

# Models Used to Select Strategic Planning Experts for High Technology Productions

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**Abstract.** The article deals with the problems and specific aspects in organizing works of experts involved in assessment of companies that manufacture complex high-technology products. A model is presented that is intended for evaluating competences of experts in individual functional areas of expertise. Experts are selected to build a group on the basis of tables used to determine a competence level. An expert selection model based on fuzzy logic is proposed and additional requirements for the expert group composition can be taken into account, with regard to the needed quality and competence related preferences of decision-makers. A Web-based information system model is developed for the interaction between experts and decision-makers when carrying out online examinations.

## 1. Introduction

Modern enterprises manufacture a variety of complex high-technology and science - based products for different industries. Product design developing, production facilities setting, manufacture mastering and production supporting require significant work in the field of researches and development, as well as drawing up accompanying documents [1]. Decisions made in these fields are strategic, because they adjust the organization's direction in future and can have potential critical effects on company's activities. Mistakes made at this level can be fatal for the company. The process of making strategic decisions is always characterized by decision-making in the environment of uncertainty in the context of incomplete and unclear information [2]. In this connection, internal and external experts are invited to justify strategic decision-making [3]

The quality of assessment made by experts directly depends on the quality of selecting an expert group; and experts should have sufficient experience and knowledge in the field of the current trends in science and technology in their industry. Examinations by expert groups increase the objectivity and the accuracy of results, but there is a problem of how to determine an adequate number of experts in the group, as the excessive or insufficient number of consultants may have a negative impact on final outcomes [4]. Even the most competent experts in the examination can make a big difference of opinion within the group and this sometimes results in inadequate examination results [5]. In this regard, one of the objectives when organizing the process of making an examination is to assess the consistency of opinions across the expert group in order to eliminate possible deviations with due



consideration of opinions by experts, giving recommendations close to reality. For example, the work in [6] represents a model of coordinating experts based on the assessment of quality of several criteria which helps identify experts having opinions with the maximum deviation from the mean value over the group evaluation.

The more an expert has carried out examinations, the more data on his opinion deviating from the group opinion and / or the actual values of parameters evaluated is obtained to have the more accurate assessment of his competence in a given field of knowledge. So, the expert's knowledge and his experience as a universal parameter are very important in assessing the competence of the expert [7]. But different areas of expertise have their specific aspects, and it is needed to assess the expert's knowledge, practical skills and experience received from conducting examinations in particular and relevant disciplines. On the basis of these data, when preparing for the next examination, a person, making a decision, is able to choose the most experienced and competent experts in the required field. This is especially critical for high-tech enterprises, since decision-making is carried out across a number of function areas of its activity: innovation, marketing, production, research and others.

At the same time, for instance, assessments after reviewing the same function area at different enterprises can have its own characteristics associated with peculiarities of companies assessed, their business processes, leadership personalities and others. For this reason it is important to develop tools towards achieving a more balanced composition of expert groups with the consideration of specific interests of decision makers.

## 2. Determining the composition of a panel of experts on the basis of self-assessment

It is a common practice to create a group for strategic planning - a consultative and coordinating body attached to the company's administration and providing coordination of management actions, as well as all relevant units involved in the strategic planning of the company. The participation of external experts is very important in this group. [8]

A standard plan to form an expert commission includes such steps as determining the number of experts to involve, outlining functionary and professional requirements imposed on experts, determining the expert commission, determining the extend of competence for each expert. The evaluation of competence for each expert, in turn, can be carried out on the basis of self-assessment, mutual evaluation through peer review or on the basis of actual data resulted from previous examinations.

A expert group should be composed of experts in every of the functional areas of the enterprise. With this, it is logical to assume that opinions of experts with the relevant expertise in the field of work needed should be particularly taken into account. For example, when evaluating performance indicators relating to the human resource, experts should have knowledge of economics and labor sociology, employment and labor legislation, and mechanisms for regulating and proper functioning of the labor market, and they are expected to have experience in this field. At the same time, opinions of other members in the expert group, having insufficient competence in this area, can not be neglected, because the isolation of assessment of certain areas is not accepted, because every problem should be viewed in conjunction with the others. Thus, there is a need to determine the weight of relevance relating to experts in evaluating different performance parameters.

We suggest determining the minimum number of experts according to formula (1).

$$N = 0.5 \left( \frac{3}{\alpha} + 5 \right) \quad (1)$$

Where  $0 < \alpha \leq 1$  is the parameter that specifies a minimum error level of examination. Based on this condition, the minimum number of experts is equal to 4 (for  $\alpha = 1$ ).

For evaluating every expert, it is necessary to identify his level of competence for each set of performance indicators.

The basic requirements for an expert are usually as follows: the broad vision and knowledge of the subject area, a quantity of scientific papers written and the presence of practical experience, the ability

to meet challenges in a creative way, independence of thoughts and others. Thus, the task to identify the competence of experts is multi-criteria. The weighted sum model is the most popular multi-criteria method for evaluating a number of alternatives.

The following evaluation criteria and rating scores for alternatives are proposed to use:

1. Level of education: Secondary (1 point), vocational (2-4 points), higher (5-8 points), a scientific degree (9-10 points).

2. Consistency of education with the knowledge domain (namely a specific area of functioning) inconsistent (1 point), slight extent (2-4 points), some extent (5-8 points), consistent (9-10 points).

3. Experience in the knowledge domain: none (1 point), little (2-4 points), not very much (5-8 points), much (9-10 points).

4. Administrative and economic independence in this area: none (1 point), low (2-4 points), medium (5-8 points), high (9-10 points).

5. Ability to solve creative tasks and experience in assessments: none (1 point), low (2-4 points), medium (5-8 points), high (9-10 points).

The total evaluation score regarding the level of competence of the  $s$ -th expert according to the  $i$ -th function module is determined by the formula (2).

$$OK_{is} = \sum_j W_j O_{js} \tag{2}$$

Where  $OK_{is}$  is the evaluation of the competence level of the  $s$ -th expert according to the  $i$ -th function module,  $s = \overline{1, d}$   $i = \overline{1, n}$

$O_{js}$  is the evaluation of the expert according to the  $j$ -th criterion,  $j = \overline{1, m}$  ;

$W_j$  is the weight of criterion to evaluate the expert, provided  $\sum_j W_j = 1$  .

For the purpose of convenience, the obtained evaluations  $OK_{is}$  are suggested summarizing in the table Competence of Experts (Table 1).

Table 1

Function modules	Experts				max $OK_{is}$
	1	2	...	$d$	
Module 1	$OK_{11}$	$OK_{12}$	...	$OK_{1d}$	max $OK_{1s}$
Module 2	$OK_{21}$	$OK_{22}$	...	$OK_{2d}$	max $OK_{2s}$
...	...	...	...	...	...
Module $n$	$OK_{n1}$	$OK_{n2}$	...	$OK_{nd}$	max $OK_{ns}$

On intersections of rows and columns in this table there are the evaluations of the competence level of the  $s$ -th expert according to the  $i$ -th function module.

When making analyses, planning and forecasting future actions to develop a company, this table can be useful for:

1) Determining the most competent experts against particular function module parameters (in the case of an individual method of expert estimations). It will be the expert with the highest estimate for the  $i$ -th module (max  $OK_{is}$ );

2) Determining the weights of importance of experts in the case of the group expert examination. The weight of importance of the  $s$ -th expert according to the  $i$ -th function module is defined as:

$$W_{is} = \frac{O_{K_{is}}}{\sum_s O_{K_{is}}} \quad (3)$$

At the initial stage of system's operation, when statistically accumulated data is not enough, the self-assessment of experts is very important at this stage. This stage is based on the experience of experts in the field needed, supported by certificates and diplomas to confirm their relevant qualifications. Thus, after setting each expert in terms of rates, we get the table to show the competence of experts which can be used for selecting the most competent experts in each function module. An example to calculate the competence of experts considering self-assessment is given in Table 2.

Table 2

Competence of Experts for the Strategic Planning

Function Module	Experts							
	1	2	3	4	5	6	7	Most competent expert
Manufacturing Automation	0.135	0.182	0.138	0.096	0.147	0.149	0.153	No. 2
Engineering support	0.198	0.095	0.122	0.115	0.138	0.168	0.164	No.1
Ecology of production	0.129	0.131	0.156	0.198	0.122	0.139	0.125	No. 4
Manufacturing infrastructure	0.188	0.148	0.152	0.126	0.125	0.122	0.139	No. 1
Manufacturing	0.143	0.126	0.132	0.158	0.144	0.151	0.146	No. 4
Finance	0.144	0.159	0.168	0.193	0.124	0.125	0.087	No. 4
<b>Average</b>	<b>0.156</b>	<b>0.140</b>	<b>0.145</b>	<b>0.148</b>	<b>0.133</b>	<b>0.142</b>	<b>0.136</b>	No. 4

### 3. Expert selection on the base of decision maker judgments

The decision on recruiting and levels of professional and psychological qualities, which experts are required to have, is made depending on complexity and specific features of a problem under research, and further potential use of results. In most cases, a medium level of professionalism is required that is sufficient for understanding tasks and struggling against conformism, with the ability to establish constructive communication with other group members and stakeholders. When reviews are made in non-industrial sectors and their results do not have a direct effect on manufacturing processes, a level of professionalism expected from candidates is lower objectively.

A decision maker can often have additional requirements as to the composition of an expert team, expert's quality and competence levels. In this case, the decision maker may express his preferences by making up a set of attribute-based suggestions and comments. In this regard, the task is to develop models that take into account the set of special requirements and select the most compliant candidates under these requirements.

The tables with the resulting qualification of competence based on self-assessment can be used to form a rating list of candidates that is used for the final selection according to the additional requirements. A fuzzy model is proposed for the selection of expert candidates based on decision

maker’s judgments. Fuzzy models allow decision-makers to take into account the attribute-based suggestions in regard to required qualities and competence levels of experts [9-11].

To facilitate the selection of expert candidates for projects we use the multi-criteria method of evaluating alternatives.

To evaluate expert candidates we developed the following fuzzy rules:

$d_1$ : «If a candidate is an experienced researcher having a certain work record and experience as an expert in an economy and engineering related field, then he is suitable (meets the requirements)»;

$d_2$ : “If in addition to the above requirements he has intuition, then he is more than suitable”;

$d_3$ : “If in addition to the conditions of  $d_2$  he is able to find a customer of INP, then he is perfect”;

$d_4$ : “If he has all specified in  $d_3$ , except for intuition, then he is a highly suitable”;

$d_5$ : “If the candidate is a highly experienced researcher and a good expert able to find a customer, but does not have a work record, then he is still suitable”;

$d_6$ : “If he does not have a qualification as a researcher or a proven expertise to conduct relevant works, then he is not suitable”.

Analyzing six modules of information gives five criteria used in the decision making process:  $X_1$  – researching capacities;  $X_2$  – a work record;  $X_3$ – work experience as an expert;  $X_4$  – the possession of intuition;  $X_5$  – the ability to find a customer. Linguistic variables are created for the all criteria [12]. A variable  $Y$  “suitability” is also linguistic and is defined in the set  $J = \{0;0.1;0.2;...;1\}$

Suitability is defined as  $\mu_s(x) = x, x \in J$ ,

More than suitable as  $\mu_{ms}(x) = \sqrt{x}, x \in J$ ,

Perfect as  $\mu_p(x) = \begin{cases} 1, & \text{если } x = 1; \\ 0, & \text{если } x \neq 1. \end{cases}$

Highly suitable as  $\mu_{vs}(x) = x^2, x \in J$ ;

Not suitable as  $\mu_{us}(x) = 1 - x, x \in J$ ;

In the selection process, the suitability can be found for each of the above according to the compositional rule [13] of interference, and the corresponding point estimate is calculated.

The selection is made among five candidates who received the highest average estimate on competence based on self-assessment results (according to Table 2). Evaluations of experts on the criteria are given in Table. 3.

Table 3

Inputs for the Expert Candidate Selection

Alternatives	Criteria -based evaluation									
	$\mu$	Qualified researcher	$\mu$	Work record	$\mu$	Expert Capacity	$\mu$	Intuition	$\mu$	Ability to find a customer
Candidate No.1	0.8	Qualified	0.5	Medium	0.6	Average	1.0	High	0.0	None
Candidate No.2	0.6	Satisfactory	1.0	Long	0.9	Very high	0.3	Низкая	0.5	Average
Candidate No.3	0.5	Medium	0.0	None	1.0	Excellent	1.0	High	1.0	Very high
Candidate No.4	0.1	Bad	0.5	Average	0.7	High	0.0	None	0.8	High
Candidate No.5	0.3	Lower than average	1.0	Long	1.0	Excellent	0.0	None	0.1	Low

When selecting an expert, the variable “suitability” is determined for each of the rules and the corresponding point estimate is calculated according to the compositional rule of interference. The outputs using the fuzzy inference system are shown in Table 4 and it can be used complementarily by a company’s director to verify the right selection of the expert.

Table 4

Outputs using Fuzzy Interference System

Rule (Output)	Alternatives				
	No.1	No.2	No.3	No.4	No.5
Rule No.1 (Suitable)	0.5	0.6	0	0.1	0.3
Rule No.2 (More than suitable)	0.5	0.3	0	0	0
Rule No.3 (Perfect)	0	0.3	0	0	0
Rule No.4 (Highly suitable)	0	0.5	0	0.1	0.1
Rule No.5 (Less suitable)	0	0	0	0.01	0
Rule No.6 (Not suitable)	0.4	0.4	0.5	0.9	0.7
<b>Point estimate</b>	0.553	0.554	0.425	0.298	0.391

Thus, the suitability point estimate for the alternative  $\mu_1$  is 0.553, for  $\mu_2$  is 0.554, for  $\mu_3$  is 0.425, for  $\mu_4$  is 0.298, for  $\mu_5$  is 0.391. The alternative  $\mu_2$  is selected as the best suitable, i.e. decision makers preferred a candidate with the long work record (the degree of preference is 1) and a high expert capacity (the degree of preference is 0.9); while the capacity for researches and the possession of intuition as criteria shows a lesser degree of preference (0.6 and 0.3 respectively). This can be explained by the fact that a capacity for researches is strengthened during the theoretical work and a level of intuition can be obtained with increasing the work record. This decision-making method using the fuzzy inference system is an adaptation of fuzzy logic to the decision-making processes with inputs in the form of point estimates.

#### 4. Structure of informational support for the evaluation and selection of experts

Most expert assessments and reviews can be carried out by experts working remotely via the Internet that allows the reduction of travel expenses and accommodation for experts. It is therefore important to develop a system that helps organize the work of experts on-line for both remote examinations and direct cooperation of expert groups on the ground of enterprises. Web-based systems will make possible to unify the process of assessment and involve experts in different fields of knowledge, as well as to provide easier access to reports for decision-makers. Crowd sourcing is now actively developing and changing, enabling you to obtain service needed for solving many tasks. [14]

Figure 1 shows the interaction of key roles in the system. A decision maker specifies requirements for an expert relating to the examination and assessment process on the server and views the most competent expert candidates to be selected for a job in the expert group. The experts, in turn, interact with each other, with self-assessing and assessing their colleagues in the process of examination, and carrying out the tasks assigned, and the results obtained after such interactions are stored on the server and can be reported to the decision maker. The most competent experts can be selected with regard to the results in three basic components: self-assessment, peer assessment and assessment of the expert compiled on the basis of examinations and reviews he has taken part in. Already after the first expert assessment, the server will store statistical data and select the most competent experts in the relevant field according to a particular algorithm. The decision maker also can decide independently what kind of data should be taken into consideration for selecting the most competent experts to build a team. This can also be an average reading over all three components: self-assessment, peer assessment and the data on the basis of the jobs completed. In turn, the decision maker can trust the algorithm to select

the most competent experts, or to amend a composition of the expert team on account of personal preferences. It is up to the person in charge to have a final word in the selection of experts.

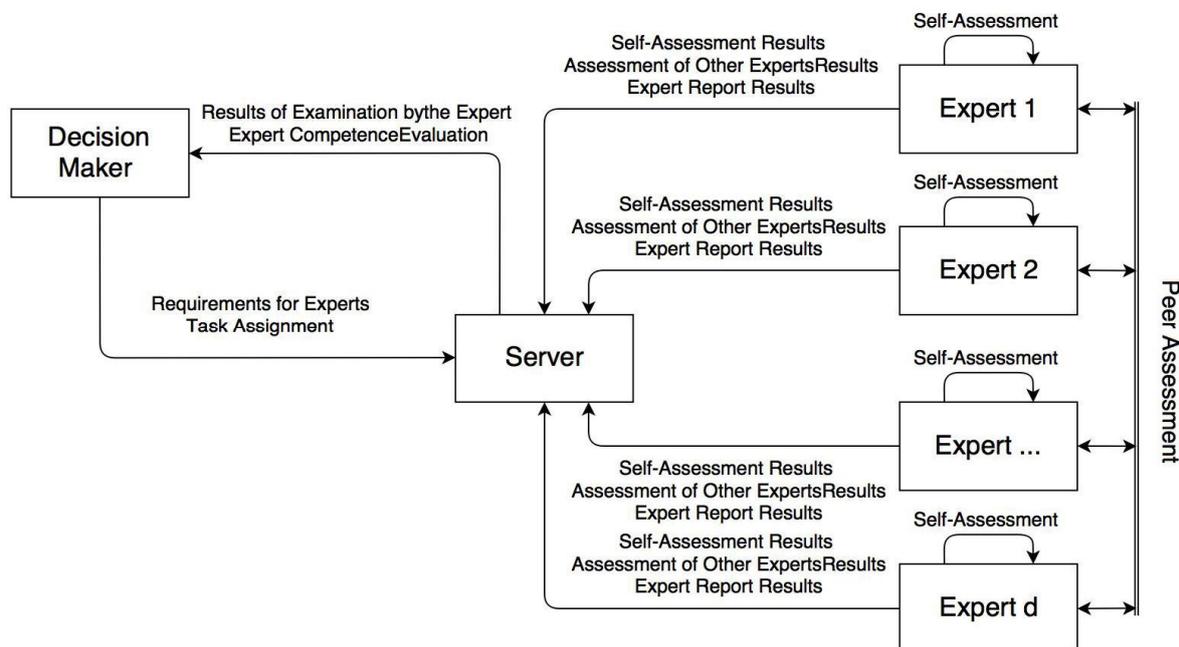


Figure 1. Web-based communications model for interaction between experts and decision makers

## Conclusion

The process of reviewing with the purpose to assess high-technology enterprises requires the involvement of internal and external experts, the selection of experts for such a job is a complicated and important task. The proposed in this article model is used for the selection of experts based on determined table – driven competence levels and enables stakeholders to build up a group of experts according to the selected competence-related criteria in specific functional areas of expertise. The results of self-assessment, peer assessment or assessment on earlier examinations made by experts can be summarized in the competence tables. The expert group formed on the basis of the competence tables can be approved a decision maker without any changes. In case of additional requirements of the decision maker for the composition or competence levels of experts, the fuzzy model serves the purpose to select experts on the basis of decision maker judgments. This model allows us to take into account qualitative preferences of decision-makers relative to their needs and interests.

With a view to provide the online examinations by experts, it is relevant to develop a Web-based information system. The information system enables decision-makers to form a group of experts with the highest competence levels within the needed areas of expertise. The stored database of expert candidates with their profiles and examination records are used to determine the competence levels of expert candidates over the three analytical components: self-assessment, peer assessment and expert evaluation on the basis of their examination record.

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