



MANAGING THE PROCESS OF PREPARATION FOR PRODUCT DEVELOPMENT - IDEAS ASSESSMENT AND EVALUATION

M. Stevanović, D. Marjanović and M. Štorga

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1. Introduction

Innovation has become a strategic necessity for any company. The companies that does not use its business opportunities, or does not respond to them in a timely manner, are usually replaced in the market competition. Over time, the process of managing product development has undergone several periods in which the different factors had a dominant influence on the process, and its outcomes. The analysis of McGrath [2004] highlights four generations of product development management: Innovation and Commercialization Generation, Project Success Generation, Time-to-Market Generation, and R&D Productivity Generation. A decrease in the investment in research and development, and the need of companies for new products that would secure income as soon as possible has led to a new paradigm in the fourth generation (R&D Productivity Generation), which, according to McGrath-u started at the beginning of this century, and which is expected to create additional value by increasing the productivity of product development management particularly in its earliest part. It is important to emphasize that the pace of change is continuously increasing, and that important factors of one generation are being rapidly upgraded or even replaced by new ones. Bringing a new product or service into development, means to make choices, to determine priorities and to allocate resources.

The early part in the product innovation process, the so-called preparation for product development (PPD), front end of innovation (FEI), or fuzzy-front end (FFE), is the stage of the innovation process where product strategy formulation, opportunity identification and selection, idea generation, evaluation, and selection, and concept development and testing [Smith and Reinertsen 1991], [Koen 2001], [Stevanovic 2012]. This first part in the engineering design process have the largest impact on the end result of the project, and the highest payback to one's investments [Dewulf 2012]. Accordingly, the front-end of innovation is often described as being the root of success for any company hoping to complete on the basis of innovation [Reid and DeBrentani 2004]. The PPD is recognized as the most difficult stage to manage in the innovation process [Kim and Wilemon 2002], as it involves a significant degree of uncertainty [Chang et al. 2008]. The PPD is characterizes by unstructured processes and chaos [Bulinger 2008]. In addition, the PPD is often characterized by ad hoc decision making and conflicting organizational pressures [Khurana and Rosenthal 1998], [Montoya-Weiss and O'Driscoll 2000]. Information for decision-making is usually informal and approximate in nature rather than quantitative, formal, and precise. Fuzziness comes from uncertainty about technology, customer requirements, markets, required resources, company-fit, capabilities, and company limits, such information is necessary to decide whether or not to develop the product [Kim and Wilemon 2002]. Because of the crucial importance of new, creative ideas for the success of product innovation, the idea management is

imposed as extremely important, and, according to some authors, a key process during the PPD [Bullinger 2008], [Stevanovic 2012], [Alexe et al. 2014]. It is important for companies to identify the most promising product ideas very early in the product development process in order to use the available resources for the right projects. Consequently, the question arises how the most promising product ideas can be identified. A potentially good way to achieve this goal is by applying a systematic process for idea selection [Messerle et al. 2013].

In this research, we tried to partially point out the ways of carrying out some activities during the preparation of product development primarily related to the life cycle of ideas, such as the valuation, evaluation, ranking and selection of ideas. We believe that this is one of the important factors that may contribute to faster decision-making at this stage of product development which is full of uncertainty and shorten the duration of the process. We also believe that through the systematic implementation of valuation of ideas for pre-defined criteria and attributes, unique semantics can be defined which will ensure a better understanding throughout the process and unique metrics that will provide the possibility of better comparison of ideas during the process and after it. This paper presents a part of the study, which covers the methods of assessment and evaluation of ideas and criteria and attributes on which to carry out the assessment. Verification of the proposed methods was carried out using different methods of multi-attribute evaluation in the process of innovation of several products, and here are some of the results of the verification for one of the products.

2. Literature review

Idea management is often an integral part of the process of product innovation. According to Summa [2004], idea management includes the following phases: generation or ideation, gathering, evaluation, development, implementation, and follow-up and rewarding. The author states that idea selection is a critical step in managing innovation. Another way of defining phases in the process of idea management is found in Iversen et al. [2009], in which the authors point out the following processes: inspiring and involvement, generation and capturing, development and enrichment, evaluation and selection, implementation, post-implementation learning and feedback. In the paper Westerski and Iglesias [2011] distribute a lifetime of ideas in five sections: generation, improvement, selection, implementation and deployment. According to Malik [2014], the process of idea management includes: genesis and gathering, evaluation and selection, feedback and recognition, implementation and idea bank. In dissertation Glassman [2009] defines idea management as the process of capturing, storing and organizing ideas and also, idea management can be used to perform preliminary evaluation and screening of ideas as well as diffuse ideas across the company.

Idea assessment, evaluation and selection are the most important activities during the PPD or as stated in [Koen et al. 2001] „The critical activity is to choose which ideas to pursue in order to achieve the most business value“. The process of assessment, evaluation and selection of ideas reduces the risk and uncertainty in the future product development, which has been discussed by several researches [Sherman et al. 2005], [Salomo et al. 2007]. Unlike the process of creating ideas, which is primarily a creative (divergent) process, a process of evaluation and selection of ideas is primarily analytical (convergent) process. The process of evaluation and selection of ideas is based on estimation of “goodness” of ideas and conformity to the overall set of goals: business, strategy, development, production, customer, marketing, finance, management, market, etc. [Feyzioglu and Buyukozkan 2005]. The more risk factors and uncertainties over the PPD are discovered, there will be fewer opportunities for mistakes in the specification and conceptualisation of the future product. Evaluation and selection of ideas have been the subject of many researches [Montoya-Weiss and O'Driscoll 2000], [Alves et al. 2005], [Binz et al. 2007], [Aagaard 2008], [Ferioli et al. 2008], [Paasi and Valkokari 2010], [Messerle et al. 2010, 2012], [Roussel et al. 2012], [Stevanovic et al. 2012, 2013, 2014, 2015]. In the research reports authors have approached the problem from different angles, depending on the particular case of their research. Thus Aagaard [2008] describes examples of new product idea evaluation emphasizing "the metrics are critical in idea evaluation and idea improvement", and specifying criteria defined by Montoya-Weiss and O'Driscoll [2000] as follows: marketing, technology, business and human factor. Alves et al. [2005], state that in the process of reducing the number of ideas they were looking for convergence techniques based on analytical and logical processes. In study Binz et al. [2007] claim that for the technical products

is not enough just to be a new (novelty criteria) but it is also necessary to be successful in the market (success potential). Application of unremarkable multi-attribute methods and processes of group decision making may be found in the work of Chang et al. [2008], in which the authors present a model of ideas evaluation process for product development. While implementing the evaluation, they used following evaluation criteria: compatibility with the business strategy, synergies with other products, technological feasibility, market attractiveness and competitive advantage. However, despite a significant number of papers and many research findings, there is still a large gap between the process of idea generation for product development and innovation of product. There is no unique methodology for description, assessment, evaluation and selection of ideas. The above activities are studied and implemented on a case-by-case basis. According to the report [AMS 2006], comprehensive global survey that included over 1,300 respondents, and that is based on a series of interviews with companies that are considered the best-in-class in innovation management, nearly half (48%) of the respondents reported that they "don't have a standard policy for evaluating ideas.". The next common responses: about 17% said that they use an "independent review and evaluation process", while 15% said "ideas were evaluated by the unit manager where the idea was proposed". The survey clearly indicates that there is no obvious strategy for selecting or even evaluating ideas. The research presented is attempting to contribute to overcome these gaps.

3. Idea assessment and evaluation

As already mentioned, the main problem we face during the PPD is primarily a large number of uncertainties conditioned by a large number of events that could have affect the future success of innovation, and which cannot be completely understood at such an early stage of development, or presumed or assessed which values it would take. This implies and a lack of knowledge about the possible scenario of innovation especially in cases of radical innovation, which would be enough for the concept of future products. At the same time, participants in the process of innovation are expected to create new solutions, suggest new products and make relevant decisions which will ensure a successful innovation for companies. In order for participants in PPD to achieve greater productivity, it is necessary to provide methods that will help them in faster elimination of uncertainties, and methods that will ensure efficient, maximum reliable, and, most importantly, a reproducible assessment of potential opportunities and the ideas that are the basis for new concepts.

According to a study conducted by Kim and Wilemon [2002], at the beginning of PPD we find an extremely high degree of uncertainty (Figure 1). Over time, with the determination of the value of each factor, the degree of uncertainty is reduced. If we look at the two processes which guide the preparation of product development for the same product, one driven by good methodology assessment and evaluation of ideas and the second led by a slightly weaker methodology with more repetitions of activities, one can clearly visualize the difference of time necessary for the completion of both processes to the level of expected knowledge required to complete the concept of future products.

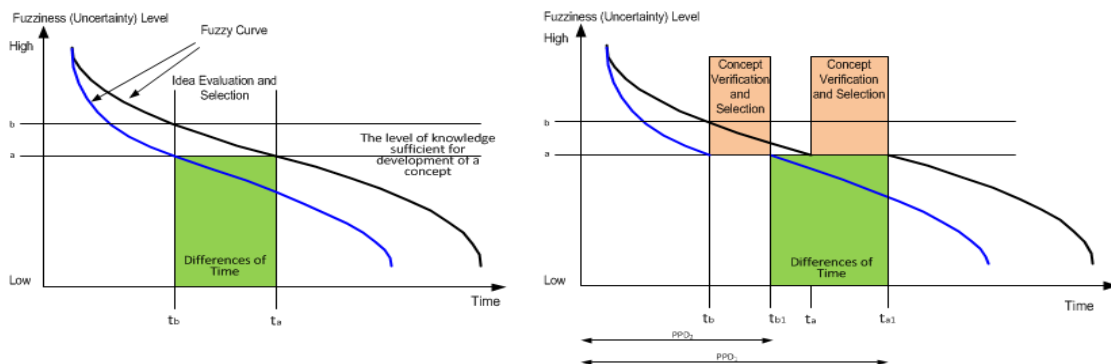


Figure 1. The impact of process of idea evaluation (left) and concept selection (right) on the PPD

Also, if we continue to observe these two processes (Figure 1, right), the second documented process' insufficient reproducibility and non-uniform language (ontology) requires from participants who carry

out the verification and selection of concepts additional activities and more time to start NPD. Therefore, for the processes guided by imprecise and unclear methodology of ideas assessment and evaluation, we require significantly more time for the beginning of the product development process, and thus the costs are higher and its productivity significantly lower.

Simply put, if we possess methods for the effective reduction of uncertainty in the process of PPD, we can significantly shorten the duration of the PPD process, have an earlier start on the process of product development (NPD), and reduce the total cost of product innovation through increased productivity.

3.1 Model for idea assessment and evaluation

As indicated, one of the essential problems for the assessment and evaluation of ideas is a way of determining the transformation of the cognitive process of content analysis of collected ideas into a formal process for which an unambiguous methodology could be defined. An aggravating circumstance is an expressed multidimensionality of the process (application of ideas in many areas, the impact of ideas on many levels), its non-linearity (ideas build upon each other, connect and separate, etc.) and a large number of factors that affect the level of risk, i.e. the degree of uncertainty of the outcome of analysed events. Due to the complexity of the problem a decomposition process of assessment and evaluation of ideas was conducted on four levels (Figure 2).

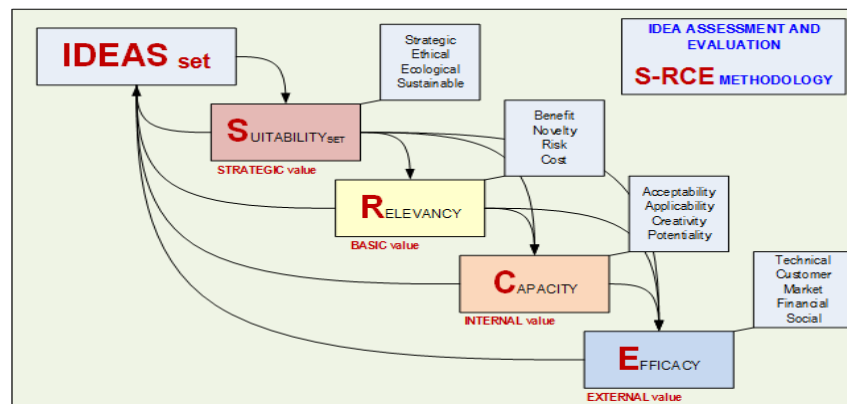


Figure 2. Idea assessment and evaluation process (S-RCE methodology)

It is necessary to note that before the assessment of the idea set, and before recording the idea in an idea database, we need to carry out the screening of ideas, and make sure that the database records only ideas that are appropriate or at least partly appropriate for potential further action. Ideas retained in the system are further processed prior to their application. They are described according to the attributes on multiple levels, categorized, sorted, optionally upgraded, merged, recorded, and subjected to qualitative evaluation of a selected set of ideas. Qualitative evaluation is carried out by reviewers, who are either qualified persons or experts in the relevant area. The goal of the qualitative assessment is reduction of the set of ideas and their grouping and completion, and the definition of the initial attribute values for further quantitative assessment of the value of the idea.

On the first level we try to assess how much ideas are suitable for innovation, which is a normative level of decisions based on an assessment of ideas on the basis of strategic eligibility, ethical and environmental eligibility, and impact of ideas on sustainability in the environment over the entire life-cycle of the product.

At the second level, the Relevancy factor (Relevancy for Innovation), which attempts to measure the value that the idea brings to the company, through the following criteria: benefit, novelty, risk, cost, with the goal of early recognition of extremely good and extremely bad ideas, guidance of ideas towards their potential application, and the creation of subsets of ideas for further evaluation.

At the third level, the Capacity factor (Capacity for Innovation) of collected ideas is assessed, which tries to determine how acceptable, applicable, and creative the idea is, and what their general potential for product innovation is. It should be noted that the product at this stage of innovation do not have clearly defined all goals. At the same time, the product requirements, constraints, and restrictions are

often not yet precisely defined, so the list of requirements and constraints partially depends on the content of the analysed ideas.

At the fourth level, the idea Efficacy factor (Efficacy for Innovation) is assessed and ideas are, i.e. the subset of ideas is evaluated in relation to the goals, requirements and constraints, defined for a specific product in order to maximize technical (production), market, financial, customer and social effects of innovation. The evaluation of idea efficacy factors aims to create a priority list within the set of ideas, on the basis of assessment of potential of each idea to produce the very results which are expected from the product. The evaluation of efficacy of ideas is based on three sets of data that are available at the time of an assessment. The first group is data about the ideas. The second group of data consists of objectives, requirements and constraints that we have defined in relation to the product which we are developing, and the third group of data is comprised of metrics for the implementation of the assessment and evaluation of ideas, i.e. the criteria and attributes which we will analyse in the evaluation process and which we will try to determine. As already stated, the metric is often critical to the process of idea evaluation. The literature mentions various attributes which can be applied to similar evaluations.

During empirical research, evaluation of a certain set of attributes was conducted in practice of companies. Following the results of a broad and detailed analysis of the available literature and empirical research, an unambiguous metric was determined for the implementation of the evaluation of ideas ability that successfully comes to fruition expected goals. The determined metric is unambiguously applicable for all ideas from a set of ideas, and the basis of the defined vocabulary allows for an unambiguous communication between the different actors in the process of idea evaluation, regardless of their area of expertise and familiarity. Below, Table 1, shows the defined metrics for the part of idea Efficacy factor, for sub-criteria: Technical (Production) Efficacy. Metrics are composed of attributes whose value is estimated, the basic questions that the assessor should answer when assessing ideas and a matrix frame of corresponding numerical values for each of the answers. The process of estimation of value contained in ideas, in the process of product development, is a typical case of a problem of multi-attribute analysis. Therefore, for the above described four levels of assessment and evaluation of ideas, we have created four hierarchical structures, and the very implementation of the assessment of ideas can be carried out by using methods of multi-attribute analysis, through the use of a defined or another type of applicable metrics. It is important to take into account the transitivity of methods and possibilities of checking the sensitivity of obtained values in relation to the change in value of defined criteria.

Table 1. The attributes for technical / production criteria and associated metrics

TECHNICAL / PRODUCTION	Basic question	Value		
		1	5	9
PRODUCTIVITY	How the idea affects the possibility to production?	We do not have the necessary resources for the realization of such products	We have the necessary resources or resources can be easily found	We have the necessary resources, knowledge and ideas to improve our production knowledge
FUNCTIONALITY	How the idea affects the functionality of the product?	The idea does not provide the full functionality according to known criteria	The idea provides the expected functionality for set criteria	The idea offers more than the expected functionality of the set criteria
RELIABILITY	How the idea affects the reliability of the product?	The idea significantly reduces the reliability of the product	The idea does not significantly affect the reliability of the product	The idea increases reliability
SAFETY	How the idea affects the safety of the product?	The idea essentially reduces the safe use of a product	The idea does not significantly affect the safe of use of the product	The idea increases the safety of the product
ECOLOGICALLY	Does the idea affect the environment?	The idea has a negative impact on environmental parameters (energy, pollution ...)	The idea does not significantly affect the environmental parameters	The idea contributes significantly to environmental characteristics of the product (green product)
AESTHETICS	Does the idea affect the aesthetics of the product?	The idea reduces the overall aesthetics of the product	The idea does not significantly affect the overall aesthetics of the product	The idea contributes significantly to the overall aesthetics of the product

In the process of evaluation of ideas it is desirable to use more levels on which an assessment and evaluation of ideas is performed, but this is not essential. The total value of an idea is only a numerical value on which the ranking is carried out in a set of ideas and priorities created in order for the participants of the decision making process to have the possibility of a transparent selection.

4. Idea assessment and evaluation in practice - case study

In order to verify the applicability of the proposed model, we conducted several assessments and evaluations of ideas. The verification process included identifying and assessing business opportunities,

defining the objectives, requirements and constraints for the product, defining needs, gathering ideas, ranking and evaluation of collected ideas, and creation of a product concept. In this paper important parts of the verification which was performed will be presented; and because of the scope of the work, elements and activities that are not directly related to the verification of the proposed methodology will not be displayed.

In order to generate ideas, we used two sources. One source were the engineering students, who, as a part of their activities, worked on creating ideas for defined product features on several occasions. Another source were participants in the development process in the company, who created a set of ideas on their own, and who subsequently worked on assessing and evaluating ideas from both groups. It was important to identify the degree of individual preferences towards ideas in relation to the place of origin of ideas (i.e. the owner of ideas). In the process of assessing and ranking of ideas we had, on one side, a group of employees (Group 1, four employees, mostly technical training), and on the other, consultants-associates with referential experience in the areas of: technology, marketing, sales and finance (Group 2, four associates). In the process of assessment and evaluation of the ideas we used two methods of multi-attribute analysis: SAW-Simple Additive Weighting [Afshari et al. 2010] and AHP - Analytical Hierarchy Process [Saaty 1980].

Group 2 conducted an initial screening and qualitative evaluation of the collected ideas and carried out an evaluation of the remaining ideas from the set after a qualitative evaluation by application of the AHP method (Results AHP2). Group 1 evaluated the ideas from an identical set by applying the SAW and AHP methods. The evaluation of ideas from a set using the SAW method was conducted by the appraisers independently (each of them) and the overall score was created as the arithmetic mean of their score for each evaluated attribute. The evaluation of ideas from a set using the AHP method was conducted by appraisers in groups (team). In all cases when evaluating the attributes, the appraisers used an interval scale with values from 1 to 9 (Saaty's scale), and in order to have comparable results, following the evaluation of criteria and ideas, they conducted a normalization of values.

In the process of idea creation we gathered more than 200 ideas, but after the initial screening we retained 189 ideas in the database. After the suitability assessment, 62 ideas were rejected, while the qualitative assessment discarded a further set of 116 ideas. The result of the "preliminary" work of Group 2 was 101 ideas pushed back to the starting set of ideas and 26 ideas retained for further assessment and evaluation. Roughly one working day was necessary for these activities.

For the remaining 26 ideas, the evaluation was conducted with SAW method by each of the four members of the Group 1. To carry out this evaluation, the group spent about 4 hours of work. The results of the assessment of the observed set of ideas are shown in Table 2. As can be seen, the appraisers have defined the weight of each of the criteria (Relevance, Capacity, Efficacy), and the weight of each of the sub-criteria.

Table 2. Results of assessment of the ideas set (SAW method, Group 1, S-RCE methodology)

Idea / Criterium	Suitability					Relevance Value				Capacity Value				Efficacy Value					Normalized							
	Strategic	Ethical	Ecological	Suitability	V _S	Benefit	Novelty	Risk	Cost	V _B	Acceptability	Applicability	Creativity	Potentiality	V _C	Technical	Market	Financial	Customer	Social	V _E	Suitability	Relevance	Capacity	Efficacy	Overall Value
w _i					0,40	0,20	0,20	0,20	0,30	0,25	0,25	0,25	0,25	0,30	0,30	0,20	0,20	0,20	0,10	0,10	0,40	V _S ⁿ	V _B ⁿ	V _C ⁿ	V _E ⁿ	V _T ⁿ
1	1	1	1	1	1	4,40	3,87	5,00	3,41	1,51	6,44	3,71	3,41	3,87	4,36	5,00	5,00	3,56	4,40	4,40	4,53	1,00	11,72	9,94	11,56	11,13
2	2	1	1	1	1	3,00	3,87	5,92	4,40	0,96	6,44	3,41	3,00	3,41	4,06	3,56	3,56	3,87	3,00	3,56	3,56	1,00	7,44	9,27	9,10	8,65
3	3	1	1	1	1	3,00	3,00	5,66	3,41	0,99	5,66	3,00	1,32	3,00	3,24	3,87	1,71	3,56	1,73	1,50	2,71	1,00	7,71	7,41	6,92	7,30
4	4	1	1	1	1	3,00	3,41	4,79	4,40	1,02	5,66	3,00	2,28	3,00	3,49	3,27	3,56	3,56	3,00	3,00	3,30	1,00	7,96	7,96	8,43	8,15
9	5	1	1	1	1	5,00	6,44	3,00	3,87	2,39	6,44	5,44	5,44	6,44	5,94	5,29	5,00	3,56	5,44	4,40	4,83	1,00	18,60	13,55	12,32	14,57
13	6	1	1	1	1	1,00	1,00	5,00	5,00	0,30	4,21	3,00	1,73	3,00	2,99	2,26	3,56	3,56	2,28	1,32	2,69	1,00	2,33	6,82	6,86	5,49
21	7	1	1	1	1	3,00	3,00	6,44	5,44	0,76	4,21	3,00	1,73	3,00	2,99	2,26	3,56	3,56	2,28	1,32	2,69	1,00	5,89	6,82	6,86	6,56
22	8	1	1	1	1	2,28	3,00	5,00	5,00	0,76	4,79	4,40	1,73	3,00	3,48	3,27	3,56	3,56	3,00	1,73	3,18	1,00	5,88	7,94	8,11	7,39
23	9	1	1	1	1	3,00	3,00	5,00	5,44	0,86	4,21	3,41	3,00	3,00	3,41	3,27	3,56	3,56	3,00	1,73	3,18	1,00	6,70	7,77	8,11	7,59
24	10	1	1	1	1	3,00	3,00	5,92	6,44	0,73	3,71	3,41	3,00	3,00	3,28	3,00	3,56	3,56	3,00	1,73	3,10	1,00	5,67	7,48	7,90	7,11
25	11	1	1	1	1	5,92	5,92	3,00	3,87	2,58	7,00	6,44	5,92	7,00	6,59	5,92	6,26	3,56	5,92	5,00	5,42	1,00	20,08	15,04	13,83	16,07
										12,9					43,8						39,2		100	100	100	100

Then they made an estimate of the value of each attribute, of each sub-criteria, and based on that got the value of ideas for each sub-criteria, criteria, and the overall value for each idea. The far right of the table

shows the normalized values of ideas for each criterion and the total normalized value of the idea. Maybe it is necessary to emphasize that, for the criterion of suitability; the assessment is not carried out as for the other criteria. The reason for this is that we believe that the criteria of Suitability corresponded to the general admissibility of some ideas regardless of the criteria. Thus, the assessment of ideas for the criteria of Suitability was conducted using a binary set (0 = Unsatisfactory, 1 = Satisfactory), for each of the sub-criteria. Table 2 shows the results for only those ideas that met all four sub-criteria of Suitability.

After the assessment by the SAW method, the ranking of ideas from the analysed set can be performed clearly. The values for each sub-criterion are defined as a geometric mean value for each of criterion's attributes. Relevance, Capacity, and Efficacy value, are determined by multiplying the corresponding value of the weight of each criteria and values that the idea was assessed in relation to the relevant criteria. The total value for each idea is determined in the same manner. Figure 3 (left) shows the total value for each of the ideas implemented after normalization, and Figure 3 (right) shows the outline of the value of ideas implemented before normalization.

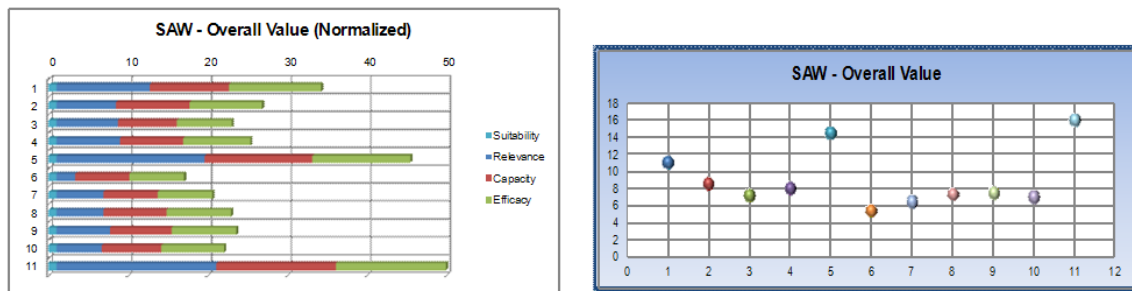


Figure 3. The normalized overall value (left) and overall value of ideas after assessment (right)

After the valuation of ideas using the SAW method, we approached the valuation of the same idea for the same set of criteria by using the AHP method. The assessment performed by the AHP method took Group 1 approximately 5 hours to complete, while Group 2 took a little more than 6 hours. The reason for this is twofold: first, Group 1 had already ranked the set of ideas using the SAW method, and has already partly been familiarized with the content of ideas. Secondly, Group 1 was homogeneous with regards to their qualifications, and it took less time to harmonize positions on the assessment of individual ideas. The following table (Table 3) shows the results of the evaluation of a set of ideas by Group 1 (normalized values).

Table 3. The evaluation of a set of ideas (AHP method, Group 1, S-RCE methodology)

AHP-1	Relevance				Capacity				Efficacy					Score			Total
	Cost	Risk	Novelty	Benefit	Acceptabl	Creativity	Potential	Applicabi	Technical	Customer	Social	Financial	Market	Relevanc	Capacity	Efficacy	
	0,3	0,3	0,2	0,2	0,30	0,30	0,20	0,20	0,35	0,25	0,10	0,15	0,15	0,35	0,25	0,40	1,00
ID-001	10,83	10,12	7,65	10,00	10,53	8,49	10,14	9,05	11,93	12,88	13,91	10,44	12,90	9,82	9,56	12,15	10,69
ID-002	10,03	6,09	7,65	7,20	9,50	5,30	5,00	5,15	6,75	11,35	9,41	10,44	9,01	7,79	6,48	8,98	7,94
ID-003	10,13	6,09	7,65	6,55	10,57	4,73	7,65	6,65	10,45	5,23	5,61	10,44	5,12	7,71	7,44	7,78	7,67
ID-004	9,70	7,63	9,10	8,40	9,53	7,53	7,65	6,50	8,35	8,25	9,41	10,44	9,01	8,71	7,96	8,75	8,54
ID-005	9,26	14,19	17,00	17,75	10,53	15,42	15,09	12,94	12,69	15,21	13,91	10,44	12,90	13,99	13,40	12,98	13,44
ID-006	8,90	9,16	2,50	2,80	7,27	6,00	6,20	7,80	4,51	4,39	4,00	4,59	5,39	6,48	6,76	5,68	6,23
ID-007	7,76	6,66	7,65	8,40	8,37	6,96	7,65	7,80	4,51	4,39	4,80	4,59	5,39	7,54	7,68	4,55	6,38
ID-008	8,50	8,66	7,65	5,55	7,40	10,69	5,15	11,79	8,35	8,25	9,41	10,44	9,01	7,79	8,80	8,75	8,43
ID-009	7,40	9,12	7,65	8,40	7,27	8,49	8,80	6,30	8,35	8,25	9,41	10,44	9,01	8,16	7,76	8,75	8,30
ID-010	6,16	8,09	7,65	8,40	6,27	9,46	8,85	9,05	7,59	5,07	4,40	7,31	5,39	7,48	8,28	6,20	7,17
ID-011	11,33	14,19	17,85	16,55	12,77	16,92	17,84	16,99	16,53	16,74	15,72	10,44	16,86	14,53	15,88	15,45	15,24
	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

The following figure (Figure 4) shows the overall values of idea set obtained by evaluating by all criteria by Group 1 (AHP1) on the left, and by Group 2 (AHP2) on the right side.

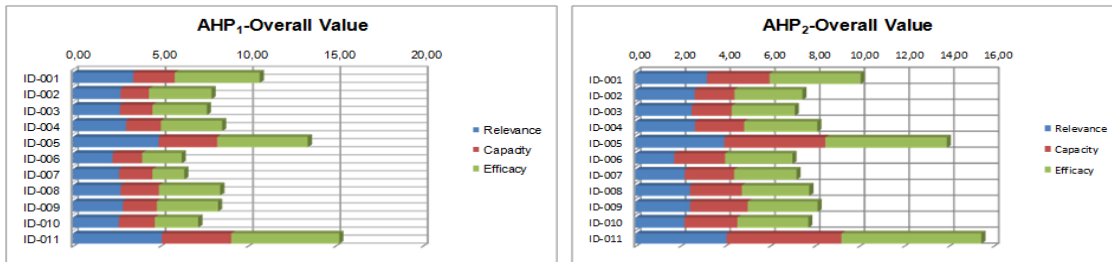


Figure 4. The overall value of idea set following the evaluation by Group 1 and Group 2

For evaluation of ideas by the SAW method, an independently created application was used, while the evaluation of ideas done by using the AHP method the application MakeItRational (www.makeitrational.com) was used.

5. Discussion

Assessment and evaluation of the set of collected ideas for the product development indicated the possibilities and limitations in the application of suggested assessment methods. The initial set of ideas was successfully reduced in several steps to an acceptable set of 26 ideas for the implementation of quantitative evaluation, during which the group was further reduced to 11 ideas that could successfully meet the requirements, in this case the set of technological-functional design goals and all the restrictions. By further application of multi-attribute analysis methods SAW and AHP, the evaluation of a set of 11 ideas for each of the defined criteria was conducted. Based on the Criteria of Relevance, we tried to answer the question about the relevance of the ideas with regards to planned innovation observed in relation to the benefits and risks for the company. Based on the Criteria of Capacity, we have tried to answer the question about the innovative capacity of every idea in order to implement innovations based on the idea that contains a higher level of innovative capacity. Based on the Criteria of Efficacy, we tried to determine how efficacy the application of certain ideas is to ensure successful innovation, primarily in terms of the realization of technical and manufacturing features, the market value, financial results, value to the user (customer) and social values in relation to the community and in relation to others who do not own the product. All assessments and evaluations, have been conducted with two groups of assessors, of which the first group conducted the assessment using the SAW and the AHP method and the other group by only using the AHP method. Comparison of the results received for the criteria of Relevance and Capacity is shown in Figure 5.

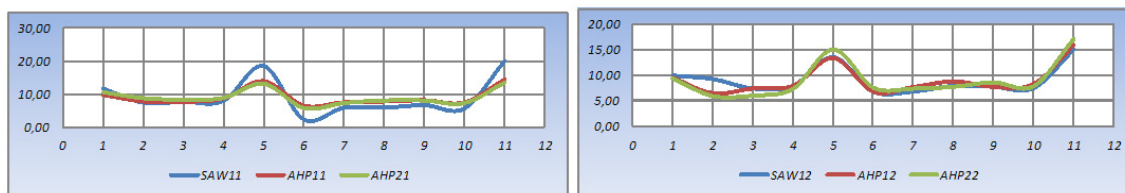


Figure 5. Comparison of implemented evaluation criteria for Relevance and for Capacity

Comparison of the results of criteria of Efficacy and the Overall value based on all the criteria for each of the assessments is shown in Figure 6.

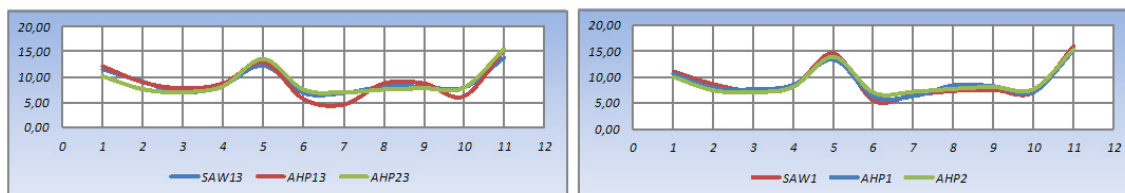


Figure 6. Comparison of implemented evaluation criteria for Efficacy and for Overall value

Correlation of results was checked by calculation of Pearson's and Spearman's coefficient of rank. Correlations are positive and have high values, in all cases greater than 0.5 and in most cases greater than 0.8, indicating the existence of correlation, usually a strong positive correlation.

6. Conclusion

Increasing the productivity of the process of product innovation, especially in the early stages when very large degrees of uncertainty are attached to the assessment of business opportunities, ideas for the implementation and value of the product concept, is the basic goal of this paper. One of the ways of increasing the productivity during the preparation of product development is to shorten the process by using appropriate methods and tools for faster and better resolving of uncertainties. This paper proposes a model for the assessment and evaluation of a set of ideas for the various stages of implementation in the process of product innovation. The model contains multiple stages, the stages are hierarchically organized, independent of each other, and the realization of each stage implements a reduction in the initial set of ideas, and allows faster decision-making based on sound knowledge for decision-makers. At each stage of the proposed model a hierarchical model of criteria and attributes is defined, together with unambiguous metrics for assessing the value of each attribute, which allows for an easy implementation of multi-attribute analysis methods. The conducted verification of the proposed methodology indicated a high degree of applicability and a high degree of correlation in terms of the methods used, in terms of individual or group application, and in view of the knowledge of different groups of assessors. Contrary to expectations, the time required for the implementation of individual assessments and rankings, with appropriate information technology support, was below expectations, and we think that the application of such a systematically defined methodology, certainly has an advantage over the usual "ad hoc" evaluation.

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Dr. sc. Milan Stevanovic
 Markot.tel, Product Development
 Augusta Prosenika 13, 10000 Zagreb, Croatia
 Email: milan.stevanovic@fsb.hr