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Competences-based Comparison and Ranking of Industrial Enterprises using PROMETHEE Method

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Abstract

New organizational concepts like manufacturing networks or production networks, or even everyday enterprise's task like supplier selection, require comparison and ranking of some enterprises. A proper comparison method and procedure needs to be established. In this research a procedure for comparison and ranking of industrial enterprises is based on enterprise's competences. For each enterprise a special set of competences has been defined and evaluation for each competence has been made. These evaluations were submitted to PROMETHEE method and ranking results were obtained. The results show that it is possible to design transparent comparison and ranking procedure.

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1. Introduction

Today, everyday need of one enterprise is a comparison and ranking of other enterprises [1]. No matter if it is a question of supplier selection [2] or a partner selection for manufacturing network [3], enterprises must be compared and ranked. In order to perform ranking of enterprises, a proper comparison method and procedure needs to be established [4]. In this research a procedure for comparison and ranking of industrial enterprises is based on enterprise's competences [5]. For each enterprise a special set of competences has been defined and evaluation for

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each competence has been made using specially designed questionnaires. Data, gathered using questionnaires, were submitted to Multi-Criteria-Decision-Making (MCDM) method and enterprises comparison and ranking were performed. Additionally, experts were interviewed to determine criteria weights.

However, the problem of the selection or the ranking of alternatives submitted to a multi-criteria evaluation is not an easy problem. Usually there is no optimal solution; no alternative is the best one on each criterion. There are several decision aid methods or decision support systems that have been proposed to help in the selection of the best compromise alternatives. In this paper the PROMETHEE method (Preference Ranking Organisation METHod for Enrichment Evaluations [6]) was chosen because this method is known as one of the most efficient, but also as one of the most transparent method for MCDM [7].

2. PROMETHEE method

An input for PROMETHEE method is a matrix consisting of set of potential alternatives (actions) A, where each a element of A has its $f_j(a)$ which represents evaluation of criteria j. Each evaluation $f_j(a_i)$ must be a real number. Method PROMETHEE I ranks actions by a partial pre-order, with the leaving flow [6]:

$$\Phi^{+}(a) = \frac{1}{n-1}\sum_{x\in A}\pi(a,x) \tag{1}$$

and entering flow:

$$\Phi^{-}(a) = \frac{1}{n-1}\sum_{x\in A}\pi(x,a) \tag{2}$$

where a denotes a set of actions, n is the number of actions and π is the aggregated preference index defined for each couple of actions. The PROMETHEE I method gives the partial pre-order. A net outranking flow is obtained from PROMETHEE II method which ranks the actions by total pre-order [6]:

$$\Phi\ (a) = \Phi^{+}(a) - \Phi^{-}(a) \tag{3}$$

In the sense of priority assessment net outranking flow represents the synthetic parameter based on defined criteria, priorities among criteria and criteria weights. Additionally, different sets of criteria weights can be used and then each set represents one scenario. Usually MCDA problems have more than one scenario.

3. Ranking of enterprises

To rank enterprises it is necessary to design a set of criteria that will represent all the important parameters which need to be taken into account for comparison of enterprises. No matter if it is a question of supplier selection or a partner selection for manufacturing network, there will be a criteria which evaluations change often and others that do not change so often. Therefore, a set of criteria which will be used can be divided into two sets [8]:

- **Dynamic criteria** – criteria whose evaluations (values) change often, for example every month or similar (an example of such criteria is the price of the product or delivery day).
- **Static criteria** – criteria whose evaluations (values) do not change so often, or at most a few times a year (an example of such criteria is a technology of enterprise).

Furthermore, set of Static criteria can be divided onto:

- **Competence criteria** – criteria covering all the competencies of the enterprise: technical, organizational and human competence.
- **Economic criteria** – criteria that consider economic feasibility or risk of cooperation.

- **Sociological criteria** – criteria which analyze sociological impact of cooperation with certain enterprise.

An input matrix for PROMETHEE method, i.e. criteria evaluation for each alternative (enterprise), is made using data gathered in special questionnaire. This questionnaire was sent to the production enterprises of Split-Dalmatia County. In the following figures (Fig. 1 and Fig. 2) an input matrix for 7 enterprises is shown. However, star names are used instead of real names of enterprises.

		Dynamic criteria		Static criteria						
				Competence criteria						
ID	Name	Price per piece	Delivery day	Technology	References	Information system	Employees qualification	Employees specialist level	Quality certificate	Continuous improve-ment
		Minimum	*Minimum*	*Maximum*	*Maximum*	*Maximum*	*Maximum*	*Maximum*	*Maximum*	*Maximum*
		€	*Day*	*0-5 grade*	*0-5 grade*	*0-5 grade*	*0-6 grade*	*0-5 grade*	*0 - 1 (no - yes)*	*0-5 grade*
1	Alpha Centauri	103	31	4	1	1,5	2	4	1	1
2	Beta Ursae Minoris	102	33	4	2	1	3	3	1	1
3	Alpha Ophiuchi	110	33	4	3	0,5	3	0	1	1
4	Beta Aquarii	115	35	4	4	2	4	2	1	1
5	Alpha Orionis	116	32	3	2	0,5	3	4	1	1
6	Alpha Virginis	111	33	4	1	1,5	3	3	1	1
7	Delta Leonis	100	35	2	2	3,5	2	2	0	2

Fig. 1. Input matrix for dynamic and competence criteria.

		Static criteria				
		Economic criteria			Sociological criteria	
ID	Name	Deadline reliability	Network cooperation	Financial reliability	Number of employees	Area of special state care
		Maximum	*Maximum*	*Maximum*	*Maximum*	*Maximum*
		0-5 grade	*0-5 grade*	*0-5 grade*	*Employee*	*0 - 1 (no - yes)*
1	Alpha Centauri	5	2	5	90	0
2	Beta Ursae Minoris	4	3	4	300	0
3	Alpha Ophiuchi	5	0	5	30	1
4	Beta Aquarii	5	3	5	25	0
5	Alpha Orionis	4	3	4	190	0
6	Alpha Virginis	5	1	5	80	0
7	Delta Leonis	4	1	4	1300	0

Fig. 2. Input matrix for economic and sociological criteria.

These matrices were submitted to PROMETHEE method. Criteria preference function type and preference thresholds were obtained by in-built function *"Preference Function Assistant"* of *Visual PROMETHEE* software, developed by Bertrand Mareschal at *ULB*, Bruxelles [9]. Following results were obtained using criteria weights determined by experts (Fig. 3).

This analysis showed that 2 enterprises (*Beta Ursae Minoris* and *Beta Aquarii*) are dominant in comparison with other enterprises. These 2 enterprises have very similar domination, so *Beta Ursae Minoris* have minimal

domination over *Beta Aquarii*. If one enterprise has to select co-operator or supplier from these 7 enterprises, it can select either *Beta Ursae Minoris* either *Beta Aquarii*, it will be almost the same.

Another different aspect of analysis is that enterprise *Beta Aquarii* has very high value of criteria *Delivery day* and *Price per piece*. So, if enterprise *Beta Aquarii* improves its offer (price and delivery day) it could have much higher score. On the other hand, enterprise *Beta Ursae Minoris* has one of the best offers (price and delivery day), and that's why it is ranked as best enterprise, although its other criteria values are lower than values of other enterprises. Enterprise's offer plays important role in selection of co-operator or supplier, and that aspect has been highlighted by experts giving greater weights to those criteria.

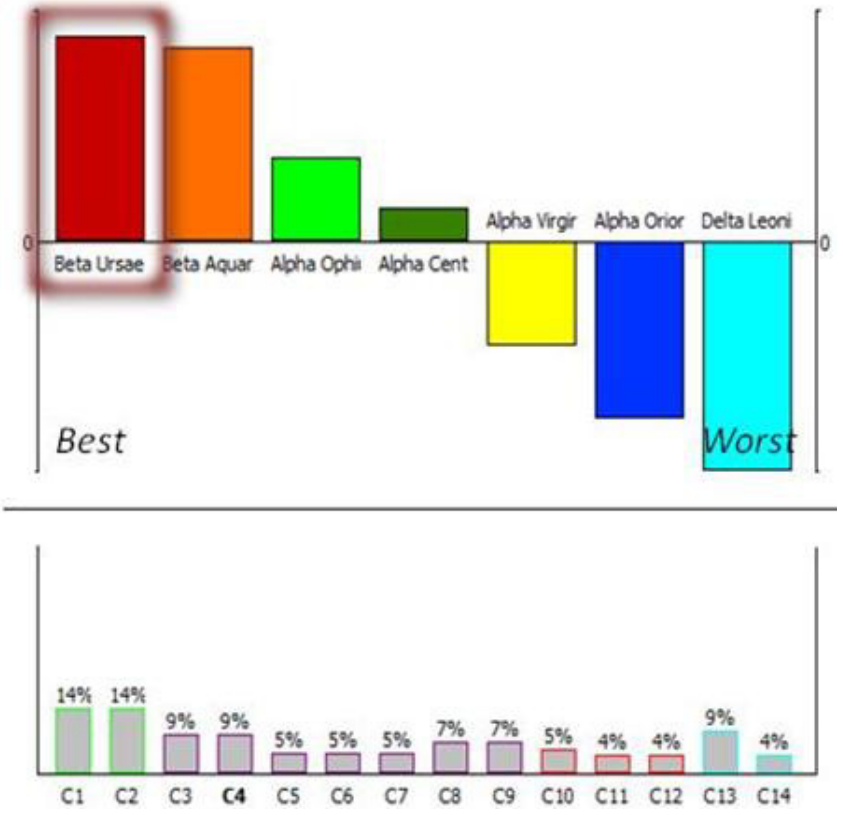

Fig. 3. Ranking results and criteria weights of comparison of enterprises.

Conclusion

This paper demonstrated approach for comparison and ranking enterprises based on enterprises' competences. It is clearly shown that, using PROMETHEE method, enterprises can be evaluated taking into account their competences, i.e. taking into account what enterprise possess in the terms of technology, references, information system, etc. Furthermore, economic and sociological criteria can also be added into analysis. All data were gathered using specially designed questionnaires. Additionally, experts were interviewed to determine criteria weights. In such a way a transparent procedure for comparison and ranking of enterprises is achieved. Because, transparency of comparison and ranking process is one of the most important issues. However, decision-making process can be affected by values criteria weights. Therefore, a determination of criteria weights must be a transparent process also. Unstable criteria weights set must be avoided. So, further research will be stability intervals analysis to determine which criteria weights set is the most stable one.

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