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Multi-Criteria Model for the Performance Measurement of Companies and its Application to Participants of the Olomouc Region Entrepreneur of the Year

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Abstract: The aim of this paper is to develop a multi-criteria model suitable for the performance measurement of firms. The constructed model will consider in addition to the traditionally used quantitative financial criteria (return on assets, current liquidity ratio, indebtedness, and asset turnover ratio) also nonfinancial qualitative ones such as customer feedback or company involvement in activities in the region. Also, the cooperation of the firms with foreign countries will be taken into account within the model. The model will be created using a weighted average operation, which is mathematically sufficiently complex as well as easy to use for practical evaluation problems. The created model will be subsequently applied to analyze selected companies that participated in the competition Olomouc Region Entrepreneur of the Year in previous 14 years. The analysis of companies will be carried out for two years, 2018 and 2020, which will enable besides other to examine the COVID-19 pandemic impact on these companies.

Keywords: multi-criteria model; weighted average operation; enterprises; Covid impact; Olomouc region entrepreneur of the year competition

JEL Classification: C65; M21; M41

1. Introduction

Performance measurement in companies is an important topic for economists engaged in either practice or theory. The process of performance measurement is very complex and various measures have been used during history (Wagner, 2011). Various financial metrics which are now taken as standard and well established in textbooks served as traditional performance measures (Atkinson et al., 2012; Drury, 2015). The latest research in the field of performance measurement is shifting towards the Key Performance Indicators (KPI) which is the term set up in 1992 (Kaplan & Norton, 1992). The goal of the KPIs was to cover other non-financial areas which are important for the performance measurement (Norton, 1999). The systematic approach towards the KPI (usually within the framework of BSC) has been researched in the past two decades (Kaplan & Norton, 2001; Niven, 2005; Jones, 2011; Lawrie & Cobbold, 2014; Uddin et al., 2020). Since some of the KPIs (or just PIs) have high level of uncertainty, new methods of dealing with the uncertainty have been developed (Pokorný &

Menšík, 2014; Malviya & Kant, 2019). As in the past decade, the importance of Environmental issues is increasing the specific tools to measure the environmental aspects have been introduced (Jasch, 2003; Chytilová & Jurová, 2012; Rafiqet al., 2020).

The performance measurement has been, among other uses, used for comparing companies and benchmarking. There are many contests on national or international level where "the best" companies of the year are announced. Within these contests, traditional financial performance as well as the modern non-traditional is in use.

The traditional performance measures are well understood, exactly defined, determined by mathematical formulas, based on the audited and verified data. This is not the case for the new, modern KPIs. The KPIs are often highly individual, based upon internal data, often with fuzzy nature (Zadeh, 1975; Pokorný & Menšík, 2014).

From the methodological perspective, different mathematical approaches have been used for the performance measurement and evaluation of the firms from the various points of view. E.g., structural equation modelling was applied to test correlations between the variables analyzed in Wall, 2021 in order to evaluate family firms in Thailand. In Eickelpasch et al., 2016, firms' evaluation of location quality by regression analysis was analyzed dealing with East German firms. Except for those statistical methods, fuzzy sets theory has been also used for creating the firms´ evaluation methods (see, e.g., Ertuğrul & Karakaşoğlu, 2009; Magni et al., 2006; Magni et al., 2020). The advantage of such attitude lies in the fact that it enables to properly implement the qualitative criteria into the analyzed model as well as the uncertainty of the inputs. On the other hand, it is usually quite difficult for practitioners to apply fuzzy sets theory evaluation methods to their specific problems.

In this paper, we will focus on creating a multi-criteria model for the performance measurement of companies. This model will consider, in addition to the traditionally used financial criteria, several other aspects - customer feedback, company involvement in activities in the region, etc. This model is not purposed to replace or substitute bankruptcy models (Wu et al., 2010; Mossman et al., 1998). The purpose of the model is to measure the performance of companies while using traditional financial measures as well as nonfinancial measures and compare the situation before and during the COVID pandemic. The model will be created using weighted average operation that allows to consider the importance of the criteria and that is very easily applicable to practical evaluation problems. The outputs of the evaluations will be described by real numbers in the interval [0,1], which represent the value-creation power of the firms. The created model will be subsequently used to analyze selected companies that participated in the competition Olomouc Region Entrepreneur of the Year in previous years. The analysis of companies will be carried out in two years – before the COVID-19 pandemic and during it, which will examine its impact on these companies.

2. Methodology

If we consider the multi-criteria evaluation problem in which n variants

$$a_1, a_2, \dots, a_n$$

are to be evaluated with respect to k criteria

$$c_1, c_2, \dots, c_k,$$

then it is possible to describe the variant $a_i, i = 1,2, \dots, n,$ by the vector of criteria values

$$(y_{i1}, y_{i2}, \dots, y_{ik}).$$

If we consider all criteria and variants together, then the following criteria matrix fully describes the inputs of the studied multi-criteria problem:

$$Y = \begin{pmatrix} y_{11} & y_{12} & \cdot & \cdot & \cdot & y_{1k} \\ y_{21} & y_{22} & & & & y_{2k} \\ \cdot & & \cdot & & & \cdot \\ \cdot & & & \cdot & & \cdot \\ \cdot & & & & \cdot & \cdot \\ y_{n1} & y_{n2} & \cdot & \cdot & \cdot & y_{nk} \end{pmatrix}$$

Figure 1. Criteria matrix for n variants and k criteria

After the specification of the criteria, the variants and their criterion values, it is necessary to evaluate each of variants and to compare the results of the evaluation process. Many different methods have been used for such an evaluation (see the Introduction for the brief overview). In this paper, the weighted average operation will be applied for the calculation of the final evaluations since it is very easily applicable for the practitioners on one side and mathematically complex enough on the other side.

The application of the weighted average operation consists of few steps:

1. Determination of the types of criteria.
2. Rescaling the values y_{ij} from the criteria matrix into the unit interval.
3. Expressing the importance of the criteria by normalized weights.
4. Computation of the overall evaluation.
5. These steps will be described in more details in the following paragraphs.

Step 1. In order to convert all the values from the criteria matrix into the same scale, it is necessary to determine the type of each criterion. Quantitative criterion of maximization type is the criterion with numerical values satisfying "the more the better"; a typical example of such a criterion is profit. On the other hand, quantitative criterion of minimization type is the criterion with numerical values satisfying "the less the better" – e.g., average collection period. The criteria with non-numerical values are called qualitative.

In practical applications, it is sometimes necessary to deal with other types of criteria than the above-mentioned standard ones. As an example, we can consider current liquidity ratio, which is a quantitative criterion but neither maximization nor minimization type, since its optimum value lies usually in the interval between 1.5 and 2.5. Too small values of this criterion may mean a low ability to pay short-term liabilities; too high may indicate

inefficiency in management. Therefore, it is necessary to deal with the criterion individually and to use non-standard, sometimes nonlinear, re-scaling in such cases.

Step 2. After the determination of the types of criteria, it is necessary to rescale the values y_{ij} into the same scale – standardly, to the interval [0,1]. The way how this rescaling is done depends on the type of criterion. For the quantitative criterion of maximization type, the formula is:

$$b_{ij} = \frac{y_{ij} - y_j^{min}}{y_j^{max} - y_j^{min}} \qquad (1)$$

where y_j^{min} is the minimum value of the j-th criterion in the considered problem and y_j^{max} is the maximum one. For the quantitative criterion of minimization type, the rescaling formula is again linear and has the following form

$$b_{ij} = \frac{y_j^{max} - y_{ij}}{y_j^{max} - y_j^{min}} \qquad (2)$$

where y_j^{min} and y_j^{max} have the same meanings as above.

If the quantitative criterion is neither of maximization nor of minimization type, then it is not appropriate to use the standard re-scaling formulae (1) or (2) and it is necessary to create an individual re-scaling formula by which the input values are transformed into the values from the interval [0,1].

Finally, the values b_{ij} for the qualitative criteria are generally set by the experts directly on the scale [0,1], where 0 is standardly assigned to the worst variant and 1 to the best one.

Step 3. After rescaling the values of the criteria into the unit interval, it is necessary to describe the importance of the criteria by normalized weights, i.e. by positive real numbers v1, v2, … vk satisfying $\sum_{i=1}^{k} v_i = 1$.

Step 4. Finally, the overall evaluation h_i of the i-th variant is computed by formula

$$h_i = \sum_{j=1}^{k} v_j b_{ij}. \qquad (3)$$

Final evaluation values can serve for the comparison of the variants or can be used to find the best variant which is the one with the highest overall evaluation.

For more details about weighted average operation and other aggregation methods, we recommend the book (Atkinson et al., 2012). If the weights or the values of the criteria are set imprecisely or vaguely, it is appropriate to use the fuzzy weighted average of fuzzy numbers instead of the weighted average operation (see, e.g., Dubois & Prade, 1981; Pavlačka & Pavlačková, 2021).

The multi-criteria model, which will be developed in the paper, will be subsequently applied to the research sample that will be formed by the companies that ranked first in the competition "EY Entrepreneur of the Year Olomouc Region" since its inception in 2006. These companies are evaluated by a jury, and the rules of the competition stipulate that, in addition to monitoring financial indicators (but exact selection of indicators is not listed), it also monitors the impact and involvement of companies in the region, their relationship with employees, the overall business story, etc. Thus, to win such a competition, it is not enough

to have good financial results, a company must have something more. Hence, we also collected non-financial measures / data.

The information on the winners of each year's competition was obtained from a publicly available database maintained by the Ministry of Justice of the Czech Republic. The financial statements of the companies are published in this database. From the financial statements, the information was transferred to a spreadsheet in MS Excel during the spring and autumn of 2021 to obtain the initial data on the research sample file. Using this data, indicators that are considered common or standard in financial analysis (profitability, activity, liquidity, and debt ratios) were calculated. These indicators have the character of traditional financial performance indicators and although other key performance indicators (KPIs) are also currently used, for the purposes of our research we take these traditional indicators as sufficient. To follow the intention of the contest we also collected the data from public databases or portals. The first of the non-financial measures is the customer feedback, which reflects the BSC approach and measures how these companies are perceived by its customers. The second non-financial measure serves as the proxy for 3rd generation BSC external perspective (Jones, 2011; Lawrie & Cobbold, 2004) and depicts the company's involvement in the region where it is active. This could be also proxy variable for the CSR activities (Bernardová et al., 2019). The last non-financial measure is the international activities, this shows whether the company is doing business on the international level.

3. Results

In this section, the multi-criteria evaluation model suitable for rating of companies based on the weighted average operation will be developed. Afterwards, this model will be used for the evaluation of the selected companies that participated in the competition Olomouc Region Entrepreneur of the Year in previous years. The analysis of companies will be carried out for two years 2018 and 2020 – before the COVID-19 pandemic and during it, which will enable to examine its impact on these companies.

3.1. Multi-Criteria Evaluation Model for Firms' Rating – Criteria

As the first step for the creation of the multi-criteria evaluation model, it is necessary to specify the criteria the evaluation process is based on. For this purpose, a few experts from the firms' managements have been addressed and according to their ideas, 7 criteria will be taken into the consideration. The importance of criteria is specified by normalized weights; their values are again set according to the experts´ recommendations. The recommended values differs according to region or country as well as during the time, hence we used values typical for Czechia from the textbooks (Knápková et al., 2013; Rejnuš & Fio banka, 2014). For the overview of the criteria, their types and the corresponding normalized weights (that describes the importance of the criteria) see Table 1.

3.2. Multi-Criteria Evaluation Model for Firms' Rating – Variants and Criterion Values

Usually the firms from the same sector or the companies engaged in the same activities are considered to be the variants of the firms' evaluation. On the other hand, it is possible to also analyze companies that are connected in some other sense. In this paper, the selected

Table 1. The criteria and the normalized weights describing their importance

Criteria	Criteria type	Normal. weights
c_1 = Return on assets	quantitative, maximization	0.30
c_2 = Current liquidity ratio	quantitative, neither max. nor min.	0.05
c_3 = Indebtedness	quantitative, neither max. nor min.	0.20
c_4 = Asset turnover ratio	quantitative, maximization	0.25
c_5 = Customer feedback	qualitative	0.10
c_6 = Company involvement in activities in the region	qualitative	0.05
c_7 = Cooperation with foreign countries	qualitative	0.05

Table 2. The criteria matrix for the year 2018

	c_1	c_2	c_3	c_4	c_5	c_6	c_7
SIWATEC	5.92%	2.74	0.08	0.46	Above average	Partly	Yes
HOPAX	4.38%	1.70	0.71	0.94	Highly above average	Partly	Yes
SHM	22.44%	9.40	0.35	0.94	Above average	Above average	Yes
SEV Litovel	-2.81%	4.31	0.36	0.88	Above average	Partly	Yes
Česko-slezská výrobní	17.90%	2.10	0.26	2.27	Average	Average	Yes
Fenix Trading	63.02%	7.95	0.12	3.18	Above average	Above average	Yes
Ing. Petr Gross	0.86%	0.93	0.68	0.97	Above average	Average	Yes
Koutný	24.73%	11.95	0.08	1.12	Highly above average	Average	Yes
FARMAK	6.78%	10.42	0.07	0.57	Average	Average	Yes
Brazzale Moravia	5.99%	1.85	0.58	1.36	Highly above average	Average	Yes
ABO valve	8.50%	3.49	0.26	0.98	Average	Partly	Yes

Table 3. The criteria matrix for the year 2020

	c_1	c_2	c_3	c_4	c_5	c_6	c_7
SIWATEC	1.68%	4.91	0.05	0.22	Above average	Partly	Yes
HOPAX	0.38%	1.55	0.70	0.77	Above average	Partly	Yes
SHM	18.45%	5.92	0.06	0.82	Above average	Above average	Yes
SEV Litovel	0.09%	4.23	0.29	1.05	Above average	Partly	Yes
Česko-slezská výrobní	18.61%	1.92	0.31	2.07	Above average	Average	Yes
Fenix Trading	52.70%	8.31	0.11	2.59	Average	Above average	Yes
Ing. Petr Gross	0.49%	1.05	0.67	0.70	Above average	Average	Yes
Koutný	16.40%	15.08	0.05	1.00	Highly above average	Average	Yes
FARMAK	8.71%	12.42	0.09	0.58	Average	Average	Yes
Brazzale Moravia	4.72%	3.02	0.61	1.34	Highly above average	Average	Yes
ABO valve	5.35%	3.94	0.27	0.81	Above average	Partly	Yes

companies that that have won the competition Olomouc Region Entrepreneur of the Year during last 14 years will be taken into account as the variants of the evaluation.

Since the analysis will be carried out for years 2018 and 2020, it will be necessary to select only the firms that existed in both years and that have published the balance-sheets for both years. Therefore, the following 11 variants $a_1 - a_{11}$ will be analyzed by the multi-criteria evaluation model for the firms' rating – SIWATEC, a.s., HOPAX, s.r.o., SHM, s.r.o., SEV Litovel, s.r.o., Česko-slezská výrobní, a.s., Fenix Trading, s.r.o., Ing. Petr Gross, s.r.o., Koutný s. r.o., FARMAK, a.s., Brazzale Moravia, a.s. and ABO valve, s.r.o. The corresponding criteria matrices for years 2018 and 2020 are shown in Table 2 and Table 3 above.

In order to compute the final evaluations of the variants in years 2018 and 2020, respectively, it is necessary to re-scale the values in the Table 2 and 3 into the interval [0,1] in accordance with the methodology. Since return on assets and asset turnover ratio are the maximization criterion, the transformation of the first and the fourth arrows will be done according to the formula (1). Customer feedback, company involvement in activities in the region, and cooperation with foreign countries are qualitative criteria, therefore, the values in the corresponding arrows will be re-scaled directly according to the experts´ opinions.

The arrow corresponding to the criterion c_2, current liquidity ratio, will be transformed according to the following formula

$$b_{i2} = \begin{cases} 0, & for\ y_{i2} < 0.5 \\ 2y_{i2} - 2, & for\ y_{i2} \in [0.5; 1.5] \\ 1, & for\ y_{i2} \in (1.5; 2.5] \\ -y_{i2} + 3.5, & for\ y_{i2} \in (2.5;\ 3.5] \\ 0, & for\ y_{i2} > 3.5. \end{cases}$$

The formula is derived from the fact that the current liquidity ratio between 1.5 and 2.5 is supposed to be ideal and values greater than 3.5 are considered to be completely unsatisfactory. For the purpose of this paper, we used the values from literature (Knápková et al., 2013; Rejnuš & Fio banka., 2014), however the values in the model can be calibrated or updated based upon the future research among the best companies or among the companies which have bankrupted.

Since the 4th criterion, indebtedness, is also neither maximization nor minimization, it will be necessary to derive the rescaling formula individually like in the case of current liquidity ratio. Since the values of the indebtedness between 0.3 and 0.6 are supposed to be ideal and values higher than 1.5 are referred to as completely inappropriately high, the re-scaling formula will be the following:

$$b_{i3} = \begin{cases} \frac{10}{3} y_{i3}, & for\ y_{i3} < 0.3 \\ 1, & for\ y_{i3} \in [0.3; 0.6] \\ -\frac{10}{9} y_{i3} + \frac{5}{3}, & for\ y_{i3} \in (0.6;\ 1.5] \\ 0, & for\ y_{i3} > 1.5. \end{cases}$$

We used the values based upon the literature, however for the precise calibration for the model, we suggest the future research.

The overall evaluations of the firms will be calculated from values in Table 4 and Table 5 according to the formula (3); weights of the criteria that are taken into account in the formula are specified in Table 1.

Table 4. The criteria matrix after re-scaling for the year 2018

	c_1	c_2	c_3	c_4	c_5	c_6	c_7
SIWATEC	0.13	0.76	0.27	0.08	0.70	0.30	1
HOPAX	0.11	1.00	0.88	0.24	0.90	0.30	1
SHM	0.38	0.00	1.00	0.24	0.70	0.70	1
SEV Litovel	0.00	0.00	1.00	0.22	0.70	0.30	1
Česko-slezská výrobní	0.31	1.00	0.87	0.69	0.50	0.50	1
Fenix Trading	1.00	0.00	0.40	1.00	0.70	0.70	1
Ing. Petr Gross	0.06	0.00	0.91	0.25	0.70	0.50	1
Koutný	0.42	0.00	0.27	0.30	0.90	0.50	1
FARMAK	0.15	0.00	0.23	0.12	0.50	0.50	1
Brazzale Moravia	0.13	1.00	1.00	0.39	0.90	0.50	1
ABO valve	0.17	0.01	0.87	0.26	0.50	0.30	1

Table 5. The criteria matrix after re-scaling for the year 2020

	c_1	c_2	c_3	c_4	c_5	c_6	c_7
SIWATEC	0.07	0	0.17	0.00	0.70	0.30	1
HOPAX	0.05	0	0.89	0.19	0.70	0.30	1
SHM	0.32	0	0.20	0.20	0.70	0.70	1
SEV Litovel	0.04	0	0.97	0.28	0.70	0.30	1
Česko-slezská výrobní	0.33	0	1.00	0.63	0.70	0.50	1
Fenix Trading	0.84	1	0.37	0.80	0.50	0.70	1
Ing. Petr Gross	0.05	0	0.92	0.16	0.70	0.50	1
Koutný	0.29	0	0.17	0.26	0.90	0.50	1
FARMAK	0.18	0	0.30	0.12	0.50	0.50	1
Brazzale Moravia	0.11	0	0.99	0.38	0.90	0.50	1
ABO valve	0.12	0	0.90	0.20	0.70	0.30	1

Table 6. The final firms´ evaluations in years 2018 and 2020

	2018	**Rank 2018**	**2020**	**Rank 2020**	**Difference**	**Rank difference**
SIWATEC	0.29	10	0.19	11	-0.10	-1
HOPAX	0.47	5	0.37	7	-0.10	-2
SHM	0.53	4	0.34	9	-0.19	-5
SEV Litovel	0.39	9	0.41	4	0.02	5
Česko-slezská výrobní	0.62	2	0.60	2	-0.02	0
Fenix Trading	0.79	1	0.71	1	-0.07	0
Ing. Petr Gross	0.41	7	0.39	6	-0.02	1

Koutný	0.42	6	0.35	8	-0.07	-2
FARMAK	0.24	11	0.27	10	0.02	1
Brazzale Moravia	0.55	3	0.49	3	-0.06	0
ABO valve	0.40	8	0.40	5	0	3

4. Conclusion and Discussion

Based upon the results presented in the Table 6, we can conclude that there is only marginal change in the performance of the companies. Since the metric is positive (the higher or closer to 1.00 the better) the original ranking in 2018 and the new ranking in the 2020 is depicted and, except for the companies SHM and SEV Litovel, there is no significant change. The change in the metric or in ranking is very small. This confirms the conclusion previously made by the jury – these companies are to be "the best" within the region and that is why these companies are expected to handle the COVID pandemic successfully as well. The first three companies in 2018 are the same as in 2020 (see column Rank difference in Table 6).

Despite the conclusion stated in the first paragraph of this section, there is visible trend – almost all the companies have slightly lower performance in 2020 compared to 2018 (see column Difference in Table 6). That shows expected – pandemic is influencing everyone.

The company SHM experienced the biggest downfall. The company is active in the coating materials business. Our guess is that this industry has been hit as a result of the problems in the automotive industry and generally engineering industry, which is a huge customer for SHM.

On the contrary, the company SEV Litovel experienced the biggest rise. This company produces gramophones, windscreen washers and regulators for vacuum cleaners. One possible explanation of their success could be the change in the behavior of consumers. During the pandemics there is significant change in the behavior of customers (they stay at home more often) that is why they are probably more interested in house electric appliances. However, these conclusions are yet to be confirmed or rejected based upon future research.

Based upon our findings, the best company in both observed years is Fenix Trading. As it is the producer of electric heating systems, we conclude that this company is successful thanks to the current ecological and sustainability trends, when the whole economy is reducing the fossil fuels and is searching for ecological / clean energy such as solar or wind.

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