APPLICATION OF THE ORDERED WEIGHTED AVERAGING (OWA) AND TOPSIS METHOD IN COMPETENCY MODELLING

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Abstract

Presently competency models are widely used by companies for several human resources activities. If the competency model is well designed, it can be used by the companies' management and human resource management for various activities, such as hiring, compensation, rewards, training and development and others. What differentiates effective employees from less effective employees? If developing managerial skills is so crucial for organizational success, what skills have to be the focus of our attention? Competencies have to lead to effective performance, which means that the performance of a person with competency must be significantly better than that of a person without it. Competencies are components of a job, which are reflected in behavior that is observable in a workplace. The question is how we can find the key competencies of a high performer. The goal of this paper is to present a case study of finding key competencies for a specific position in an automotive production company and providing a framework how the ordered weighting averaging (OWA) method and TOPSIS method can be used for various HR activities, i.e. employees' selection, compensation, rewards etc.

Key words: competency model, human resources, OWA, TOPSIS

JEL Code: C49, M12, M51

Introduction

In all organizations there are many and various resources that affect the organizational performance. Organizations of all sizes must manage four types of assets: physical, financial, intangible and human. All of these assets play a crucial part in varying degrees in different organizations. However, the human assets are the "glue" that holds all the other assets together. Human capital is the collective value of the capabilities, knowledge, skills, life experiences, and motivation of an organizational workforce. Overall, HR should be involved in implementing strategies that affect and are influenced by people. (Mathis, Jackson, 2012).

1 Competency modelling

Competence, a term, which has been first used in Great Britain as a basic part of the process for creating standards for the State Scottish System of Technical Qualification. Competence can be defined as "functional analysis", which determines what people in a specific roles have to be able to do and what work standards are expected of them. (Bartoňková, 2010). Boyatzis (2009) defines competency as a capability or ability. According to Veteška and Tureckiová (2008), the term competence can be defined also as a unique human ability to successfully act and further develop his/her potential on the basis of integrated set of own sources, that is in the specific context of various tasks and life situations connected with the possibility and willingness (motivation) to decide and take the responsibility for own decisions. Page and Wilson (1994) defined competencies as the skills, abilities, personal characteristics required by and "effective" or "good" manager. Vazirani (2010) states that competencies can be divided to observable and testable competencies such as knowledge and skills, and less accessible competencies related to personal characteristics or personal competencies. Forrest and Peterson (2006) state that competencies can be classified by several ways, i.e. there is an American concept that is aimed at individual characteristics of the job bearer, i.e. personal characteristics, or behavioral characteristics; British concept which is aimed especially at the outcomes deriving from the working position, i.e. determined competencies have to be compliant with the defined professional standards. Competence can be divided to "soft" and "hard" skills. Hard skills can usually include technical knowledge, skills, abilities, talent and attitude, which pertain to the technological, financial, economic and procedural aspects of work. On the other hand, soft skills include the area of behavior and ability to deal with people that includes everything pertaining to the work with people, that influence communication and dealing with individuals and groups. (Prokopenko, Kubr et al., 1996).

2 Applied methods

Quantitative research will be executed through semi-structured interviews. For creation of competency models analytic hierarchy process (AHP) method has been used (see Kashi, Friedrich 2013). Also the the MCDM methods can be used for various decision making problems, see e.g. Minarčíková (2015), Franek, Kresta (2014), Michnik (2013), Zmeškal, Dluhošová (2015), Kashi, Franek (2014a, 2014b). OWA method was used to evaluate group of five employees (managers) according to the competency model and performance in particular competencies.

2.1 OWA method

One of the main objectives set by fuzzy theory was to develop a tool to model multiple attribute decision making (MADM) problems using linguistic variables. In this framework, the criteria are represented as fuzzy subsets over the space of decision alternatives and fuzzy set operators are used to aggregate the individual criteria to form overall decision function. It implicitly implies a requirement that all criteria must be satisfied by a solution to the problem. As Yager (1993) pointed out this condition may not always be appropriate relationship between the criteria. For example, a decision maker may be content if most of the criteria are satisfied. Yager (1988) suggested use of ordered weighted averaging operators as a tool to implement these aggregations. OWA is a class of multi-criteria operators (Yager, 1988). It involves two sets of weights: criterion importance weights and order weights. An importance weight is assigned to a given criterion (attribute) for all locations in a study area to indicate its relative importance (according to the decision-maker's preferences) in the set of criteria under consideration. The order weights are associated with the criterion values on a location-by-location (object-by-object) basis. They are assigned to a location's attribute values in decreasing order without considering which attribute the value comes from. The order weights are central to the OWA combination procedures. They are associated with the degree of "orness", which indicates the degree to which an OWA operator is similar to the logical connective or in terms of its combination behavior. The parameter is also associated with a trade-off measure indicating the degree of compensation between the parameters associated with the OWA operations serves as a mechanism to obtain results for different decision maker's perspectives. Thus, the "orness" measure allows for interpreting the results of OWA in the context of the behavioral theory of decision making.

The *OWA* operator provides a parameterized family of aggregation operators which are used in many applications. The definition of the *OWA* operator was introduced by Yager, (1988).

Definition: An *OWA* operator of dimension *n* is a mapping $OWA\colon R^n \rightarrow R$ that has an associated weighting vector $w = (w_1, w_2, \ldots, w_n)^T$ of dimension *n* having the properties,

$$w_j = Q\left(\frac{\sum_{k=1}^{j} u_k}{T}\right) - Q\left(\frac{\sum_{k=1}^{j-1} u_k}{T}\right), \tag{1}$$

$$w_j \in [0,1], \; \sum_{j=1}^{n} w_j = 1 \tag{2}$$

and such that $F_{OWA}(a_1, a_2, ..., a_n) = \sum_{j=1}^{n} w_j b_j$,

where Q is linguistic quantifier "orness" (see Table 1), a_i is from R^n, b_j is the j^{th} largest of the a_i, for all i, T is total sum of weights.

A fundamental aspect of this operator is the reordering of the arguments, based on their values. That is, the weights rather than being associated with a specific argument, as in the case of the usual weighted average, are associated with a particular position in the ordering. In the following Table 1 a family of linguistic quantifiers and their relevant values for optimistic coefficient and optimistic condition is shown.

Tab. 1: Linguistic quantifiers for OWA

Linguistic quantifiers	**Optimistic coefficient (degree of orness)**	**Optimistic condition**
At least one	0.001	Very optimistic
At least a few	0.1	Optimistic
A few	0.5	Fairly optimistic
Half	1	Neutral
Most	2	Fairy pessimistic
Almost all	10	Pessimistic
All	0.001	Very pessimistic

Source: Yager, (1993)

Assume $w = (0.4, 0.3, 0.2, 0.1)^T$, *where* T is "most"=2. Then,

$$F_{OWA}\ (0.7, 1.0, 0.2, 0.6) = (0.4 \cdot 1.0) + (0.3 \cdot 0.7) + (0.2 \cdot 0.6) + (0.1 \cdot 0.2) = 0.75\ .$$

2.2 TOPSIS method

TOPSIS method is one of the methods which uses the calculation of distance from the ideal variant for criteria's evaluation. For the calculation it is necessary that all criteria are maximization type, therefore all criteria are modified based on relation $y_{ij} = -y_{ij}$. The calculation procedure can be summarized into following steps. Conversion of minimization criteria to maximization ones,

$$r_{ij} = \frac{y_{ij}}{\left(\sum_{j=1}^{p} \left(y_{ij}\right)^2\right)^{1/2}}, \text{ i = 1, 2,…p, j = 1, 2,…, k,} \tag{3}$$

where v_j is the weight of j[th] criteria. The columns in this matrix are after transformation created by vectors of unitary length based on Euclid's metrics. Consequently, it is necessary to find weighted criteria matrix W so that every j-th column of normalized criteria matrix R is multiplied by relevant weight v_j

$$W = \begin{bmatrix} w_{11} w_{12} \dots w_{1k} \\ w_{21} w_{22} \dots w_{2k} \\ \dots\dots\dots\dots\dots\dots \\ w_{p1} w_{p2} \dots w_{pk} \end{bmatrix} = \begin{bmatrix} v_1 r_{11} v_2 r_{12} \dots v_k r_{1k} \\ v_1 r_{21} v_2 r_{22} \dots v_k r_{2k} \\ \dots\dots\dots\dots\dots\dots\dots\dots \\ w_1 r_{p1} w_2 r_{p2} \dots w_k r_{pk} \end{bmatrix}. \tag{4}$$

Next step is to determine ideal variants $H = (H_1, H_2, ..., H_k)$ and basal variant $D = (D_1, D_2, ..., D_k)$ regarding to values in weighted criteria matrix, where:

$$H_j = \max_i w_{ij},\ j = 1, 2, ..., k,$$
$$D_j = \min_i w_{ij},\ j = 1, 2, ..., k. \tag{5}$$

It follows with calculating the distance of variant from the ideal variant.

$$d_i^+ = \left(\sum_{j=1}^{k} \left(w_{ij} - H_j \right)^2 \right)^{1/2},\ i = 1, 2, ..., p, \tag{6}$$

and distance of individual variants from basal variant.

$$d_i^- = \left(\sum_{j=1}^{k} \left(w_{ij} - D_j \right)^2 \right)^{1/2},\ i = 1, 2, ..., p. \tag{7}$$

In both of these cases, Euclid's range of distance is used. Second to last step is to find the relative indicator of the variant's distance from the basal variant.

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-},\ i = 1, 2, ... p, \tag{8}$$

.

where for values c_i is considered:

$$0 \le c_i \le 1,$$
$$c_i = 0 <=> a_j \approx \left(D_1, D_2, ... D_k \right),$$
$$c_i = 1 <=> a_j \approx \left(H_1, H_2, ... H_k \right). \tag{9}$$

By ranking the variants based on descended values c_i complete ranking of all variants is obtained and there is the possibility to determine the best variant, Fiala, Jablonsky, Manas, (1994).

3 Results and discussion

The evaluation of the criteria and sub-criteria has been done by five experts in a real company. All of them have filled in pre-prepared matrices for all levels of the competency model hierarchy. The results for individual matrices for each competency are described and evaluated below. Firstly, the HR managers/owner evaluated groups of competency based on pair comparison. Then the weights for individual group of competency were calculated based on the formulas. Then the consistency was checked. Consistency ratio index was fulfilled for all matrices. The results of global weights for competencies for one position i.e. top manager is shown in Table 2.

Tab. 2: Global weights for competencies for the position of top manager

Ranking	Competency	Global weight
1	Strategic thinking	19.04%
2	Business knowledge	13.30%
3	Change management	8.81%
4	Proactivity	7.77%
5	Mental agility	6.83%
6	Professional knowledge	6.76%
7	Leadership	6.62%

Source: Kashi, Friedrich 2013

Next, first seven core competencies were selected for the yearly appraisal of the employees. The employees were evaluated on all the competencies; however the most important competencies (seven first) i.e. professional knowledge, analytic thinking, proactivity, mental agility, team cooperation, effective communication and stress resilience will be linked to the employees' total reward. The data in Table 3 show what evaluation employees 1 to 5 received for the core (first seven) competencies. The ranking was on a scale 0 to 100, i.e. 100 is the highest possible score any employee can reach.

Tab. 3: Evaluation of employees according to seven most important competencies

	C1	C2	C3	C4	C5	C6	C7
Alternative	**Strategic thinking**	**Business knowledge**	**Change management**	**Proactivity**	**Mental agility**	**Professional knowledge**	**Leadership**
Employee 1	87	64	87	74	68	65	63
Employee 2	95	75	88	75	65	58	68
Employee 3	88	78	67	66	70	67	58
Employee 4	75	68	71	73	68	60	56
Employee 5	78	55	72	68	58	65	78

Source: own elaboration

In the following Table 4 the initial global weights for seven most important competencies were normalized to calculate local weights.

Tab. 4: Initial weights derived from AHP

Competency	**Global weight**	**Local weight u_k (Normalized)**
Strategic Thinking	19.04	0.275
Business Knowledge	13.3	0.192
Change management	8.81	0.127
Proactivity	7.77	0.112
Mental agility	6.83	0.099
Professional knowledge	6.76	0.098
Leadership	6.62	0.096

Source: own elaboration

Following Table 5 shows an example of OWA method application in evaluation of Employee 1 from the fairly pessimistic perspective (performs best in most criteria). Criteria are ordered according to respective performance of the employee in seven competencies. *Local criteria weights u_k are added up to make a cumulative total.* Then the ordered weights w_j are calculated. Finally, a weighted sum of ordered weights and employee performance is calculated.

Tab. 5: Example of Ordered Weighting Averaging method for „most criteria"

Alternative/ criteria	Employee 1	u_k	*cumulative* u_k	w_j	F_{owa} (weighted sum)
C1	87	0.275	0.275	0.076	6.600
C3	87	0.127	0.403	0.086	7.520
C4	74	0.112	0.515	0.103	7.636
C5	68	0.099	0.614	0.112	7.587
C6	65	0.098	0.712	0.130	8.428
C2	64	0.192	0.904	0.311	19.899
C7	63	0.096	1.000	0.182	11.488
				Total	69.158

Source: own elaboration

The applicant's ranking is, within the OWA method, determined based on value F_{OWA}, since it deals with distance minimization from the ideal variant, whereas the values are in descending order. The results of employees' rankings compared with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) (see Kashi, Horváthová, 2014) are shown in Table 6 and Table 7.

Tab. 6: Employee evaluation based on OWA compared with TOPSIS

	At least one	At least a few	A few	Half	Most	Almost all	All	TOPSIS
Employee 1	86.82	85.30	79.70	74.79	69.16	63.43	63	0.60
Employee 2	94.75	92.65	85.15	78.84	71.78	61.06	58	0.88
Employee 3	87.78	85.94	79.48	74.22	68.64	61.03	58	0.57
Employee 4	74.91	74.17	71.44	68.94	65.72	58.40	56	0.31
Employee 5	77.87	76.72	72.41	68.44	63.41	55.60	55	0.19

Source: own elaboration

Tab. 7: Employee evaluation based on OWA compared with TOPSIS

	At least one	At least a few	A few	Half	Most	Almost all	All	TOPSIS
Employee 1	3	3	2	2	2	1	1	2
Employee 2	1	1	1	1	1	2	2	1
Employee 3	2	2	3	3	3	3	3	3
Employee 4	5	5	5	4	4	4	4	4
Employee 5	4	4	4	5	5	5	5	5

Source: own elaboration

From the tables Table 6 and Table 7 above, it is evident that based on TOPSIS employee 2 is the closest to the ideal variant, followed by employee 1 and employee 3. Employee 5 has received the worst evaluation with 0.19, which is very far from 1 – the ideal variant. However, the OWA method can be perceived as kind of sensitivity analysis of decision maker's attitude (from optimistic to pessimistic). Results show that the fairly optimistic, neutral and fairy pessimistic attitudes produce similar results to TOPSIS method. (Franek, Kashi, 2014 a, b)

Conclusion

AHP method helped to scale down the number of measures and helped to determine the most important competencies, which lead to the achievement of firm's strategic goals. According to study's findings, one may use the AHP to study the design of competency models as a HR strategic management system. Using OWA method helped the decision makers to choose appropriate optimistic coefficient and determine set of weights based on order of criteria. AHP and TOPSIS are also able to capture the consensus of a potentially divergent group of managers and can be quickly and easily updated as desired. This paper can be used as a framework for any company which either uses or would like to use a competency model for HR activities. This paper also shows that various multiple criteria decision making methods can be used for human resources activities in order to get more objective results.

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