International Journal of Innovation

Received on October 10, 2017 / **Approved on** June 21, 2018
Responsible Editor: Leonel Cezar Rodrigues, Ph.D.
Evaluation Process: Double Blind Review
E-ISSN: 2318-9975

OPEN ACCESS

doi> http://dx.doi.org/10.5585/iji.v6i3.236

DECISION MAKING SUPPORT FOR MANAGERS IN INNOVATION MANAGEMENT: A PROMETHEE APPROACH

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ABSTRACT

The purpose of this paper is to present a decision making model as a support for selection of innovation management concept using multiple criteria decision making methods. Based on the specific nature of innovation management concepts a novel decision making model was designed. Ten defined innovation management concepts are firstly evaluated using set of criteria, which priorities are expertly evaluated using Saaty method and then the PROMETHEE outranking method is used for evaluating and selecting of innovation management concepts. To apply this model in the practice the Visual PROMETHEE software tool is incorporated to the model. The model was applied on a large manufacturing company. Using our approach in this company, the concept of value analysis was selected as the best. This study is limited for decision making processes in large companies. The results of Saaty method are based on expert but subjective assessment and therefore relevant for this particular company at that particular time. In addition, we suggest that this model can help managers to solve similar decision making problems using combination of Saaty method or analytic hierarchy process together with Visual PROMETHEE software. The logic and process of the decision making model elaboration as well as the decision model itself can be used as a framework for managers facing decision making problems with similar nature as innovation management concepts i.e.: ERP systems, information systems, technologies, business models.

Keywords: Innovation concepts; PROMETHEE software; Managers; Decision making model; Buisness models; Innovation management.

Cite it like this:

Peterková, J., & Franek, J. (2018). Decision Making Support for Managers In Innovation Management: a PROMETHEE approach. *International Journal of Innovation, 6*(3), 256-274. http://dx.doi.org/10.5585/iji.v6i3.236

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INTRODUCTION

Managers in organizations at all levels encounter a variety of decision situations with varying degrees of complexity. For some types of situations, it is sufficient to take a decision based on previous experience from previous years, but in solving situations that are more complex a decision to evaluate several criteria is needed.

As a rule, the manager chooses the optimal solution from a number of variants, taking into account the selected criteria, as well as the contradictory ones. This type of decision making situation is typical for managers of innovative activities.

They must decide how to manage innovative activites during the innovation process.

They also must choose the necessary concept of innovation management, taking into account the decision making criteria such as the type of implemented innovation, the simplicity in applying the concept etc.

At the same time, the decision making process influences the results, which have a long-term effect on the effective functioning of the innovation activities in the company. In a highly changing environment, the correct management of companies' capabilities to introduce and maintain continuous innovation can signify competitive advantages in terms of cost reduction, increment on products' life cycles, increment in sales and a global market perspective.

When facing such complex decisions the multiple criteria decision making methods (MCDM) can be applied. Another advantage comes from the fact that the MCDM methods are supported by software tools, which helps to operationalize their practical applications.

One of those that is readily available is the Visual PROMETHEE software utility, which is based on non-compensatory multiple criteria decision making method the PROMETHEE II. It also allows working with contradictory decision making criteria and provides clearly presented results.

The **goal of the paper is** to present a decision making model including the Visual PROMETHEE software tool for decision making process of innovation managers to choose the appropriate innovation concept.

Criteria for the decision model will be selected and evaluated by experts (3 academics + 3 professionals) along with the investigators using Saaty method. Weighted decision making criteria will be used in qualitative analysis to determine the usability variants of selected innovation concepts and to select the appropriate innovation management concept for a particular company.

The **Visual PROMETHEE tool** is applied for selection of the best variant. This decision making model for innovation managers is created for selection of the best innovations management concept in a large company. This particular study contributes to the quick and effective selection of appropriate innovation concept in an actual food processing company from the Czech Republic.

Theoretical reference framework

On the one hand, many companies are aware of the importance of innovation for their further development (Keles and Battal, 2017; Peterková and Ludvík, 2015; Zelený, 2012), but they struggle how to manage, implement, and evaluate them.

On the other hand, in literature and business resources, there are a number of principles on how to create an innovative business, the best practices of successful companies, and a range of approaches to how to manage, implement and evaluate innovation (Pereira, 2017; Hecker, 2017).

There is a contradiction between companies' ability to position themselves in the approaches they offer to innovation management and the existence of a large number of approaches that can be used to address a particular type of innovation problem (Hecker, 2017).

Alfaro-García et al. (2017) studied the measurement of innovation management and suggested that innovation strategy, organization and structure, knowledge management and project management are the most valued areas.

This supports the need for clear framework of solutions that respond to the ability of an enterprise to innovate and manage innovations. In this paper, we describe these frameworks as innovation concepts.

Thus, the innovation concept is seen as a framework of a solution that facilitate the enterprise's innovation activities. The concept is an abstraction representing a way to solve an innovation problem. Innovation concepts give the managers insight into what they think is important and how they solve the innovation problem (Tidd and Bessant, 2013). The position that innovation concepts occupy in innovation management is captured in Figure 1. Implementation of innovation concepts depends on the strategic framework in the enterprise.

At the same time, individual innovation concepts can be used at another stage of the innovation process. It is important to get the knowledge from the realization of the innovation process and use the feedback.

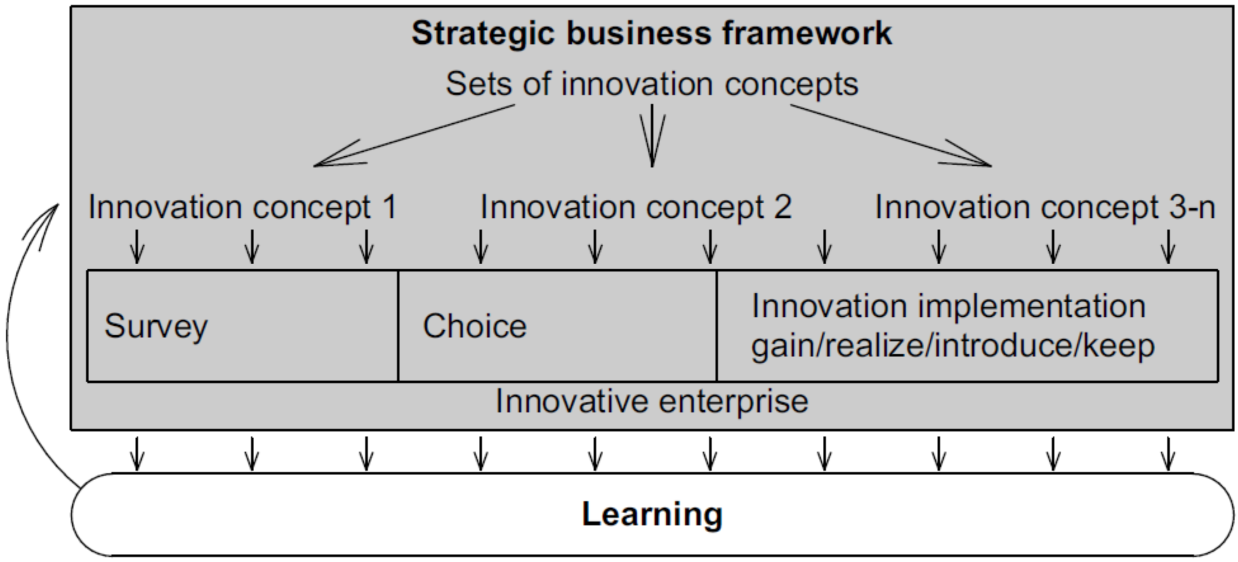

Figure 1: The Position of Innovation Concepts in Innovation Management in an Enterprise
Source: Extended approach according to Tidd and Bessant (2013).

Based on the research findings at the time of publication, which were obtained from available domestic and foreign literary sources, research reports, results from research projects and available business resources, a set of ten innovation concepts has been created (Peterková, 2018). The set is represented by the concept based on the measurement of innovation performance (I_1), the Balanced Scorecard (I_2) concept, the Innovative Innovation Assessment (I_3) concept, the Value Analysis concept (I_4), the concept based on organizational readiness Innovation (I_5), Innovation Potential (I_6) concept, Innovative Radar (I_7) concept, Innovation Index (I_8) concept, Innovation Interactive Panel concept (I_9), concept based on experience from corporate practice practice (I_{10}). This set of ten innovation concepts, including citations of selected authors, is outlined in Table 1.

Table 1: Innovation concepts

Concept title	Concept Abbreviation	Determination according to following authors
Concept based on measurement of innovation performance	I_1	(Šulák and Vacík, 2005; Gupta and Trusko, 2014; Žižlavský, 2012; Mlčoch, 2002)
Concept Balanced Scorecard	I_2	(Kaplan and Norton 1996, 2000, 2004, 2006, 2010; Parmenter, 2010)
Concept based on the evaluation of innovations through investment efficiency indicators	I_3	(Dvořák, 2006; Pitra, 2006; Hauschildt, 2004)
Concept of value analysis	I_4	(Miles, 1972; Vlček 1986, 2002, 2008, 2010, 2011)
Concept based on organizational readiness for innovation	I_5	(Company The Creative Problem Solving; Company PA Consulting Group; Studt In Gupta a Trusko, 2014)
Concept based on determination of innovative potential	I_6	(Kováč and Sabadka, 2004; Mikoláš et al., 2011; Kopčaj, 2007)
Concept based on the creation of innovative radar	I_7	(Sawhney, M., Wolcott, R.C, Arroniz, I., 2014)
Concept based on the innovation index	I_8	(Rogers from Institut Melbourne in: Gupta and Trusko, 2014)
Concept based on an innovative interactive panel	I_9	(Gala et al., 2009; Few, 2006)
Concept based on experience from corporate practice	I_{10}	(Košturiak and Frolík, 2012; Košturiak and Chal´, 2008)

Source: Elaborated based on Peterková (2018).

The presented innovation concepts differ in their focus on the innovation problem and the way they function. Each concept is developed in order to fit a certain business situation. When talking about innovation concepts, we focus on the effect that is associated with the expected result from the implemented innovation. Sometimes we can meet the concept of benefit, which is identical in terms of content to the notion of effect, also related to the definition of the result from the implemented innovation.

Some of the presented concepts were already applied and some concepts are not known to be have been used in practice. Some are just based on the experience of consultancy firms with their application. Bearing in mind that the presented innovation concepts are different in focus on the innovation problem and in the way of working, all the concepts can be compared according to common characteristics of the innovation management, but differ in their applicability. It is generally possible to identify the innovative problem that can be applied to the concept, what is the elaboration of the concept, i.e. whether the concept can be applied in corporate practice, the manner of evaluating the innovation and whether the concept of innovation has already been verified in practice. At the same time, the concepts indicate problematic areas mainly associated with the assessment of the effects of innovation.

The issues that innovation concepts help to solve can be viewed from different perspectives, for example from a time perspective or focusing on an innovation problem. The management and the company's owners solve the problems ex ante or ex post i.e. after innovation processes had already started. Innovation concepts focus differs in the area of discovering innovation potential, organizational readiness for innovation and achieved level of innovation climate or in the implementation of the innovation process itself, and in evaluating the benefits from the implemented innovations. The elaboration of the presented concepts is either in the form of a general framework or methodology with specific implementation steps.

However, knowledge about presented concepts of innovation management does not answer the question about which concept is the best for particular company or type of innovation. This requires a managerial decision that will affect the whole organization. Innovation processes are loaded with points of decision making and distribution of responsibilities and therefore rely heavily on managerial action to occur fully.

We must consider each process of decision making of individuals in organizations (Cyert and March, 1992; March and Simon, 1993) and the thesis that individuals, groups and organizations are subject to limited rationality (van Knippenberg et al., 2015, Puranam et al., 2015) as a constant problem. According to studies, (De Dreu, Nijstad, & van Knippenberg, 2008; Ocasio, 2011; Tversky & Kahneman, 1974) individuals and organizations show signs of cognitive and motivational distortions in taking the information on which they base their decisions. However, the attitude to decision making and the established management and behavior styles (van Knippenberg et al., 2015) did not develop at the same rate as the availability and diffusion of information. The large amount of information available and the growing global competition exert pressure on individuals, groups and organizations, and create over-information.

Costs of sorting and storing this information and data are growing, and there is a growing risk of loss of attention to relevant information and work as such. Thus, it is useful to create decision making guidelines using MCDM as a structured and logical means of synthesizing judgements for evaluating appropriate variants of innovation concepts or tools as suggested by Kosonen & Kianto (2007).

According to Biemans et al. (2007), the decision making in the area of innovation management in the last 20 years has been the second most frequently discussed subject area together with strategy and planning. Research of decision making in innovation management is mainly focused on following issues: improving decision making for successful innovation (Schewe, 1994; van Riel & Lievens, 2004; Keupp et al., 2012; Nagano et al., 2014; Busse & Wallenburg, 2015; Bromphey et al., 2015; Aswoll, 2017), decision making support (Haustein & Weber, 1983; Kortler & Lindemann, 2011; Kunz & Warren, 2011; Daher et al., 2015; Yilmaz Eroglu & Kilic, 2017; Kralisch et al., 2018), differences in individuals' evaluations of project attributes (Behrens, 2016), top management and cultural influence (Hoffman & Hegarty, 1993; Li et al.; 2013), innovation portfolio management (Meifort, 2015; Kock & Gemünden, 2016) decision making during the organizational life-cycle (Yujun, 2010; Danvila-del-Vale et al; 2018); selection of innovation projects or innovative technologies (Shen et al., 2010). Regarding this body of knowledge there is a growing interest in improvement of decision making in innovation management as a whole.

MCDM approach is a one of the methods used to support decision making in innovation management and therefore appropriate for developing a conceptual model. The literature review suggests interest on strategic decisions such as selection of innovation management approach.

This could be solved by developing of a model for decisions requiring selection of the innovation concept.

APPLIED DECISION MAKING METHODS

a) Saaty method and Analytic hierarchy process (AHP)

Analytic Hierarchy Process (AHP) developed by Saaty (1980) provides a framework for making effective decisions in complex decision situations while helping to simplify and decompose the decision making process. It represents a linear decomposition method that provides an objective mathematical procedure for the inevitable subjective and personal determination of individual or group preferences in decision making (Saaty, 2012).

The decision criteria can be both qualitative and quantitative and can be expressed in numbers or words. However, in problems which do not contain of complex set of criteria, the simple Saaty weighting method can be used. Firstly, the user is able and willing to determine not only the order of importance of criteria but also the ratio of importance between pairs of criteria. Calculations of the AHP are well established as well as its use in

Excel or other available software e.g., SuperDecisions. Consequently, they will not be further explained here but by means of the application presented in Section 4. For additional information on calculations, see Saaty (2001). For comparisons of criteria the original Saaty scale is used. The weights are derived using row geometric mean method (RGMM) and the consistency is checked using geometric consistency index (GCI).

In practice, the most commonly used method of weights determination is to use the row geometric mean method (RGMM). This solution is based on calculation of geometric mean of individual rows from the decision matrix (multiplying the elements of the individual rows of this matrix and determining the k root of these sums). By normalizing these row geometric means (by dividing them by the sum of these geometric means) we obtain the criterion weights w_i (Ishizaka and Alessio, 2011):

$$w_i = \frac{\left[\prod_{j=1}^{k} s_{ij}\right]^{1/k}}{\sum_{i=1}^{k}\left[\prod_{j=1}^{k} s_{ij}\right]^{1/k}} \quad \text{pro } i=1,\ldots,k. \qquad (1)$$

The GCI is calculated as follows (Escobar et al., 2004):

$$GCI = \frac{2}{(n-1)(n-2)}\sum_{j\geq i}\left(\log(s_{ij}) - \log\frac{w_i}{w_j}\right)^2 \qquad (2)$$

,

where n represents number of criteria, w_i/w_j is a ratio of approximate weights. Escobar et al. (2004) set approximate threshold values for consistency assessment.

In AHP, the group decision making is considered as beneficial in order to get more precise solution. Several methods can be used to determine priorities using group decision making (multiple decision makers). Decision makers are encouraged to discuss the decision problem in the panel of users (experts), they will decide on a single evaluation of the pair comparison table with the assistance of the facilitator, and then the weights are calculated based on consensus.

b) PROMETHEE II and Visual PROMETHEE

The principal outranking methods assume data availability broadly similar to that required for the MAUT (multiple attribute utility theory) methods. That is, they require alternatives and criteria to be specified, and use the same data of the decision table, namely the a_{ij}'s and w_i's.

Main reason for implementing PROMETHEE/GAIA for processing the acquired data was the specific advantages of this method in regards to other MCDM methods. These advantages are mostly attributable to the way of structuring the problem. High quantity of data, which can be processed; ability to quantify qualitative values, good software support and presentation of processed data.

The PROMETHEE method presents an outranking method for a fixed set of alternatives. The PROMETHEE method is based on determining the positive (Φ^+) and the negative flow (Φ^-) for each alternative towards outranking relations and in correlation with the acquired weight coefficients for each criterion.

The positive preference flow expresses how much an alternative dominates over the others; therefore, the greater the value ($\Phi^+ \rightarrow 1$), the more significant is the alternative. The negative preference flow expresses the preference of all the other alternatives compared to the analyzed one. An alternative is more important if the value of the output flow is smaller ($\Phi^- \rightarrow 0$). The complete ranking of PROMETHEE II is based on the calculation of a net outranking flow value (Φ) that represents the balance between the positive and the negative outranking flows. The higher the net flow is, the better the alternative.

For the application of this method, it is necessary to define a specific preference function and to assign a weight of significance (weight coefficient) to each criterion. The preference function defines the rank of one option with respect to another and translates deviation between two parallel alternatives into a unique parameter, which is associated with the degree of preference. The degree of preference presents a growing deviation function, whereby, in case of small deviation, it refers to a weak preference and in the case of large deviation; it represents a strong preference associated with a reference alternative (Brans and Vincke, 1985). Brans and Mareschal (1994) and Behzadian et al. (2010)

give thorough review of the PROMETHEE methods and their applications.

The GAIA visual modelling method offers a visualization technique by projecting the points on a two-dimensional plane, where the plane is defined so that as few information as possible gets lost by the projection. The GAIA plane provides the decision maker with a powerful tool for the analysis of the differentiation power of the criteria and their conflicting aspects.

Clusters of similar alternatives as well as incomparability between two alternatives are clearly represented. The projection of the vector of the weights of criteria suggests the direction, where the most promising alternatives can be found on the plane. The methodology applied in GAIA appeared earlier in statistics as a visualization tool under the name of principal components analysis.

The main advantage of the PROMETHEE method is to integrate the most recent ideas of preference modeling in a very simple way.

The main reason for implementing Visual PROMETHEE for processing the acquired data was the specific advantages of this method in regards to other multiple criteria decision making methods such as: noncompensatory nature, visual tools for further analysis (GAIA), combination of qualitative and quantitative information, sensitivity analysis tools. Number of researchers claimed that the combination of these tools produces a new more powerful and compatible tool (Visual Decision Inc., 2008, Hanafizadeh, 2011; Daher, 2015).

c) Combination of AHP and PROMETHEE methods

Some ideas of AHP can also be applied in the PROMEETHE methodology. Recently, Macharis et al. (2004) proposed to use the pairwise comparison technique of AHP to determine the weights of the criteria. Similarly, the use of the tree-structure to decompose the decision problem into smaller parts can also be beneficial. The main advantage of the PROMETHEE method is to integrate the most recent ideas of preference modelling in a very simple way. It is claimed by a number of researchers that the combination of these tools produces a new more powerful and compatible tool. The extensions of the outranking methods for group decision support have also been developed. Macharis et al. (1998) presents a PROMETHEE procedure for group decision support.

The extensions of the outranking methods for group decision support have also been developed. Macharis et al. (1998) presents a PROMETHEE procedure for group decision support. Although the number of studies that apply the integration of AHP and PROMETHEE to find facility location are few, the results of these researches are significant.

DECISION MAKING MODEL FOR SELECTION OF INNOVATION CONCEPTS

a) The decision making model

Based on assumptions from the literature background and MCDM methods properties the model for decision making was elaborated (see Figure 1). It consist of six steps. The first step is research on innovations concepts that provided initial information and properties of innovation concepts used in manufacturing companies. The result is a set of 10 innovation concepts (see Table 1). It follows with expert discussion about evaluation criteria.

The expert group established a final number of eight criteria, which were applied (with the help of the researchers) for the evaluation of the innovation concepts and subsequently for the definition of ten variants of innovation management concepts (see Table 2).

Evaluation is the result of the consensus of the individual members of the expert group. This evaluation of weights concerns five criteria that can be qualitatively assessed by AHP. Expert evaluation of the concepts and weights estimated using AHP are the inputs for PROMETHEE table. The table was elaborated in Visual PROMETHEE software. Ranking of innovations concepts was made using PROMETHEE II method that is included in the software.

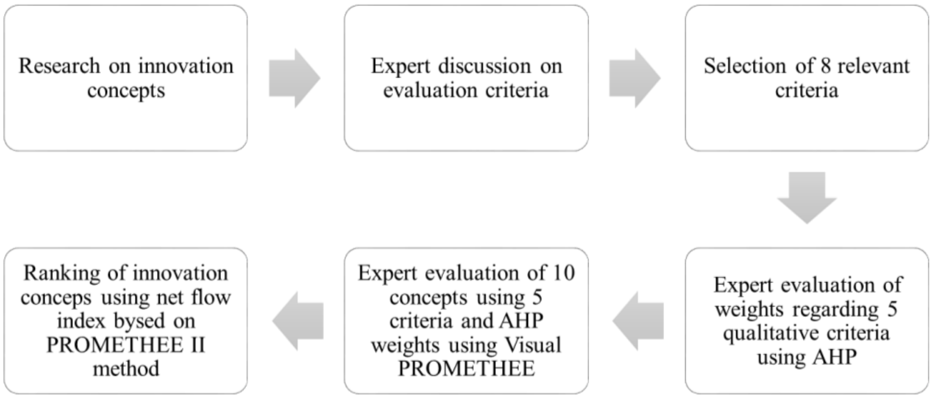

Figure 2: Decision making framework for selection of innovation concepts.
Source: Authors.

b) Evaluation of criteria for innovation concepts selection

Criterion is understood as an element of evaluation of innovation concepts with regard to their usability in an enterprise (Fotr and Švecová, 2010). Based on an expert's discussion (3 + 3 persons) a list of eight criteria was elaborated in order to evaluate innovation concepts. Criteria were mainly assessed according to their use (operability), interrelations among the individual criteria (independence), and whether they are not redundant. The list of criteria for evaluation of innovation concepts are organized according to their importance and logical continuity are presented in Table 2.

Table 2: List of criteria for evaluation of innovation concepts

Final criteria for evaluation of innovation concepts	Abbrev.	Rating scale
type of innovation problem	C_1	(A - problem solving during the invention creation, B - problem solving during innovation creation, C - problem solving during innovation spreading).
subject of realized innovation	C_2	(A - product, B - process, C - marketing, D - organization, E - cannot be determined).
verifiability of the concept of innovation in practice	C_3	(1 - very low, 2 - low, 3 - medium, 4 - high, 5 - very high).
using the concept of innovation with regard to the time of the implementation of the innovation project	C_4	(A - before the implementation of an innovative project - ex ante, B - during the implementation of the innovation project - innovation cycle, C - after completion of the innovation project - ex post).
usability of the concept of innovation in an enterprise	C_5	(1 - very low, 2 - low, 3 - medium, 4 - high, 5 - very high).
level of elaboration of the concept of innovation into management levels	C_6	(1 - very low, 2 - low, 3 - medium, 4 - high, 5 - very high).
determination of innovation metrics and their form	C_7	(1 - very low, 2 - low, 3 - medium, 4 - high, 5 - very high).
savings resulting from training of existing employees when implementing the concept of innovation	C_8	(1 - very low, 2 - low, 3 - medium, 4 - high, 5 - very high).

Source: Authors.

For criteria C_1, C_2 and C_4, the rated object can be categorized into certain defined categories, and for these criteria, the scale is defined by the categories indicated by letters A through E. On the other hand, criteria C_3, C_5, C_6, C_7, and C_8 evaluate an object by expressing a certain intensity of the rating on a given scale from one to five. At the same time, the criteria that directly influence the selection of the concepts of innovation itself in the innovation management process have been examined in detail, concretely company size and branch according to CZ-NACE.

For that purpose results from the Czech Statistical Office, results from university project (Ludvík et al, 2012) and findings from Tidd and Bessant (2013) were used. It means that selection of innovation concepts relates to the enterprises with the number of employees from 250 to 999 and operating in section C - Manufacturing according to classification CZ NACE.

In case of five criteria (chosen from eight) selected by the expert group it is possible to determine order of importance. The analytic hierarchy process (AHP) enables to organize criteria based on an assessment of the preference of individual experts. Selected criteria see Table 3 have the nature of the maximization criteria.

Table 3: Selected criteria for applications in decision models.

Criteria for evaluation of innovation concepts	Determined rating scale
C_3 - verifiability of the concept of innovation in practice	(1 - very low, 2 - low, 3 - average, 4 - high, 5 - very high).
C_5 - usability of the concept of innovation in an enterprise	(1 - very low, 2 - low, 3 - average, 4 - high, 5 - very high).
C_6 - level of elaboration of the concept of innovation into management levels	(1 - very low, 2 - low, 3 - average, 4 - high, 5 - very high).
C_7 - determination of innovation metrics and their form	(1 - very low, 2 - low, 3 - average, 4 - high, 5 - very high).
C_8- savings resulting from training of existing employees when implementing the concept of innovation	(1 - very low, 2 - low, 3 - average, 4 - high, 5 - very high).

Source: Authors.

Using the analytic hierarchical process (AHP) experts determined the weights of the individual criteria using the Saaty method and author also determined the order of each criterion based on the calculated weights w_i according to Saaty (2012).

The created Saaty matrix, see Table 4, is the result of the consensus of the expert group of (3 + 3) who have agreed on the evaluation of the pair comparison in the table with the assistant of the investigator (author). The weights are calculated according to the equation (1) using RGMM method.

Finally, consistence of Saaty pair-wise comparison matrix was checked using geometric consistency index (GCI). GCI was calculated using equation (2) and its value is 0.37, which refers to the limit value for the five criteria.

Table 4: Determination of the weights of the criteria using the Saaty matrix

Criterion	C_3	C_5	C_6	C_7	C_8	RGMM	Weight (w_i)	Order
C_3	1	2	8	8	8	4.000	0.504	1
C_5	1/2	1	6	6	6	2.551	0.321	2
C_6	1/8	1/6	1	1/2	3	0.500	0.063	3
C_7	1/8	1/6	2	1	1/2	0.461	0.058	4
C_8	1/8	1/6	1/3	2	1	0.425	0.054	5

Source: Authors.

c) Qualitative evaluation of the use of innovation concepts by the expert group

For qualitative evaluation of the usability of innovation management concepts (I1 to I10) see Tab. 1. Each concept was evaluated by the criteria (C1, C2, C3, C4, C5, C6, C7, C8), see Table 2. The expert group with the help of the author of the paper determined the ratings according to proposed rating scale. Qualitative analysis was carried out on ten concepts of innovation based on expert group discussion (Maxwell, 2013).

The expert group of 6 experts was composed of three academics and three industry experts. This step of the decision making model includes work with the Visual PROMETHEE software that enables the decision maker to organize all information into a one matrix.

Combining eight evaluation criteria and weights estimated for the five selected criteria from the Table 4 and evaluation of the innovations concepts from the Table 3 we can create following PROMETHEE table on the Figure 3.

However, only the criteria with assigned scales were used for final evaluation. Criteria C_1, C_2 and C_4 are deemed negligible in this application concerning large food processing company.

Table 5. Evaluation of the Use of Innovation Concepts by 8 Criteria

Concepts	Criteria for evaluation																																				Variants
	C_1			C_2					C_3					C_4			C_5					C_6					C_7					C_8					
	A	B	C	A	B	C	D	E	1	2	3	4	5	A	B	C	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
I_1			x	x	x	x	x			x						x			x							x					x				x		V_1
I_2		x	x	x	x	x	x						x	x		x				x						x					x		x				V_2
I_3	x		x	x	x	x	x			x						x			x							x					x				x		V_3
I_4	x	x	x	x	x	x	x						x	x	x	x					x					x					x		x				V_4
I_5	x							x					x	x					x					x						x			x				V_5
I_6	x			x	x	x	x						x	x						x						x				x			x				V_6
I_7			x					x		x					x	x		x								x				x		x					V_7
I_8			x					x		x					x	x			x							x					x		x				V_8
I_9			x					x		x						x		x						x				x				x					V_9
I_{10}		x	x	x	x	x	x						x		x	x			x							x					x		x				V_{10}

Source: authors.

Scenario1	C1	C2	C3	C4	C5	C6	C7	C8
Unit	5-point	5-point	5-point	5-point	5-point	5-point	5-point	5-point
Cluster/Group								
Preferences								
Min/Max	max	max	max	max	max	max	max	min
Weight	1,00	1,00	0,50	1,00	0,32	0,06	0,06	0,05
Preference Fn.	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- P: Preference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Statistics								
Minimum	n/a	n/a	1,00	n/a	2,00	3,00	4,00	1,00
Maximum	n/a	n/a	5,00	n/a	5,00	5,00	5,00	4,00
Average	n/a	n/a	3,40	n/a	3,20	4,80	4,70	2,20
Standard Dev.	n/a	n/a	1,62	n/a	0,87	0,60	0,46	0,98
Evaluations								
I1	n/a	n/a	very low	n/a	medium	very high	very high	high
I2	n/a	n/a	very high	n/a	high	very high	very high	low
I3	n/a	n/a	low	n/a	medium	very high	very high	high
I4	n/a	n/a	very high	n/a	very high	very high	very high	low
I5	n/a	n/a	very high	n/a	medium	medium	high	low
I6	n/a	n/a	very high	n/a	high	very high	high	low
I7	n/a	n/a	low	n/a	low	very high	high	very low
I8	n/a	n/a	low	n/a	medium	very high	very high	low
I9	n/a	n/a	low	n/a	low	very high	very high	very low
I10	n/a	n/a	very high	n/a	medium	very high	very high	low

Figure 3: PROMETHEE evaluation table
Source: Authors.

The Figure 3 provides evaluation of ten concepts (I_1, I_2.....I_{10}) based on eight criteria. The results can be described using following explanation.

I_1 - concept usability based on innovation performance measurement: solution of problems in the innovation process in the creation and when spreading the innovations → the subject of the implemented innovation can be product, process, marketing, organization → degree of verifiability of the concept in practice is very low → utilization during the implementation of the innovation project → usability of the concept is average → elaboration of the concept into four management levels of control → developed evaluation system with rating factors up to the level of specific indicators → the savings from training of existing staff is high.

I_2 - usability of the concept of the method BSC: Solution of problems in the innovation process in the creation and when spreading the innovations → the subject of the implemented innovation can be product, process, marketing, organization → the degree of verifiability of the concept in practice is very high → the use before the implementation of the innovation project itself and the completion of the innovation project → the usability of the concept is high → elaboration of the concept into four levels of management → developed evaluation system with evaluation factors up to the level of specific indicators → the savings from training of existing employees are low.

I_3 - usability of the concept based on evaluation of innovations through investment efficiency indicators: Solving problems in the innovation process when creating inventions and spreading innovations → the subject of the implemented innovation can be product, process, marketing, organization → degree of verifiability of the concept in practice is very low → use before the implementation of an innovative project and after the completion of the innovation project → the usability of the concept is average → elaboration of the concept into four levels of management → developed evaluation system with evaluation factors up to the level of specific indicators → the savings from training of existing employees are high.

I_4 - usability of the concept based on value analysis: Solution of problems in the innovation process in the creation of invention, innovation and dissemination of innovation → the subject of the implemented innovation can be product, process, marketing, organization → degree of verifiability of the concept in practice is very high (experience from a number of enterprises) → use before the implementation of the innovation project, during the implementation of the innovation project and after the completion of the innovation project → the usability of the concept of innovation is very high → the elaboration of the concept into four levels of management → the developed evaluation system with evaluation factors up to the level of specific indicators → the savings from training of existing employees are low.

I_5 - concept based on organizational readiness for innovation: Solving problems in the innovation process when creating inventions → the subject of the implemented innovation cannot be determined → the degree of verifiability of the concept in practice is very high (experience of consultancy firms) → the use before the implementation of the innovation project itself → the usability of the concept of innovation is average → the elaboration of the concept into two levels of control → rating system with assessment factors → the savings from training of existing employees are low.

I_6 - concept based on the determination of innovation potential: Solving problems in the innovation process when creating inventions → the subject of the implemented innovation can be product, process, marketing, organization → degree of verifiability of the concept in practice is very high → use before the implementation of the innovation project → the usability of the concept of innovation is high → the elaboration of the concept into four levels of management → developed evaluation system with rating factors → the savings from training of existing staff is low.

I_7 - concept based on creation of innovation radar: Problem solving related to the assessment of the innovation process within the diffusion of innovation → the subject of the implemented innovation cannot be determined → the degree of verifiability of the concept in practice is very low → the use during the implementation of the innovation project and the completion of the innovation project → the usability of the innovation concept is low → the elaboration of the concept into four levels management → developed evaluation system with assessment factors → the savings from training of existing employees is very low.

I_8 - concept based on innovation index: Solution of problems related to the assessment of the innovation process in the area of evaluation of innovation benefits → the subject of the implemented innovation cannot be determined → the degree of verifiability of the concept in practice is very low → the use during the implementation of the innovation project and the completion of the innovation project → the usability of the innovation concept is average → the elaboration of the concept to four levels of management → developed evaluation system with rating factors up to indicator level → the savings from training of existing employees are low.

I_9 - concept based on innovation interactive panel: Solving the problems related to the monitoring of results in the area of evaluation of innovation benefits → the subject of the implemented innovation cannot be determined → the degree of verifiability of the concept in practice is very low → the use after the completion of the innovation project → the usability of the innovation concept is low → the elaboration of the concept into two levels of control → general characteristics of rating → the savings from training of existing employees are very low.

I_{10} - concept based on the experiences from a business practice: Solution of problems in the innovation process in the creation of innovation and within the diffusion of innovation → the subject of the implemented innovation can be product, process, marketing, organization → degree of verifiability of the concept in practice is very high → use during the implementation of the innovation project and after completion of the innovation project → usability of the concept is average → the elaboration of the concept into four levels of management → a developed evaluation system with evaluation factors up to the level of specific indicators → the savings from the training of existing employees are low.

Selection of the innovation concept based on decision-making model in Visual PROMETHEE

This step of the decision making model includes work with the Visual PROMETHEE software that enables the decision maker to organize all information into a one matrix. Combining eight evaluation criteria and weights estimated for the five selected criteria from the Table 4 and evaluation of the innovations concepts from the Table 5 we can create following PROMETHEE table on the Figure 3. Each criteria is included. However, only the criteria with assigned scales were used for evaluation. Criteria C_1, C_2 and C_4 are deemed negligible in this application.

Scenario1	C1	C2	C3	C4	C5	C6	C7	C8
Unit	5-point	5-point	5-point	5-point	5-point	5-point	5-point	5-point
Cluster/Group								
Preferences								
Min/Max	max	max	max	max	max	max	max	min
Weight	1,00	1,00	0,50	1,00	0,32	0,06	0,06	0,05
Preference Fn.	Usual	Usual	Usual	Usual	Usual	Usual	Usual	Usual
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- P: Preference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Statistics								
Minimum	n/a	n/a	1,00	n/a	2,00	3,00	4,00	1,00
Maximum	n/a	n/a	5,00	n/a	5,00	5,00	5,00	4,00
Average	n/a	n/a	3,40	n/a	3,20	4,80	4,70	2,20
Standard Dev.	n/a	n/a	1,62	n/a	0,87	0,60	0,46	0,98
Evaluations								
I1	n/a	n/a	very low	n/a	medium	very high	very high	high
I2	n/a	n/a	very high	n/a	high	very high	very high	low
I3	n/a	n/a	low	n/a	medium	very high	very high	high
I4	n/a	n/a	very high	n/a	very high	very high	very high	low
I5	n/a	n/a	very high	n/a	medium	medium	high	low
I6	n/a	n/a	very high	n/a	high	very high	high	low
I7	n/a	n/a	low	n/a	low	very high	high	very low
I8	n/a	n/a	low	n/a	medium	very high	very high	low
I9	n/a	n/a	low	n/a	low	very high	very high	very low
I10	n/a	n/a	very high	n/a	medium	very high	very high	low

Figure 3: PROMETHEE evaluation table.
Source: authors.

RESULTS AND DISCUSSION

Based on the PROMETHEE matrix (see Figure 3) we can calculate the ranking based on the net flow (Phi), positive (Phi+) and negative flows (Phi-). The results clearly show that the innovations concept I4 (Concept of value analysis) is ranked as the most favorable, followed by the I2 (Balanced Scorecard) and I6

(Concept based on experience from corporate practice).

PROMETHEE Flow Table

Rank	action	Phi	Phi+	Phi-
1	I4	0,6273	0,6393	0,0120
2	I2	0,5203	0,5680	0,0477
3	I6	0,4559	0,5487	0,0928
4	I10	0,2707	0,3897	0,1190
5	I5	0,1362	0,3633	0,2271
6	I8	-0,2333	0,1657	0,3990
7	I3	-0,2813	0,1537	0,4350
8	I9	-0,4350	0,1303	0,5653
9	I7	-0,4994	0,1110	0,6104
10	I1	-0,5613	0,0977	0,6590

Figure 4: PROMETHEE ranking
Source: Authors.

The other concepts net flows are far lower to be considered for final decision. Furthermore the results can be evaluated in detail using plenty of Visual PROMETHEE graphic tools based on the GAIA plane such as PROMETHEE Rainbow, **see Figure 5**.

This tool helps to identify which criteria are the most important regarding each variant. It can be seen that innovation concepts I_4 and I_2 are very close. The difference is in the criteria C_5 (usability in practice). On the other hand, the concept I_{10} is lagging. The main difference can be seen in the criteria C_7 (determination of innovation metrics and their form).

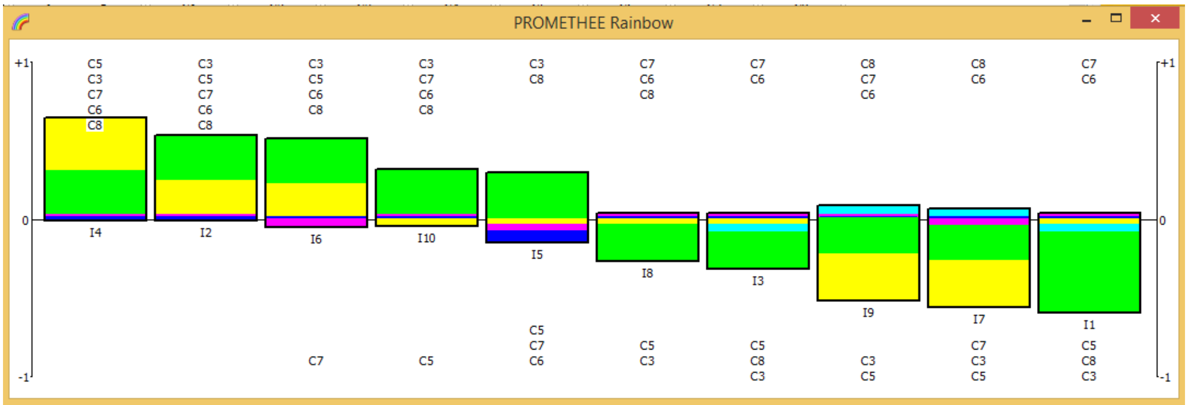

Figure 5: PROMETHEE rainbow
Source: Authors.

Managerial decision making in the field of innovation requires selection of variants based on certain criteria, often even of the opposite ones. Each variant was described by: the type of innovation problem; subject of realized innovation; verifiability of the concept of innovation in practice; using the concept of innovation with regard to the time of the implementation of the innovation project; usability of the concept of innovation in an enterprise; level of elaboration of the concept of innovation into management levels; determination of innovation metrics and their form; savings resulting from training of existing employees when implementing the concept of innovation. Sole description does not allow ranking the concepts according to their characteristics. Therefore, a model based on the combination of AHP and PROMETHEE was implemented.

Decision matrix used in AHP application, introduced the decision makers' preferences in which all relevant criteria were compared against each other. The information of this matrix was used to calculate the criteria weights.

The distinct merit of AHP method is that it decomposes a decision problem into its constituent parts and builds hierarchies of criteria.

However, in the case of many criteria and alternatives, it may become very difficult for decision makers to obtain clear view of the problem and to evaluate the results. The amount of interaction with the user increases dramatically with an increase in the number of alternatives and this increase prevents the user from continuing the analysis and leading to some inconsistencies. Complexity of the eigenvector method and the loss of information when converting the quantitative data into a 1-9 scale are other drawbacks of AHP.

PROMETHEE does not provide such structuring. PROMETHEE needs much less inputs; it takes into account the preference function of each criterion, determined by the decision-makers. By this way, each criterion is evaluated on a different basis and it is possible to make better decisions. PROMETHEE I identifies the alternatives which cannot be compared and the alternatives which are indifferent, by making a partial ranking (such as LSF), while PROMETHEE II provides a complete ranking for alternatives.

The Visual PROMETHEE software is a powerful tool to identify conflicts between criteria and to group the alternatives in one complex model. The PROMETHEE II is the preferred method for evaluating alternatives for the appropriate structural system selection process.

The method is consistent, easy to understand and requires little interaction with the decision makers. The linearity and the additive assumptions for the preference function is acceptable to the decision makers. By utilizing the PROMETHEE method for sensitivity analysis, the most effective criteria in decision making process are determined. These are unique features of PROMETHEE method, which are not available in AHP, or other MCDM techniques.

CONCLUSION

Innovation concepts give managers insight into what they think is important to solve the innovation problem. Presented decision making model has been applied to evaluate selected innovation concepts and the subsequent choice of best variant (concept).

This model consist of eight criteria that include five ones weighted by Saaty method and ten innovation management concepts. Those eight criteria were selected and evaluated by experts with the help of the authors. In order to evaluate and select the bets variant (innovation management concept) the Visual PROMETHEE software tool was applied. It associates both the criteria weights and evaluation of variants. The Visual PROMETHEE software is a powerful tool to identify conflicts between criteria and to group the alternatives in one complex model.

The developed decision making model combining Saaty method and Visual PROMETHEE is effective tool for managers that face decisions on the choice of the innovation management concept in large manufacturing companies.

The presented approach including the process of innovation concepts description, selection of criteria, evaluation using Saaty method and application of Visual PROMETHEE can be also adopted for decision making situations involving criteria and variants with similar nature i.e. innovations, technologies, investment alternatives, and concepts.

However, the exploratory nature of this research puts limitation to the results, this result is valid for an actual large company that comes from the food processing industry.

ACKNOWLEDGMENT

This paper was supported within Operational Programme Education for Competitiveness – Project No. ***CZ.1.07/2.3.00/20.0296.*** *The research was supported by the Czech Science Foundation (GACR Project GA 17-22662S).*

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