

SELECTION OF A FORECASTING METHOD: ANALYTICAL HIERARCHY PROCESS APPROACH

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Abstract: *Describing the future development of an organizational environment is crucial for the goal setting and strategy selection of an organization. In today's rapidly changing times it is not easy to predict how the internal and external surroundings of a company will change. Predicting the future development of an organization is not an easy task for managers but they must adopt it to succeed in market competition. Specifically managers must be familiar with forecasting methods which can help to predict the uncertain developments of the environment. There are many forecasting methods which are available, differing in their time requirements, financial demands, and in predictive accuracy. The goal of this paper is to characterize the most commonly used methods and to select the most appropriate one from the point of view of small and medium sized enterprises. These companies are usually limited in the finances that they can spend for strategy setting. They also do not employ a large number of experts, who can apply these methods. In this paper, a suitable forecasting method will be chosen by utilizing the Analytical Hierarchy Process (AHP) approach.*

Keywords: *Forecasting, Strategic management, Strategic planning, Forecasting methods, AHP method.*

JEL Classification: *C38, L10.*

Introduction

The existence of an organization and its success is influenced by outlined goals. Strategies are usually formulated based on objectives. An organization, after it determines the direction of its development, regularly faces complex decision-making problems. The definition of strategy implies that it tries to define the direction that an organization will take in the long term with respect to the environment and market conditions. Fulfillment of this requirement is difficult for several reasons. Environment is in some areas very variable, especially with regard to technological, legal and social influences. For example, due to technological progress, some sectors are completely suppressed and it is not promising to further invest. On the other hand, new demand is created by market [5, 13].

For the future development of external and internal environment, forecasting is used. There are several methods, which can be applied for forecasting. We distinguish between judgmental or statistical methods and each of these is different in financial and time demands. This paper presents an overview of forecasting methods with a brief description of their utilization and barriers of application. Application of the analytic hierarchy process (AHP) is proposed for the selection of an appropriate method for the small and medium sized company.

Paper is structured as follows. In the first part, forecasting and its methods are described, including the impact of a particular method and its properties. In the second part, selection of appropriate method for forecasting is proposed. For this selection the AHP method is applied.

1 Forecasting

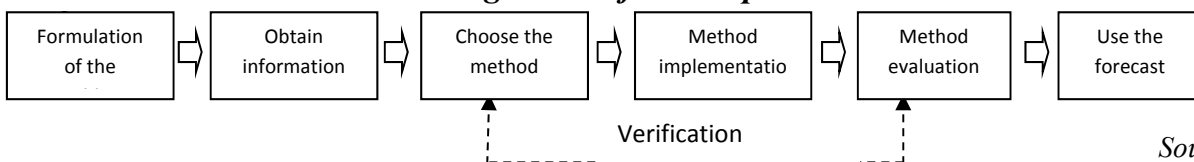
A scientific estimate of future events is called forecasting. Forecasting helps managers to assess factors affecting the future evolution of the environment of the organization. It is necessary to use a formal approach if the decision problems of the organization are complex. Formalization of procedures in the form of methods or techniques helps primarily to remove uncertainty. Forecasting is often reduced to statistical or econometric models [6] but its content is undoubtedly wider. Forecasting methods are used during strategic management, especially in the first part, which is strategic analysis. We analyze the environment of the company in order to be able to formulate the strategic goals and then organization's strategy.

Strategic goals should be simple, consistent, and long-term [3]. Long-term goals have an impact on strategic decision-making and they are formulated in changing conditions at a particular level of information uncertainty. It is essential to ensure concentrating on the long term period. The objectives with respect to basic principles must rely on a thorough understanding of the current status and future status projection. The strategy formulation must be based on the available resources of the organization. According to the possibilities of the organization, it is consequently decided on the investments that will achieve the objectives.

Forecasting is primarily used to support strategic decisions [5]. These decisions have an impact on the long-term management of the company. Strategic decisions will concentrate mainly on defining the extension or reduction boundaries of business, the impact on the values and expectations of the market, and whether are socio-demographic trends respected. The forecast usually expresses development as the tendency, trend or an ongoing process, change (as the cause of development) as the events of the phenomenon [2, 14]. The first step in creating forecasts should be identifying the problem. The second step is the solution via a strategic conception. The third step is predicting the future by some of the methods [1].

The process of finding an appropriate goal for business or non-business entities is challenging – see Fig. 1. In order to determine the long-term objectives, forecasting methods are frequently used. There are numerous kinds. They vary according to the time horizon, business, environment, technology used, etc.

Fig. 1: The forecast process



Source: [1]

The basic distribution of forecasts is based on the time horizon. To common resolution of short, medium and long-term forecasts; some authors have also added even extremely long period [14]. The authors differ in the length of time - short-term forecasts are usually in the range of 1-2 years, medium-term of 3-6 years, long-term of 7-15 years and extremely long term over 15 years (Tab. 1).

In terms of approach to forecasting, we distinguish the explorative (research) approach (where alternatives are searched trends) from the normative approach (where alternatives to given goals are found) [2, 14].

Tab. 1: Distribution of forecast methods depending on time horizon

The vertical division of forecasts (according to the degree of aggregation)	Horizontal division of forecasts (according to the time horizon)	Classification according to approach to forecasting	
The National Economics	Short term	Explorative (research)	Active
Industry	Medium term		Passive
Branch	Long term	Normative	
Company	Extreme long term		

Source: [14]

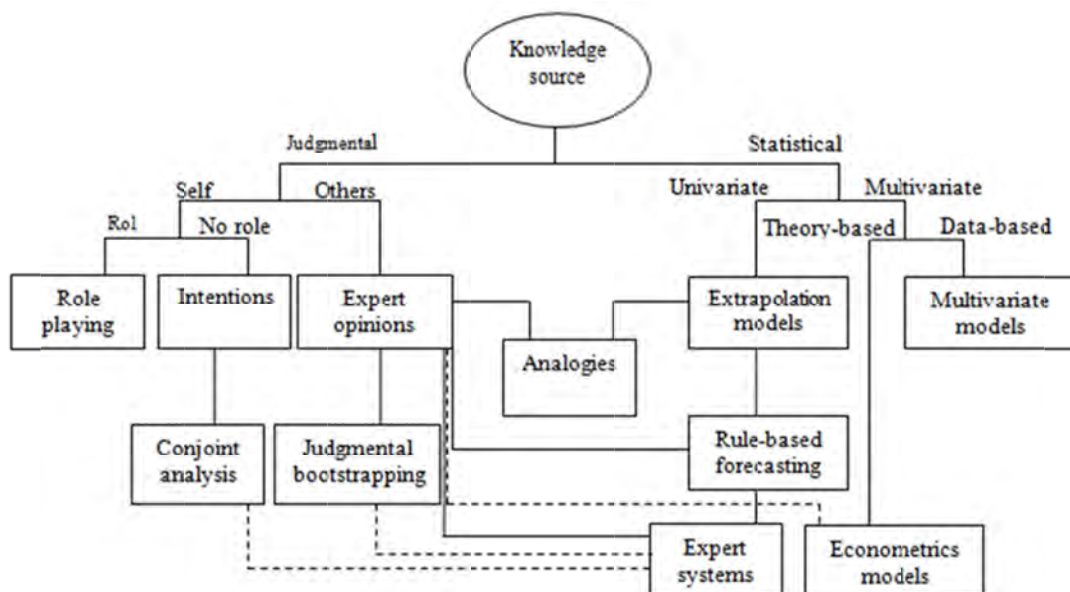
2 Selection and characterization of forecasting methods

In this section, the breakdown of the methods is done and particular methods are characterized.

2.1 Selection of methods

As already mentioned in the introduction, there are a number of forecasting methods. Armstrong [1] in his fundamental literature distinguishes two groups: judgmental and statistical methods. See the Fig. 2.

Fig. 2: Breakdown of forecasting methods by Armstrong



Source: [1]

Among judgmental methods belongs, according to Armstrong [1], role playing, expert opinions, conjoint analysis, judgmental bootstrapping etc. Among statistical methods are extrapolation models, econometric models, expert systems, multivariate models, etc. The analogy method is assigned to both groups. Although, as described above, the analogy method should be included more in the group of the judgmental methods. Some of these methods do not appear in Czech literature or they are given only minimal attention. These include role playing, conjoint analysis, and judgmental bootstrapping. Furthermore, methods such as the scenario method, Delphi, the morphological method or causal layered analyses, which are sometimes applied for forecasting, are not included in the Fig. 2.

2.2 Characteristics of selected methods

For further evaluation these forecasting methods were selected: Delphi, the analogy method, the scenario method, conjoint analysis, extrapolation models, the morphological method, econometrics and mathematical models (multivariate models). Brief characteristics of selected methods are given with regard to the necessary criteria (see Tab. 2).

Delphi technique is used to build long-term and extremely long-term forecasts (7 years or more). It uses a structured group of experts who support their forecast by arguments. During an anonymous questioning of experts, opinions should be converged but it can achieve more than one solution. Using this method is appropriate in a technical area as well as in a technological, social and multidisciplinary area. It is expensive and time-consuming [11, 1].

Analogy method is based on using the similarity of elements, features and structures. It finds and applies personal, symbolic and surreal similarity. For the use of analogy, a team is assembled that is usually led by an expert on the application of this method. The team is usually set up for a longer period of time. The method is expensive. It is used to determine the normative objectives [1, 8].

Scenario method uses systematic thinking about the future. With the participation of experts in the branch, it creates a passive prediction. It is used in the fields of technology and economics. It is not expensive, but it is time-consuming [13, 7].

Conjoint analysis is used to determine what combination of characteristics has the greatest influence on the decisions of the respondents. It is mainly used for short-term or medium-term forecasts, which are to create a model of market. It is expensive and time-consuming [4].

The extrapolation models use data about trends primarily in the technology field. Experts using this method extrapolate projections of possible future development. This model belongs to the less demanding methods of time and resources but it is necessary to have a thorough knowledge of the industry in terms of historical context [1, 13].

Morphological technique involves the process of analyzing the forms and structures of the product. Experts carry out the analytical study of various parameters (constants) of the product - the appearance, the materials and function. The result is a normative identification of new alternatives. It is mainly used in the field of technology. It is moderately expensive and time consuming and requires the participation of experts from the industry [10].

Econometrics (statistical, quantitative) methods such as analysis of trends and cycles, time series analysis, statistical trend test, correlation analysis, mathematical extrapolation based on the assumption that the future will match the previous development. The advantage of these methods is that they are usually less time and finance consuming. The disadvantage is that they fail to respond flexibly to changes in the environment. Armstrong shows that econometric models are more accurate than other methods for long-range forecasts. Evidence also suggests that the principles described for econometric methods can improve short-term forecasts [1, 6].

Mathematical models enable the expression of interdependences among many independent variables. Relationships between dependent and independent variables are examined by using multiple regressions. Subsequently, an obtained equation for forecasting future developments is obtained on the basis of the previous development. The method is

time consuming, but financially affordable [1, 6]. For our analysis the econometrics and mathematical models were put together.

3 The selection of appropriate method

Selection of a suitable method for predicting strategic goals should be based on needs, opportunities, and specific conditions of the organization. The criterion for the choice of method will surely be time horizon: short term (S), medium (M), long (L) or extremely long (EL). Further priority may be given to judgmental (J) or quantitative (Q) method. The crucial benefit is the possibility of using experts, and whether the aim of the strategy is explorative (E) or is known and identified normatively (N). Other criteria for selection can be time and financial disposition. The most demanding (+++) methods can be selected when sufficient time and financial resources are available. In contrast, the restrictive policy of the company will prioritize cost-saving (+) methods. See Tab. 2 for evaluation of selected methods.

Forecast will never be perfectly accurate, as it is always encumbered by certain error. Prediction accuracy decreases significantly with the length of time and with the speed of environmental variability.

Tab. 2: Evaluation of selected methods

Method/ criterion	Judgmental/ quantitative (J/Q)	Participation of experts Yes/No	Normative/ Explorative N/E	Time horizon	Finance /time demand
Delphi	J	Y	E	EL, L	+++/>+++
Analogy	J	Y	N	M	++/>+
Scenario method	J	Y	E	S, M	+/>++
Conjoint analysis	J	Y	N	S, M	+++/>+++
Extrapolation model	Q	Y	E	S, M	+/>+
Morphological method	Q	Y	N	M, L	++/>++
Econometrics and mathema- tical models	Q	N	E	S,M, L	+/>++

Source: own elaboration

SME seem to have certain specifics that must be respected. Conducted research shows (Baurová, Janečko, Papalová, 2013) that managers in SME realize the importance of managerial thinking in the long term period. The research also shows trend that the larger the organization is, the greater weight is given to forecasting of environmental future. Czech specific includes frequent change in the legislative. This also causes that the period in which SME plans, is shorter. Other specific is the lack of funds that the company is able to and is willing to invest in the forecasting process. Also, the possibility of participation of experts is limited. None of the researched organization uses the service of external consulting organizations to set their strategic plan. As these organizations stated the reason is fear of possible misuse of sensitive information, and also high cost of this service.

The most frequent reason for the long term foresight is the rapid growth of the organization and thus the need to systematically predict and plan. SME usually do not need their forecasts longer than in medium time horizon. Some organizations were led to the need for the long term foresight by the economic crisis in 2008-2010.

4 Using AHP method for decision making

AHP is a method of multi-criteria decision making, developed by Thomas L. Saaty and is designed to solve complex decisions [12]. It is based on mathematical techniques and human psychology. The AHP is a systematic procedure for representing the elements of any problem, hierarchically. It organizes the basic rationality by breaking down a problem into its smaller and smaller constituent parts and then guides decision makers through a series of pairwise comparison judgments to express the relative strengths or intensity of impact of the elements in the hierarchy. The AHP includes procedures and principles used to synthesize the many judgments to derive priorities among criteria and subsequently for alternative solutions. Therefore, it is possible and appropriate to use it in this case.

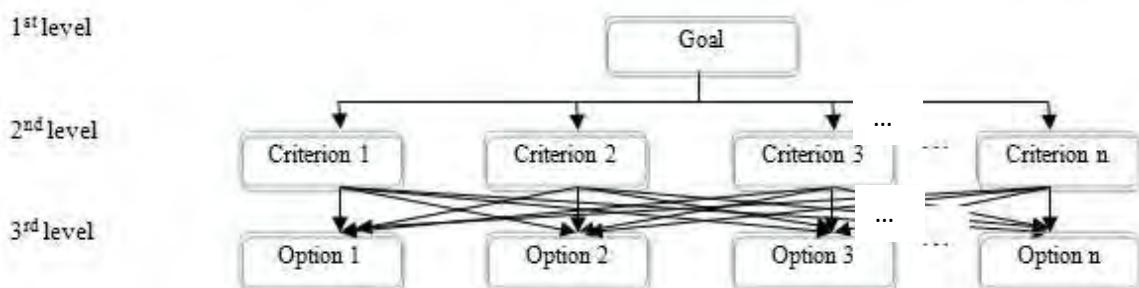
4.1 Description of AHP method

The hierarchy represents a complex problem in a multilevel structure. In the first level, there is the goal followed by criteria and sub-criteria. It can decompose a complex problem in search of cause-effect explanations into steps which form a linear chain [9].

Users of AHP firstly decompose their decision problem into a hierarchy of more easily understood sub-problems, each of which can be analyzed independently. The elements of the hierarchy can be related to any aspect of the decision problem. They could be tangible or intangible carefully measured or just roughly estimated.

Once the hierarchy is drawn, the decision makers systematically evaluate its elements by comparing them one to another with respect to their impact on the element above in the hierarchy. The AHP then converts these evaluations to numerical values, which can be processed and compared over the entire range of the initial problem. A numerical weight or priority, which is derived for each element of the hierarchy, allows that often incommensurable elements can be compared to one another in a rational and consistent way. Process of the drafting of the hierarchy does not perform only to identify all the relevant elements but also to identify the links between them. It is shown in Fig. 3.

Fig. 3: Hierarchy on three levels



Source: [12]

In the second step, the weights are set for each criteria and sub-criteria with regard to the object of decision. Method of pairwise comparisons will be used to determine these weights. For the correctness of the overall decision-making process, it is necessary to express the

weight of individual criteria. To calculate the weights of the criteria, it is necessary to build Saaty's matrix (1) of size $n \cdot n$, where c_i ($i = 1, 2, \dots, n$) are the individual criteria.

$$\begin{array}{c|cccc}
 & c_1 & c_2 & c_3 \cdots & c_n \\
 c_1 & 1 & s_{12} & s_{13} \cdots & s_{1n} \\
 c_2 & 1/s_{12} & 1 & s_{22} \cdots & s_{2n} \\
 c_3 & 1/s_{13} & 1/s_{23} & 1 \cdots & s_{3n} \\
 c_n & 1/s_{1n} & 1/s_{2n} & 1/s_{3n} \cdots & 1
 \end{array} \quad (1)$$

Certain rules are applied in the matrix. It is reciprocal, it means $s_{i,j} = 1/s_{j,i}$. The elements on the diagonal of the matrix are always equal to the value of 1. Elements of Saaty's matrix are interpreted as estimates of the proportion of weights i^{th} and j^{th} criteria:

$$s_{ij} \approx \frac{w_i}{w_j}, \quad (2)$$

$i, j = 1, \dots, n$, w_i is the weight of the i^{th} criteria and w_j is the weight of the j^{th} criteria.

For the matrix compilation are individual criteria pairwise compared. Dominance of individual criteria can be expressed by a number in the range of values [1/9; 9]. To express the size of preference, it is recommended to apply a point scale (Tab. 3).

Tab. 3: Scale of marks for rating criteria

Points	Description
1	equal importance
3	moderate importance of one over another
5	essential or strong importance
7	demonstrated importance
9	extreme importance
2,4,6,8	Intermediate values between the two adjacent judgments

Source: [12]

4.2 The calculation of the individual criteria

The weights (w_j) can be obtained via quadratic programming or logarithmic version quadratic programming. One of the simplified methods that are well resolved in practice is a method of determining the standard of weights (w_j) using the weighted geometric mean of the matrix's lines [12]:

$$w_i = \frac{\left[\prod_{j=1}^n s_{ij} \right]^{\frac{1}{n}}}{\sum_{i=1}^n \left[\prod_{j=1}^n s_{ij} \right]^{\frac{1}{n}}}, \quad (3)$$

where $i = 1, \dots, n$.

In the third step, it is necessary to check the consistency coefficient of the Saaty's matrix. The sign of relevant evaluation is that the matrix is consistent, meaning the elements fulfill the condition of transitivity. The consistency can be evaluated by the coefficient of consistency CR (4), where the consistency value is considered $CR \leq 0.1$. Saaty defined the consistency ratio as follows,

$$CR = \frac{CI}{RI}, \quad (4)$$

where CI is the consistency index and is expressed as

$$CI = \frac{\lambda_{\max} - n}{n - 1}, \quad (5)$$

where n is number of criteria (number of rows of the matrix) and λ_{\max} is characteristic number of matrix - the eigen value and is calculated according to

$$\lambda_{\max} = \sum_{i=1}^n \frac{(\mathbf{S} \cdot \vec{w})_i}{n \cdot w_i}, \quad (6)$$

where \vec{w} is vector and $(\mathbf{S} \cdot \vec{w})_i$ is i^{th} element of vector. RI is an index of randomness (random index) and assumes values in dependence on the number of selected criteria, respectively variants, and is derived from empirical research (Tab. 4).

Tab. 4: RI values for different number of elements

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: [12]

If the value of CR is ≤ 0.1 , then Saaty's matrix of pairwise comparisons can be considered sufficiently consistent and it's possible to continue calculating the weights of individual criteria.

The calculated weights of sub-criteria are not final. In order to proceed to the actual assessment of the options the weights must be on the ends of the branches of the hierarchical tree and they must be multiplied by the weight of the parent criteria. Then the determination of the weights is final and can be used in decision making.

4.3 Selection of the optimal alternative

In decision-making methods with partial criteria preferences we assume that it is possible to determine these partial preferences of criteria and also evaluate them. The most used method is weighted sum approach.

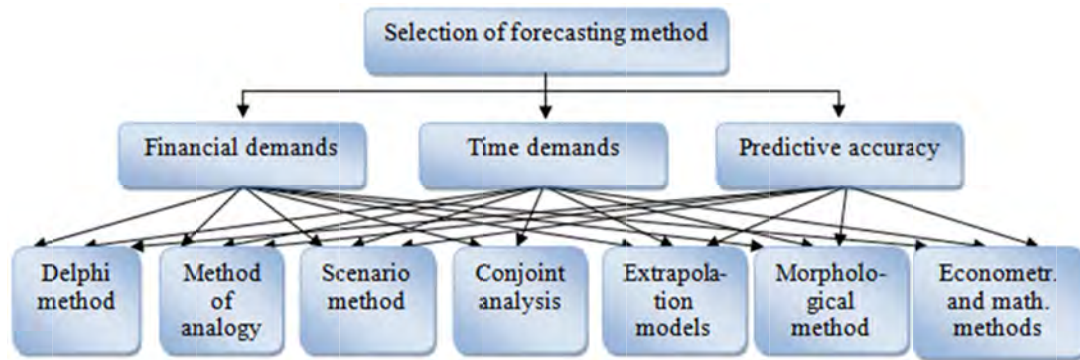
$$U_i = \sum_{j=1}^n w_j \cdot x_{i,j}, \quad (7)$$

where w_j is the normalized weight of j^{th} criteria and $x_{i,j}$ is normalized evaluation of i^{th} variant due to j^{th} criterion.

5 Application of AHP in the selection of forecasting methods

With respect to the characteristics of SME, three criteria were determined that may significantly affect the enterprise's managers in the selection of forecasting methods. They are financial demands, time demands (these two should be small) and the predictive accuracy (this should be high). Financial requirements and time requirements can be seen in Tab 2. To determine the accuracy of the predictions is the most difficult task in this evaluation. Although it is not reported in the table, mainly due to the extensiveness of the comments, we use in the processing the same sources as those used for the determination of other characteristics [1, 2, 4, 7, 10, 11]. Schematic illustration of the situation, including the linkages is shown in Fig. 4.

Fig. 4: Schematic presentation of selecting the method of forecasting using AHP



Source: own elaboration

Solving procedure was as follows. First, the weights of individual criteria using the AHP method were computed. Pairwise comparisons were performed for each criterion. It was found that the weight of financial demand is 20%, weight of time demand is 31% and weight of predictive accuracy is 49%. As was noted the determination of the prediction accuracy of the method is very difficult. For certain methods the accuracy increases with the amount of time and money needed to get information of various kinds, the involvement of experts or security of information and software systems. This discourages managers of SME from using methods of forecasting and strategic planning application.

On the basis of available resources pairwise comparisons of methods, in respect to all criteria, were conducted by authors. Computations were made in MS Excel. In the paper are included only the results, however all the computations are available upon an email request to the authors. Time and financial demands are quantitative variable, so pairwise comparisons were made on that base. Predictive accuracy is not a quantitative variable that could be assessed on the basis of cost or time and it could be loaded with subjective view. In order to prevent this, it was used the group decision making. Each decision-maker had the same weight and results for the calculation of the final weights were taken as the average.

Now follows the selection of the optimal alternative, it means, and selection of the best forecasting method. A comparison of the individual methods has been done with respect to each of the three determined criteria. The requirement of matrix consistency was fulfilled in all cases. In Tab. 5, we can see the results of the pairwise comparison of the alternatives. In perspective of financial demands (first row), we can see, that scenario method, extrapolation models and econometrics and mathematical methods are the less financial demanded. In term of time demand (second row) we can say that extrapolation models, analogy and scenario method is less time demanded. From the view of predictive accuracy we can see that scenario method, analogy and econometrics and mathematical methods were evaluated as the best.

Selection of optimal alternative is done using (7). Results are in Tab. 6. In the first to the third row, there are partial results due to the each of the criterion but in the result it is taken into consideration the weight of each criterion (rows from Tab. 5 are multiplied by parent criterion). The last row is the sum of partial results.

Tab. 5: Pairwise comparison of alternatives

Delphi	Analogy	Scenario method	Conjoint analysis	Extrapol. models	Morphol. method	Econom. and math. methods	Total
0.041	0.096	0.242	0.041	0.242	0.096	0.242	1.000
0.044	0.215	0.189	0.041	0.238	0.090	0.183	1.000
0.110	0.189	0.350	0.031	0.063	0.095	0.161	1.000

Source: own elaboration

Tab. 6: Selection of optimal alternative

Delphi	Analogy	Scenario method	Conjoint analysis	Extrapol. Models	Morphol. method	Econom. and math. methods	Total
0,008	0,019	0,047	0,008	0,047	0,019	0,047	1.000
0,014	0,067	0,059	0,013	0,074	0,028	0,057	
0,054	0,093	0,173	0,016	0,031	0,047	0,080	
0,076	0,179	0,279	0,036	0,153	0,094	0,184	

Source: own elaboration

6 Discussion

As it is obvious from Tab. 6, the best forecasting methods that could be used for SME are based on the scenario method, which reached the score 27.88%. In the same analysis, the econometric and mathematical methods reached a score of 18.39% and the method of analogy reached a score of 17.88%. All these methods are useful in predicting the medium horizon, which for small and medium-sized enterprise is also satisfactory. The disadvantage may be that the methods of scenarios and analogies often need the attendance of experts. Econometric and also mathematical models require these experts, who can work with data; however, as to the methods of small or medium financial and time constraints, they may be acceptable for a small or medium company.

Conclusion

Forecasting helps managers assess the factors affecting the future evolution of the environment, and thus the organization. This activity can help improve the strategic planning of the company. The AHP method is a method of multi-criteria decision making, which facilitates decision-making by organizing perceptions, feelings, judgments and memories of the decision maker in a framework that shows a preference that affects the decision. It is therefore possible to use it for the selection of appropriate methods of forecasting. Criteria that most influence the choice of a particular method are predictive accuracy, time demands and financial demands. These criteria and various methods of forecasting, as possible alternatives, were assessed by utilizing the AHP method. This can serve as a guide for managers in selecting the best method. Whatever method is chosen as appropriate for the organization, the result will be subject to a certain error. Forecasting accuracy decreases depending on the length of a period and is influenced by variability of the environment. Although the method accuracy is essential for the selection criterion, it is the most difficult to determine.

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