Majewska, M. (2016), Investment Attractiveness of Central and Eastern European Countries in the Light of New Locational Advantages Development, *Equilibrium. Quarterly Journal of Economics and Economic Policy*, Vol. 11, No. 1, pp. 97-119.

Jantoń-Drozdowska, E., Majewska, M. (2015), Social Capital as a Key Driver of Productivity Growth of the Economy: Across-countries Comparison, *Equilibrium. Quarterly Journal of Economics and Economic Policy*, Vol. 10, No. 4, pp. 61-83.

Jassbi, J. J., Ribeiro, R. A., Varela, L. R. (2014), Dynamic MCDM with future knowledge for supplier selection, *Journal of Decision Systems*, Vol. 23, No. 3, pp. 232-248.

Kelly, L., Kerr, G., Drennan, J. (2010), Avoidance of advertising in social networking sites: The teenage perspective, *Journal of Interactive Advertising*, Vol. 10, No. 2, pp. 16-27.

Keeney, R. L., Raiffa, H. (1976), *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, New York, Wiley.

Kornbluth, J. S. H. (1992), Dynamic multi-criteria decision making, *Journal of Multi-Criteria Decision Analysis 1.2*, pp. 81-92.

Lambrecht, A., Tucker, C. (2013), When does retargeting work? Information specificity in online advertising, *Journal of Marketing Research*, Vol. 50, No. 5, pp. 561-576.

Lang, A. (2000), The limited capacity model of mediated message processing, *Journal of Communication*, Vol. 50, No. 1, pp. 46-70.

Langheinrich, M., Nakamura, A., Abe, N., Kamba, T., Koseki, Y. (1999), Unintrusive customization techniques for web advertising, *Computer Networks*, Vol. 31, No. 11-16, pp. 1259-1272.

Leyva-Lopez, J.C., Fernandez-Gonzales, E. (2003), A new method for group decision support based on ELECTRE III methodology, *European Journal of Operational Research*, Vol. 148, No. 1, pp. 14-27.

Łyszczarz, B. (2016), Public-private Mix and Performance of Health Care Systems in CEE and CIS Countries, *Oeconomia Copernicana*, Vol. 7, No. 2.

MacCrimmon, K. R. (1968), *Decision Making Among Multiple-Attribute Alternatives: A Survey and Consolidated Approach*, RAND Memorandum, RM-4823-ARPA.

Mareschal, B., Brans, J. P. (1988), Geometrical representations for MCDA, *European Journal of Operational Research*, Vol. 34, No. 1, pp. 69-77.

Mikhailov, L., Tsvetinov, P. (2004), Evaluation of services using a fuzzy analytic hierarchy process, *Applied Soft Computing*, Vol. 5, No 1, pp. 23-33.

Morselli, A. (2015), The decision-making process between convention and cognition, *Economics & Sociology*, Vol. 8, No. 1, pp. 205-221.

Motlagh, S. M. H., Behzadian, M., Ignatius, J., Goh, M., Sepehri, M. M., Hua, T. K. (2015), Fuzzy PROMETHEE GDSS for technical requirements ranking in HOQ, *The International Journal of Advanced Manufacturing Technology*, Vol. 76, No. 9, pp. 1993-2002.

Munda, G. (1995), *Multicriteria Evaluation in a Fuzzy Environment. Theory and Applications in Ecological Economics*, Heidelberg, Physica-Verlag.

Novak, T. P., Hoffman, D. L. (1996), New Metrics for New Media: Toward the Development of Web Measurement Standards, *World Wide Web Journal*, Vol. 2, No. 1, pp. 213-246.

Olczyk, M. (2014), Structural Heterogeneity Between EU 15 and 12 New EU Members – the Obstacle to Lisbon Strategy Implementation? *Equilibrium. Quarterly Journal of Economics and Economic Policy*, Vol. 9, No. 3, pp. 21-43.

Opricovic, S., Tzeng, G. H. (2004), Compromise Solution By Mcdm Methods: A Comparative Analysis Of Vikor And Topsis, *European Journal Of Operational Research*, Vol. 156, No. 2, pp. 445-455.

Ozturk, M., Tsoukias, A., Vincke, P. (2005), Preference Modelling, In: *Multiple Criteria Decision Analysis: State of the Art Surveys*, J. Figueira, S. Greco, and M. Ehrgott (ed.), Boston, Springer, pp. 27-71.

Pavlou, P. A., Stewart, D. W. (2000), Measuring the Effects and Effectiveness of Interactive Advertising: A Research Agenda, *Journal of Interactive Advertising*, Vol. 1, No. 1, pp. 62-78.

Pietrzak, M. B., Balcerzak, A. P. (2016a), Assessment of Socio-Economic Sustainability in New European Union Members States in the years 2004-2012, In: M. Papież & S. Śmiech (eds.), *The 10th Professor Aleksander Zelias International Conference on Modelling and Forecasting of Socio-Economic Phenomena. Conference Proceedings*, Cracow: Foundation of the Cracow University of Economics, pp. 120-129.

Pietrzak, M. B., Balcerzak, A. P. (2016b), Quality of Human Capital and Total Factor Productivity in New EU Member States, In: T. Loster & T. Pavelka (eds.), *The 10th International Days of Statistics and Economics*, Conference Proceedings. September 8-10, 2016, Prague.

Promentilla, M. A. B., Furuichi, T., Ishii, K., Tanikawa, N. (2008), A fuzzy analytic network process for multi-criteria evaluation of contaminated site remedial countermeasures, *Journal of Environmental Management*, Vol. 88, No 3, pp. 479-495.

Rosenkrans, G. (2009), The creativeness and effectiveness of online interactive rich media advertising, *Journal of Interactive Advertising*, Vol. 9, No. 2, pp. 18-31.

Roy, B. (1968), Classement et choix en presence de points de vue multiples (la methode Electre), *Revue Francaise d'Informatique et de Recherche Operationnelle*, Vol. 8, pp. 57-75.

Roy, B. (1978), Electre III: un algorithme de classement fonde sur une representation floue des preferences en presence de criteres multiples, *Cahiers du CERO*, Vol. 20, pp. 3-24.

Roy, B. (1996), *Multicriteria Methodology for Decision Aiding*, Dordrecht, Springer.

Roy, B. (1991), The Outranking Approach and the Foundations of Electre Methods, *Theory and Decision*, Vol. 31, No. 1, pp. 49-73.

Roy, B. (2005), Paradigms and Challenges, In: *Multiple Criteria Decision Analysis: State of the Art Surveys*, J. Figueira, S. Greco, and M. Ehrgott (ed.), Boston, Springer, pp. 3-24.

Roy, B., Bertier, P. (1973), *La methode Electre II – une application au media planning*, Amsterdam, North-Holland Publishing Company, pp. 291-302.

Roy, B., Hugonnard, J. C. (1982), Ranking of suburban line extension projects on the Paris metro system by a multicriteria method, *Transportation Research*, Vol. 16A, pp. 301-312.

Roy, B., Skalka, J. M. (1984), *Electre IS – aspects methodologiques et guide d'utilisation*, Document du LAMSADE 30.

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

Saaty, T. L., Vargas, L. G. (2006), *Decision Making with the Analytic Network Process*, New York, Springer.

Shih, H. S., Shyur, H. J., Lee, E. S. (2007), An extension of TOPSIS for group decision making, *Mathematical and Computer Modelling*, Vol. 45, No. 7-8, pp. 801-813.

Tang, L., Rosales, R., Singh, A., Agarwal, D. (2013), *Automatic ad format selec-tion via contextual bandits*, Proceedings of the 22nd ACM international conference on Conference on information & knowledge management, ACM, pp. 1587-1594.

Tomlin, J. A. (2000), An entropy approach to unintrusive targeted advertising on the Web, *Computer Networks*, Vol. 33, No. 6, pp. 767-774.

Turatto, M., Galfano, G. (2000), Color, form and luminance capture attention in visual search, *Vision Research*, Vol. 40, No. 13, pp. 1639-1643.

Urban, G. L., Liberali, G., MacDonald, E., Bordley, R., Hauser, J. R. (2014), Morphing Banner Advertising, *Marketing Science*, Vol. 33, No. 1, pp. 27-46.

Wang, T. C., Chen, L. Y., Chen, Y. H. (2008), Applying Fuzzy PROMETHEE Method for Evaluating IS Outsourcing Suppliers, *Fifth International Conference on Fuzzy Systems and Knowledge Discovery*, Vol. 3, pp. 361-365.

Wątróbski, J., Jankowski, J. (2015), Knowledge Management in MCDA Domain, *Annals of Computer Science and Information Systems*, Vol. 5, pp. 1445-1450.

Wątróbski, J., Jankowski, J. (2016a), An Ontology-Based Knowledge Representation of MCDA Methods, *Lecture Notes in Artificial Intelligence*, Vol. 9621, pp. 54-64.

Wątróbski, J., Jankowski, J. (2016b), *Guideline for MCDA Method Selection in Production Management Area*, New Frontiers in Information and Production Systems Modelling and Analysis, Intelligent Systems Reference Library 98, Berlin Heidelberg, Springer, pp. 119-138.

Wu, G. (2007), Applying the Rossiter-Percy Grid to Online Advertising Planning: The Role of Product/Brand Type in Previsit Intentions, *Journal of Interactive Advertising*, Vol. 8, No. 1, pp. 14-22.

Yan, J., Liu, N., Wang, G., Zhang, W., Jiang, Y., Chen, Z. (2009), *How much can behavioral targeting help online advertising?* Proceedings of the 18th international conference on World wide web, ACM, pp. 261-270.

Yoo, C. Y., Kim, K. (2005), Processing of Animation in Online Banner Advertising: The Roles of Cognitive and Emotional Responses, *Journal of Interactive Marketing*, Vol. 19, No. 4, pp. 18-34.

Yoo, C. Y., Kim, K., Stout, P. A. (2004), Assessing the effects of animation in online banner advertising: Hierarchy of effects model, *Journal of Interactive Advertising*, Vol. 4, No. 2, pp. 49-60.

Yu, P. L., Chen, Y. C. (2010), Dynamic MCDM, Habitual Domains and Competence Set Analysis for Effective Decision Making in Changeable Spaces. In: Trends in Multiple Criteria Decision Analysis. Springer US, 2010. pp. 1-35. Greco, Salvatore, Matthias Ehrgott, and José Rui Figueira, eds. Trends in multiple criteria decision analysis. Vol. 142, Springer Science & Business Media.

Yuan, S., Wang, J., Zhao, X. (2013), *Real-time bidding for online advertising: measurement and analysis*, Proceedings of the Seventh International Workshop on Data Mining for Online Advertising, ACM, p. 3.

Zha, W., Wu, H. D. (2014), The Impact of Online Disruptive Ads on Users' Comprehension, Evaluation of Site Credibility, and Sentiment of Intrusiveness, *American Communication Journal*, Vol. 16, No. 2, pp. 15-28.

Zorn, S., Olaru, D., Veheim, T., Zhao, S., Murphy, J. (2012), Impact of animation and language on banner click-through rates, *Journal of Electronic Commerce Research*, Vol. 13, No. 2, pp. 173-183.

Appendix

Table 8. Data taken into consideration in the research

Variant	Conversion rate (max)											Intensity (min)	Profits (max)
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9	Period 10	Mean		
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
A1.1	0,0000	0,0003	0,0182	0,0000	0,0000	0,0008	0,0006	0,0009	0,0020	0,0031	0,00259	0,0026	0,00026
A1.2	0,0000	0,0000	0,0105	0,0455	0,0000	0,0011	0,0015	0,0007	0,0029	0,0021	0,00643	0,2584	0,00096
A1.3	0,0000	0,0005	0,0209	0,0820	0,0000	0,0018	0,0025	0,0019	0,0063	0,0052	0,01211	0,1843	0,00242
A1.4	0,0000	0,0006	0,0120	0,0000	0,0000	0,0006	0,0008	0,0002	0,0019	0,0042	0,00204	0,8474	0,00051
A1.5	0,0000	0,0003	0,0254	0,0000	0,0000	0,0013	0,0011	0,0015	0,0031	0,0038	0,00365	0,7028	0,00109
A1.6	0,0000	0,0000	0,0205	0,0469	0,0000	0,0020	0,0025	0,0018	0,0023	0,0038	0,00796	0,8386	0,00279
A1.7	0,0000	0,0000	0,0151	0,0702	0,0000	0,0014	0,0023	0,0012	0,0049	0,0040	0,00991	0,4392	0,00396
A1.8	0,0000	0,0008	0,0143	0,0156	0,0000	0,0013	0,0009	0,0018	0,0032	0,0016	0,00395	0,5785	0,00178
A1.9	0,0000	0,0008	0,0252	0,0164	0,0000	0,0012	0,0009	0,0023	0,0033	0,0017	0,00518	0,5	0,00259
A1.10	0,0000	0,0008	0,0142	0,0938	0,0000	0,0013	0,0009	0,0016	0,0066	0,0051	0,01242	0,6481	0,00683
A2.1	0,0000	0,0002	0,0270	0,0909	0,0000	0,0013	0,0005	0,0017	0,0014	0,0005	0,01235	0,0053	0,00124
A2.2	0,0000	0,0006	0,0272	0,0222	0,0000	0,0013	0,0024	0,0007	0,0015	0,0019	0,00578	0,3413	0,00087
A2.3	0,0000	0,0004	0,0130	0,0833	0,0000	0,0019	0,0013	0,0022	0,0018	0,0011	0,01049	0,1799	0,00210
A2.4	0,0000	0,0000	0,0230	0,0172	0,0000	0,0013	0,0026	0,0007	0,0033	0,0050	0,00532	0,7989	0,00133
A2.5	0,0000	0,0008	0,0126	0,0667	0,0000	0,0007	0,0008	0,0000	0,0012	0,0022	0,00849	0,7434	0,00255
A2.6	0,0000	0,0002	0,0155	0,0000	0,0000	0,0014	0,0021	0,0009	0,0029	0,0021	0,00250	0,9259	0,00088
A2.7	0,0000	0,0004	0,0277	0,0189	0,0000	0,0013	0,0010	0,0013	0,0010	0,0014	0,00529	0,5317	0,00212
A2.8	0,0000	0,0002	0,0201	0,0000	0,0000	0,0009	0,0012	0,0004	0,0037	0,0020	0,00285	0,6138	0,00128
A2.9	0,0000	0,0002	0,0257	0,0270	0,0000	0,0007	0,0012	0,0002	0,0014	0,0020	0,00584	0,3889	0,00292
A2.10	0,0000	0,0000	0,0185	0,0517	0,0000	0,0011	0,0010	0,0017	0,0013	0,0040	0,00793	0,4709	0,00436
A3.1	0,0000	0,0000	0,0001	0,0106	0,0229	0,0019	0,0013	0,0024	0,0033	0,0064	0,00489	0,0106	0,00049
A3.2	0,0000	0,0000	0,0001	0,0097	0,0242	0,0015	0,0009	0,0038	0,0046	0,0126	0,00575	0,291	0,00086
A3.3	0,0000	0,0000	0,0012	0,0096	0,0166	0,0015	0,0008	0,0019	0,0081	0,0063	0,00460	0,1693	0,00092
A3.4	0,0000	0,0000	0,0003	0,0059	0,0301	0,0017	0,0013	0,0022	0,0034	0,0092	0,00542	0,7566	0,00135
A3.5	0,0000	0,0000	0,0007	0,0062	0,0081	0,0015	0,0011	0,0020	0,0103	0,0066	0,00365	0,7063	0,00110
A3.6	0,0000	0,0000	0,0001	0,0000	0,0397	0,0025	0,0020	0,0035	0,0052	0,0015	0,00546	0,8836	0,00191
A3.7	0,0000	0,0000	0,0004	0,0132	0,0137	0,0012	0,0021	0,0007	0,0034	0,0078	0,00424	0,3519	0,00170
A3.8	0,0000	0,0000	0,0001	0,0101	0,0432	0,0016	0,0011	0,0018	0,0048	0,0096	0,00723	0,5053	0,00325
A3.9	0,0000	0,0000	0,0009	0,0043	0,0122	0,0018	0,0030	0,0011	0,0066	0,0050	0,00349	0,5952	0,00174

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
A3.10	0,0000	0,0000	0,0001	0,0118	0,0246	0,0008	0,0006	0,0012	0,0093	0,0071	0,00556	0,7302	0,00306
A4.1	0,0000	0,0000	0,0003	0,0845	0,0000	0,0008	0,0004	0,0010	0,0033	0,0025	0,00927	0,0053	0,00093
A4.2	0,0000	0,0003	0,0003	0,0160	0,0000	0,0013	0,0014	0,0009	0,0029	0,0040	0,00272	0,2937	0,00041
A4.3	0,0000	0,0000	0,0006	0,0379	0,0000	0,0004	0,0009	0,0003	0,0063	0,0089	0,00552	0,1455	0,00110
A4.4	0,0000	0,0000	0,0005	0,0387	0,0000	0,0008	0,0011	0,0002	0,0031	0,0019	0,00462	0,8201	0,00115
A4.5	0,0000	0,0000	0,0009	0,0529	0,0000	0,0003	0,0006	0,0000	0,0039	0,0080	0,00666	0,5608	0,00200
A4.6	0,0000	0,0002	0,0003	0,0323	0,0000	0,0014	0,0032	0,0012	0,0074	0,0037	0,00496	0,7989	0,00174
A4.7	0,0000	0,0000	0,0003	0,0581	0,0000	0,0009	0,0014	0,0008	0,0051	0,0038	0,00704	0,418	0,00282
A4.8	0,0000	0,0000	0,0003	0,0563	0,0000	0,0010	0,0007	0,0013	0,0046	0,0032	0,00675	0,5556	0,00304
A4.9	0,0000	0,0003	0,0009	0,0432	0,0000	0,0011	0,0004	0,0012	0,0037	0,0059	0,00567	0,6032	0,00284
A4.10	0,0000	0,0002	0,0008	0,0268	0,0000	0,0006	0,0011	0,0006	0,0056	0,0084	0,00441	0,7989	0,00243
A5.1	0,0000	0,0000	0,0005	0,0598	0,0000	0,0009	0,0007	0,0017	0,0042	0,0050	0,00727	0,0026	0,00073
A5.2	0,0000	0,0021	0,0021	0,0339	0,0000	0,0009	0,0014	0,0006	0,0046	0,0079	0,00535	0,3042	0,00080
A5.3	0,0000	0,0000	0,0017	0,0474	0,0000	0,0008	0,0004	0,0011	0,0047	0,0072	0,00633	0,1852	0,00127
A5.4	0,0004	0,0000	0,0021	0,0421	0,0000	0,0011	0,0008	0,0017	0,0104	0,0185	0,00770	0,6905	0,00192
A5.5	0,0000	0,0011	0,0013	0,0162	0,0000	0,0013	0,0016	0,0010	0,0033	0,0154	0,00411	0,672	0,00123
A5.6	0,0004	0,0000	0,0009	0,0491	0,0000	0,0007	0,0012	0,0007	0,0022	0,0058	0,00609	0,8571	0,00213
A5.7	0,0000	0,0011	0,0013	0,0204	0,0000	0,0014	0,0015	0,0012	0,0045	0,0025	0,00339	0,373	0,00136
A5.8	0,0000	0,0000	0,0005	0,0308	0,0000	0,0007	0,0009	0,0006	0,0068	0,0036	0,00440	0,672	0,00198
A5.9	0,0000	0,0000	0,0004	0,0410	0,0000	0,0008	0,0006	0,0009	0,0041	0,0027	0,00505	0,5714	0,00253
A5.10	0,0004	0,0010	0,0030	0,0408	0,0000	0,0009	0,0011	0,0008	0,0028	0,0207	0,00715	0,672	0,00393

Table 9. Utility and positions of variants in rankings in individual periods of time

Rank	Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8		Period 9		Period 10	
	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i	Var.	CC_i
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
1	A5.10	0,717	A5.2	0,616	A1.10	0,670	A1.10	0,764	A3.8	0,688	A1.10	0,673	A1.10	0,603	A1.10	0,626	A1.10	0,696	A5.10	0,662
2	A5.4	0,626	A1.10	0,541	A2.10	0,613	A1.7	0,610	A3.6	0,565	A1.7	0,543	A1.7	0,585	A2.10	0,537	A1.7	0,518	A1.10	0,542
3	A5.6	0,618	A5.10	0,482	A2.9	0,574	A2.10	0,579	A3.10	0,484	A2.10	0,542	A1.3	0,516	A3.2	0,512	A3.10	0,506	A5.4	0,525
4	A1.10	0,411	A5.7	0,434	A1.7	0,551	A1.3	0,558	A3.4	0,470	A1.3	0,495	A2.10	0,498	A3.6	0,481	A1.3	0,477	A3.8	0,453
5	A2.10	0,316	A5.5	0,403	A1.9	0,529	A2.3	0,539	A3.1	0,435	A3.8	0,485	A3.9	0,446	A2.3	0,474	A5.4	0,464	A5.5	0,443
6	A1.7	0,299	A1.9	0,381	A1.3	0,529	A2.1	0,523	A1.10	0,432	A2.3	0,480	A1.6	0,437	A1.7	0,467	A2.10	0,457	A2.10	0,422
7	A1.3	0,263	A2.5	0,356	A2.1	0,521	A4.1	0,496	A3.2	0,430	A5.10	0,448	A5.10	0,436	A1.3	0,467	A3.8	0,442	A3.2	0,418
8	A2.1	0,260	A1.8	0,340	A2.7	0,514	A4.7	0,487	A3.3	0,361	A1.6	0,428	A4.6	0,436	A1.9	0,466	A4.7	0,431	A1.7	0,402
9	A4.1	0,254	A1.3	0,335	A2.2	0,467	A5.10	0,475	A2.10	0,334	A3.1	0,419	A4.7	0,411	A3.8	0,462	A3.3	0,431	A4.3	0,379
10	A3.8	0,254	A2.10	0,309	A1.6	0,451	A4.8	0,474	A3.7	0,327	A3.6	0,415	A2.9	0,410	A3.1	0,436	A5.10	0,422	A1.3	0,369
11	A2.9	0,252	A2.3	0,302	A2.3	0,434	A2.5	0,443	A1.7	0,316	A2.1	0,412	A3.8	0,407	A2.1	0,416	A3.5	0,418	A3.10	0,357
12	A2.3	0,252	A1.7	0,292	A1.5	0,420	A5.1	0,434	A5.10	0,291	A4.7	0,397	A3.7	0,404	A5.10	0,398	A4.8	0,409	A5.3	0,348
13	A5.1	0,251	A2.2	0,284	A1.1	0,418	A4.9	0,407	A1.3	0,278	A4.8	0,397	A2.3	0,401	A5.1	0,396	A4.3	0,402	A3.7	0,347
14	A3.1	0,246	A2.1	0,275	A2.4	0,397	A2.9	0,402	A2.1	0,273	A2.9	0,397	A2.2	0,387	A3.3	0,390	A5.1	0,371	A3.1	0,343
15	A1.1	0,245	A1.1	0,272	A5.10	0,395	A5.3	0,395	A3.9	0,273	A1.9	0,387	A2.4	0,361	A4.8	0,390	A5.8	0,370	A4.10	0,336
16	A4.7	0,243	A2.9	0,269	A2.8	0,385	A4.5	0,386	A2.9	0,267	A4.9	0,378	A3.1	0,358	A1.6	0,383	A5.3	0,365	A4.9	0,334
17	A4.8	0,236	A4.9	0,253	A2.5	0,358	A1.6	0,381	A4.1	0,266	A3.3	0,377	A4.8	0,352	A4.9	0,358	A4.1	0,363	A5.1	0,332
18	A4.3	0,229	A4.1	0,249	A3.8	0,350	A5.9	0,380	A2.3	0,266	A3.9	0,368	A2.1	0,351	A3.10	0,357	A2.9	0,363	A4.5	0,332
19	A5.3	0,224	A3.8	0,248	A1.8	0,350	A4.3	0,370	A5.1	0,263	A4.1	0,366	A5.1	0,340	A4.1	0,355	A3.9	0,361	A4.7	0,327
20	A3.3	0,219	A5.1	0,246	A4.7	0,334	A3.8	0,364	A4.7	0,257	A5.1	0,364	A4.1	0,336	A4.7	0,355	A4.9	0,358	A3.3	0,323
21	A3.10	0,219	A2.7	0,246	A1.2	0,331	A1.2	0,361	A1.1	0,256	A3.7	0,351	A1.9	0,336	A1.8	0,352	A2.3	0,358	A5.2	0,321
22	A4.9	0,218	A3.1	0,241	A4.1	0,328	A5.6	0,340	A4.8	0,250	A2.7	0,351	A1.2	0,332	A3.4	0,350	A4.6	0,357	A2.9	0,316
23	A1.9	0,218	A4.7	0,237	A4.8	0,325	A1.9	0,326	A4.3	0,240	A3.10	0,350	A4.3	0,328	A5.3	0,337	A2.1	0,350	A4.8	0,311
24	A5.9	0,204	A4.8	0,230	A5.1	0,323	A3.1	0,323	A5.3	0,236	A3.2	0,347	A5.7	0,324	A5.4	0,333	A5.9	0,348	A4.1	0,310
25	A3.7	0,203	A4.3	0,224	A3.1	0,313	A5.4	0,320	A4.9	0,231	A5.7	0,344	A1.1	0,323	A1.1	0,331	A1.9	0,348	A2.1	0,303
26	A1.2	0,200	A5.3	0,219	A4.9	0,303	A3.10	0,315	A1.9	0,231	A1.1	0,343	A3.6	0,321	A2.9	0,331	A4.10	0,347	A2.3	0,303
27	A1.6	0,194	A1.4	0,218	A5.3	0,301	A5.2	0,310	A5.9	0,216	A5.3	0,336	A3.10	0,319	A2.7	0,328	A3.1	0,346	A3.4	0,301
28	A3.2	0,191	A3.3	0,215	A4.3	0,301	A1.1	0,308	A1.2	0,211	A5.9	0,329	A4.9	0,311	A3.5	0,321	A1.1	0,325	A1.1	0,300
29	A2.7	0,187	A4.2	0,215	A3.10	0,299	A3.3	0,295	A1.6	0,205	A1.2	0,324	A3.3	0,309	A5.9	0,313	A5.7	0,319	A1.9	0,271
30	A5.2	0,186	A3.10	0,214	A3.3	0,290	A3.7	0,290	A2.7	0,198	A4.3	0,319	A5.2	0,306	A5.7	0,307	A3.7	0,318	A1.6	0,266

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
31	A5.7	0,185	A5.9	0,200	A5.9	0,281	A4.10	0,289	A5.2	0,196	A2.2	0,316	A5.3	0,305	A4.3	0,292	A3.2	0,318	A5.9	0,265
32	A2.5	0,185	A3.7	0,198	A2.6	0,276	A2.7	0,287	A2.5	0,196	A1.8	0,314	A5.9	0,298	A3.7	0,289	A5.2	0,312	A5.6	0,253
33	A4.2	0,183	A1.2	0,196	A3.7	0,273	A5.8	0,285	A5.7	0,195	A4.2	0,310	A2.7	0,296	A1.2	0,279	A4.5	0,301	A1.2	0,246
34	A2.2	0,179	A4.10	0,191	A5.7	0,252	A5.7	0,281	A4.2	0,192	A3.4	0,306	A4.2	0,294	A3.9	0,272	A1.2	0,294	A3.9	0,245
35	A4.5	0,176	A1.6	0,190	A5.2	0,251	A2.2	0,271	A2.2	0,188	A2.5	0,290	A4.10	0,281	A4.2	0,267	A1.6	0,288	A4.2	0,245
36	A4.10	0,172	A3.2	0,187	A3.2	0,250	A3.2	0,260	A4.5	0,186	A5.2	0,289	A2.5	0,279	A1.5	0,263	A3.6	0,285	A5.7	0,235
37	A1.8	0,160	A4.5	0,172	A4.5	0,242	A4.2	0,256	A4.10	0,182	A4.6	0,285	A3.2	0,278	A5.2	0,255	A4.2	0,265	A2.5	0,235
38	A5.8	0,157	A5.8	0,153	A4.2	0,237	A4.6	0,254	A3.5	0,175	A5.4	0,280	A2.6	0,274	A2.2	0,254	A2.7	0,262	A2.7	0,230
39	A3.9	0,156	A3.9	0,152	A4.10	0,236	A1.8	0,242	A1.8	0,170	A3.5	0,272	A5.5	0,259	A4.6	0,251	A1.8	0,261	A3.5	0,229
40	A3.6	0,131	A1.5	0,150	A1.4	0,218	A4.4	0,242	A5.8	0,166	A4.10	0,263	A5.6	0,256	A4.10	0,248	A2.5	0,261	A5.8	0,221
41	A2.8	0,127	A2.8	0,149	A5.8	0,214	A3.9	0,214	A5.4	0,159	A5.5	0,258	A4.5	0,255	A2.5	0,235	A2.2	0,245	A2.2	0,219
42	A4.6	0,124	A5.4	0,147	A3.9	0,213	A5.5	0,181	A5.6	0,157	A4.5	0,255	A1.8	0,249	A5.8	0,229	A2.8	0,231	A1.8	0,199
43	A5.5	0,112	A4.6	0,147	A5.4	0,212	A3.6	0,175	A2.8	0,135	A5.8	0,248	A5.8	0,245	A5.6	0,225	A5.6	0,220	A2.4	0,188
44	A3.4	0,104	A5.6	0,145	A5.6	0,202	A2.8	0,170	A4.6	0,132	A1.5	0,244	A2.8	0,230	A4.5	0,223	A5.5	0,201	A4.6	0,187
45	A1.5	0,098	A3.6	0,128	A3.6	0,176	A2.4	0,166	A5.5	0,119	A2.4	0,243	A5.4	0,230	A5.5	0,216	A3.4	0,196	A2.8	0,163
46	A3.5	0,097	A3.4	0,101	A4.6	0,168	A3.4	0,145	A1.5	0,104	A5.6	0,234	A3.4	0,216	A2.8	0,177	A2.4	0,183	A3.6	0,162
47	A2.4	0,096	A3.5	0,095	A5.5	0,155	A3.5	0,137	A2.4	0,101	A2.8	0,224	A1.5	0,186	A2.4	0,168	A1.5	0,178	A1.5	0,162
48	A4.4	0,081	A2.4	0,094	A3.4	0,140	A1.5	0,131	A4.4	0,085	A2.6	0,222	A3.5	0,185	A2.6	0,154	A4.4	0,160	A1.4	0,125
49	A2.6	0,051	A2.6	0,090	A3.5	0,132	A2.6	0,067	A2.6	0,053	A4.4	0,156	A4.4	0,168	A4.4	0,108	A2.6	0,122	A4.4	0,108
50	A1.4	0,033	A4.4	0,079	A4.4	0,109	A1.4	0,044	A1.4	0,035	A1.4	0,078	A1.4	0,084	A1.4	0,053	A1.4	0,067	A2.6	0,080

Table 10. Fuzzy data and the Fuzzy TOPSIS ranking

Variant	Conversion rate (max)				Intensity (min)				Profits (max)				CC_i	Rank
	a_1	a_2	a_3	a_4	a_1	a_2	a_3	a_4	a_1	a_2	a_3	a_4		
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
A1.1	0,0000	0,0004	0,0051	0,0182	0,0000	0,0013	0,0198	0,0370	0,0000	0,0000	0,0005	0,0018	0,2877	50
A1.2	0,0000	0,0012	0,0129	0,0455	0,1852	0,2218	0,3699	0,4815	0,0000	0,0002	0,0019	0,0068	0,4188	19
A1.3	0,0000	0,0016	0,0237	0,0820	0,1481	0,1662	0,2403	0,2963	0,0000	0,0003	0,0047	0,0164	0,4851	4
A1.4	0,0000	0,0000	0,0037	0,0120	0,4074	0,6274	0,9237	1,0000	0,0000	0,0000	0,0009	0,0030	0,3608	47
A1.5	0,0000	0,0006	0,0072	0,0254	0,5185	0,6107	0,8144	0,9259	0,0000	0,0002	0,0022	0,0076	0,3932	32
A1.6	0,0000	0,0002	0,0147	0,0469	0,6667	0,7526	0,8823	0,9259	0,0000	0,0001	0,0052	0,0164	0,4456	15
A1.7	0,0000	0,0018	0,0198	0,0702	0,3333	0,3862	0,5159	0,5926	0,0000	0,0007	0,0079	0,0281	0,4982	2
A1.8	0,0000	0,0006	0,0065	0,0156	0,4074	0,4929	0,6226	0,6667	0,0000	0,0003	0,0029	0,0070	0,3796	39
A1.9	0,0000	0,0004	0,0090	0,0252	0,2963	0,3981	0,6574	0,8148	0,0000	0,0002	0,0045	0,0126	0,4078	27
A1.10	0,0000	0,0032	0,0257	0,0938	0,3333	0,4907	0,7870	0,9259	0,0000	0,0017	0,0142	0,0516	0,5607	1
A2.1	0,0000	0,0032	0,0256	0,0909	0,0000	0,0026	0,0397	0,0741	0,0000	0,0003	0,0026	0,0091	0,3936	31
A2.2	0,0000	0,0002	0,0103	0,0272	0,1852	0,2632	0,5225	0,7037	0,0000	0,0000	0,0015	0,0041	0,3879	34
A2.3	0,0000	0,0034	0,0225	0,0833	0,1111	0,1455	0,2566	0,3333	0,0000	0,0007	0,0045	0,0167	0,4868	3
A2.4	0,0000	0,0008	0,0089	0,0230	0,2963	0,5476	0,8995	1,0000	0,0000	0,0002	0,0022	0,0058	0,3868	36
A2.5	0,0000	0,0027	0,0181	0,0667	0,5926	0,6680	0,8161	0,8889	0,0000	0,0008	0,0054	0,0200	0,4768	6
A2.6	0,0000	0,0001	0,0046	0,0155	0,7778	0,8519	0,9630	1,0000	0,0000	0,0000	0,0016	0,0054	0,3727	42
A2.7	0,0000	0,0001	0,0097	0,0277	0,2963	0,4140	0,5992	0,6667	0,0000	0,0000	0,0039	0,0111	0,4070	28
A2.8	0,0000	0,0005	0,0057	0,0201	0,4444	0,5291	0,6587	0,7037	0,0000	0,0002	0,0026	0,0091	0,3894	33
A2.9	0,0000	0,0001	0,0107	0,0270	0,1852	0,2870	0,5648	0,7407	0,0000	0,0001	0,0054	0,0135	0,4140	23
A2.10	0,0000	0,0010	0,0154	0,0517	0,2222	0,3466	0,6429	0,8148	0,0000	0,0005	0,0085	0,0284	0,4789	5
A3.1	0,0000	0,0009	0,0080	0,0229	0,0000	0,0053	0,0608	0,1111	0,0000	0,0001	0,0008	0,0023	0,2967	49
A3.2	0,0000	0,0013	0,0091	0,0242	0,1852	0,2381	0,4048	0,5185	0,0000	0,0002	0,0014	0,0036	0,3825	38
A3.3	0,0000	0,0014	0,0069	0,0166	0,0741	0,1217	0,2143	0,2593	0,0000	0,0003	0,0014	0,0033	0,3706	44
A3.4	0,0000	0,0004	0,0095	0,0301	0,3704	0,5635	0,8783	1,0000	0,0000	0,0001	0,0024	0,0075	0,4002	29
A3.5	0,0000	0,0014	0,0052	0,0103	0,5556	0,6310	0,7791	0,8519	0,0000	0,0004	0,0016	0,0031	0,3610	46
A3.6	0,0000	0,0011	0,0110	0,0397	0,6667	0,7751	0,9418	1,0000	0,0000	0,0004	0,0039	0,0139	0,4291	16
A3.7	0,0000	0,0012	0,0065	0,0137	0,2593	0,3056	0,4167	0,4815	0,0000	0,0005	0,0026	0,0055	0,3733	41
A3.8	0,0000	0,0000	0,0132	0,0432	0,2963	0,4008	0,5860	0,6667	0,0000	0,0000	0,0059	0,0194	0,4476	13
A3.9	0,0000	0,0013	0,0051	0,0122	0,2963	0,4458	0,7421	0,8889	0,0000	0,0006	0,0025	0,0061	0,3718	43
A3.10	0,0000	0,0011	0,0091	0,0246	0,3333	0,5317	0,8466	0,9630	0,0000	0,0006	0,0050	0,0135	0,4102	26
A4.1	0,0000	0,0048	0,0217	0,0845	0,0000	0,0026	0,0212	0,0370	0,0000	0,0005	0,0022	0,0085	0,3852	37

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
A4.2	0,0000	0,0000	0,0049	0,0160	0,1481	0,2209	0,4246	0,5556	0,0000	0,0000	0,0007	0,0024	0,3652	45
A4.3	0,0000	0,0009	0,0109	0,0379	0,1111	0,1283	0,1839	0,2222	0,0000	0,0002	0,0022	0,0076	0,4107	25
A4.4	0,0000	0,0018	0,0102	0,0387	0,4074	0,6138	0,9101	1,0000	0,0000	0,0005	0,0026	0,0097	0,4170	21
A4.5	0,0000	0,0022	0,0143	0,0529	0,3333	0,4471	0,7063	0,8519	0,0000	0,0007	0,0043	0,0159	0,4510	11
A4.6	0,0000	0,0004	0,0094	0,0323	0,6296	0,7143	0,8624	0,9259	0,0000	0,0001	0,0033	0,0113	0,4126	24
A4.7	0,0000	0,0026	0,0154	0,0581	0,2593	0,3386	0,5053	0,5926	0,0000	0,0010	0,0062	0,0232	0,4741	8
A4.8	0,0000	0,0026	0,0149	0,0563	0,3704	0,4630	0,6481	0,7407	0,0000	0,0012	0,0067	0,0254	0,4768	7
A4.9	0,0000	0,0015	0,0118	0,0432	0,2222	0,4127	0,7460	0,8889	0,0000	0,0008	0,0059	0,0216	0,4524	10
A4.10	0,0000	0,0002	0,0082	0,0268	0,3704	0,5847	0,8995	1,0000	0,0000	0,0001	0,0045	0,0148	0,4143	22
A5.1	0,0000	0,0027	0,0159	0,0598	0,0000	0,0013	0,0198	0,0370	0,0000	0,0003	0,0016	0,0060	0,3520	48
A5.2	0,0000	0,0003	0,0100	0,0339	0,1852	0,2447	0,5225	0,7407	0,0000	0,0000	0,0015	0,0051	0,3986	30
A5.3	0,0000	0,0016	0,0131	0,0474	0,1111	0,1481	0,2778	0,3704	0,0000	0,0003	0,0026	0,0095	0,4281	17
A5.4	0,0000	0,0002	0,0137	0,0421	0,4074	0,5489	0,8452	1,0000	0,0000	0,0001	0,0034	0,0105	0,4250	18
A5.5	0,0000	0,0006	0,0069	0,0162	0,4815	0,5767	0,7619	0,8519	0,0000	0,0002	0,0021	0,0049	0,3743	40
A5.6	0,0000	0,0021	0,0131	0,0491	0,5556	0,7063	0,9286	1,0000	0,0000	0,0007	0,0046	0,0172	0,4492	12
A5.7	0,0000	0,0000	0,0061	0,0204	0,2593	0,3161	0,4087	0,4444	0,0000	0,0000	0,0025	0,0082	0,3875	35
A5.8	0,0000	0,0008	0,0088	0,0308	0,4815	0,5767	0,7434	0,8148	0,0000	0,0003	0,0039	0,0138	0,4171	20
A5.9	0,0000	0,0018	0,0109	0,0410	0,1852	0,3783	0,7487	0,9259	0,0000	0,0009	0,0055	0,0205	0,4470	14
A5.10	0,0000	0,0002	0,0132	0,0408	0,2593	0,4656	0,8360	1,0000	0,0000	0,0001	0,0072	0,0224	0,4526	9