MODEL FOR QUALITY OF LIFE EVALUATION OF NUTS 2 REGIONS WITH RULE-BASED SYSTEMS

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Abstract: *This article deals with NUTS 2 regions quality of life (QL) evaluation for the Visegrad Group in year 2015 developed by means of rules based methods. QL evaluation is a phenomenon, topical issue, dealt with by a large number of institutions and organizations. Approaches to QL evaluation however differ and there exists a whole range of indicator sets and methodologies for QL evaluation. The evaluation is based on Eurostat methodology for QL evaluation in this article. The QL evaluation works with official indicators of this methodology and uses rule-based systems methods: modification of Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) - fuzzy TOPSIS (fTOPSIS), fuzzy inference system (FIS) and Case-based Reasoning (CBR) and with using pre-defined fuzzy sets (FSs). The objective of this article is to create a model for QL evaluation based on utilization of the above-stated methods, comparing results of the individual methods and the total results of such QL evaluation. Another objective of this article is to achieve fairness supported by this model – the results from this model shall serve as recommendations for provision of subsidies for regional development including the definition for what area such subsidy should be used.*

Keywords: *Case-based Reasoning, fuzzy Inference System, Fuzzy Sets, Quality of Life, NUTS 2 Regions, TOPSIS.*

JEL Classification: *C69, D89, H89, R59.*

Introduction

The concept of QL is hard to define. Various authors, organizations and/or institutions and their approaches to QL evaluation are different and even the definition of what is QL brings about a large scale of material dilemmas, as states Budowski et al. (2016), Műhlpachr (2005), Phillips (2006), Prakash et al. (2016) and Royuela et al. (2010). This article deals with the solution of practical questions in the relation of comparability to life, QL evaluation and achievement of fairness. The article verifies and confirms the suitability of using the current Eurostat methodology. QL is evaluated using selected rule-based systems methods. To solve the problem, a model is designed to output QL estimates for each region. The extension of the model is a suggestion for allowance for the development of the region. These suggestions for allowances are based on the results of the QL evaluation of individual regions and are intended for the improvement of underdeveloped or backward regions. Regional development will help reduce disparities between regions, increase the standard of living and competitiveness of the region. The aim of the paper (and proposed model) is to achieve fairness, reduce disparities between regions and support underdeveloped or backward regions.

Austrian Bundesland of Burgenland and Operational Programme Burgenland (2007) are examples of the region's backwardness solutions. This programme involved Community support for Burgenland within the framework of "Convergence Phasing-

Out" objective. The total budget of the programme was around EUR 167 million and the Community assistance through the ERDF amounted to around EUR 125 million. The overall objective of the programme was to develop further and broader the transition of Burgenland to a knowledge based economy and society through enhancements of competitive structures, promotion of attractive regions and guarantee of environmental sustainability. This was contribute to wealth and increase in QL of all inhabitants of the Bundesland and reduction of regional disparities. Balchin et al. (1999) is also addressing the issue of backwardness in the region.

For comparison, it is also possible to list the regional evaluation according to Melecký and Staníčková (2014), Aristovnik (2014) or Markowska (2017). The assessment of fairness in the proposed model itself is based on suggestion for allowance. As will be noted below, subsidies are designed to improve the development of regions in selected areas.

1 Quality of life evaluation

QL evaluation is a complex issue. There exist a lot of opinions and approaches to this issue. QL is evaluated by means of indicators. Individual indicators then form a set of indicators or they form a whole methodology for evaluating QL. As examples of such methodologies (approaches) for QL evaluation we can quote the following: Active Ageing Index (2015); Economist Intelligence Unit Limited (2015); Eurofound (2015); Better Life Index (OECD, 2015). QL evaluation was based on the Eurostat methodology (2014) and the available Eurostat official indicators (2015) for the selected year. The data matrix was then compiled from official Eurostat measurements. The aim of the paper is not the creation of a new meta-theory, so the authors proceeded from the indicators and data of this professional institution and did not create a new set of indicators. The selection of indicators from Eurostat is also supported by the fact that the model output is the suggestion for allowance to improve the development of the region. The funding of these subsidies is proposed from the sources of the operational program. Operational programs and Eurostat fall under the European Commission. These are indicators that guide the European Commission and are in line with the European Union policy.

Below there are areas A, B, …, F of indicators i_1, i_2, …, i_{30} for QL evaluation. The area is specified for field(s) by the following way: Area A (fields Economy, Labour Market): i_1 is Gross domestic product at current market prices by NUTS 2 regions; i_2 is Income of households by NUTS 2 regions, Balance of primary incomes/National income, net; i_3 is Young people neither in employment nor in education and from 15 to 24 years; i_4 is Population 65 years or older; i_5 is Population density; i_6 is Population change, Crude rate of total population change. Area B (Education, Science and Technology): i_7 is Distribution of pupils and students enrolled in general and vocational programmes, Upper secondary education - vocational; i_8 is Participation rates in selected education levels at regional level, Tertiary education; i_9 is Population aged 25-64, Tertiary education; i_{10} is Human resources in science and technology; i_{11} is Employment in high-tech sectors. Area C (Health): i_{12} is All causes of death; i_{13} is Health personnel, Nurses and midwives; i_{14} is Health personnel, Dentists; i_{15} is Fertility rates; i_{16} is Life expectancy Less than 1 year. Area D (Digital Economy and Society): i_{17} is Households with access to Internet at home; i_{18} is Individuals who have never used a computer; i_{19} is Frequency of internet access: daily; i_{20} is Internet use: Internet

banking, selling goods or services; i_{21} is Internet use: participating in social networks, creating user profile, posting messages or other contributions to Facebook, Twitter, etc.; i_{22} is Individuals who used Internet for interaction with public authorities, Internet use: interaction with public authorities in last 12 months. Area E (Transport, Tourism): i_{23} is Nights spent at tourist accommodation establishments, Nights spent; i_{24} is Number of establishments and bed-places; i_{25} is Road, rail and navigable inland waterways networks, Motorways; i_{26} is Road, rail and navigable inland waterways networks, Total railway lines; i_{27} is Victims in road accidents. Area F (Agriculture): i_{28} is Animal populations, Live bovine animals; i_{29} is Animal populations, Live swine; i_{30} is Production of cow's milk on farms. A detailed description and meaning of individual indicators, including units can be found in the Eurostat database (Eurostat, 2015).

The model that is introduced below is useable for various states or regions. However in this article the subject of attention is the Visegrad Group (V4). The reason for this is the cohesion of this regional group, small distances between these states and also the historical importance of the V4 for the Czech Republic (Visegrad Group, 2017). For the evaluation the V4 NUTS2 (Eurostat, 2011) regions were selected to support the intended extended result – recommendation for providing subsidies to NUTS2 region to develop in the selected recommended area. The actual achievement of fairness therefore consists of a suggestion for allowance for the development of regions in selected areas. NUTS2 regions as such had been created exactly for the purpose to receive subsidies from European Operational programmes (Eurostat, 2010).

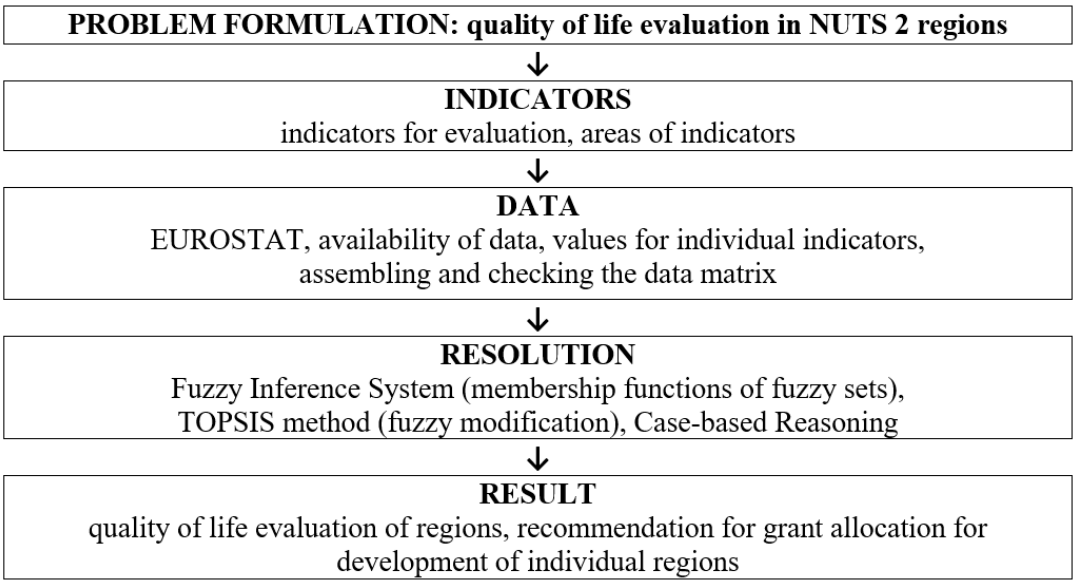
2 The model for the quality of life evaluation

As described in the text above V4 NUTS2 regions were selected for the QL evaluation. Indicators were selected for these evaluation that is based on Eurostat available data for year 2015 (for more topical evaluation even less indicators were available). The proposed model is based on Eurostat methodology, which has established methods for efficient data acquisition. From this point of view, it is desirable to rely on the already established methodology. While creating new methodologies, the availability of data can be a significant drawback. New approaches also limit the possibilities of subsequent comparison. The proposed model for QL evaluation is, compared to other models, beneficial by the use of methods that work with uncertainty. Dealing with uncertainty helps with a more appropriate description of the properties (Zadeh, 1965). Another significant benefit of the proposed model is its extension, which focuses on suggestion for allowance.

2.1 Description of the model

For the QL evaluation it has been proven that it is beneficial to use system engineering methods, for example see (Šanda, Křupka, 2016; Křupka et al., 2010; Kačmárová et al., 2013) among which there are the methods of multi-criteria decision making, rule-based systems and fuzzy logic. A combination of these methods has been used to deal with the defined problem and to create the model. In this model methods TOPSIS (its fuzzy modification respectively), FIS and CBR were used for dealing with the problem and also for QL evaluation for the individual regions. The model then worked with defined FSs. In the Fig. 1 below we can see a general schema of the model.

Fig. 1: Model for Quality of Life Evaluation



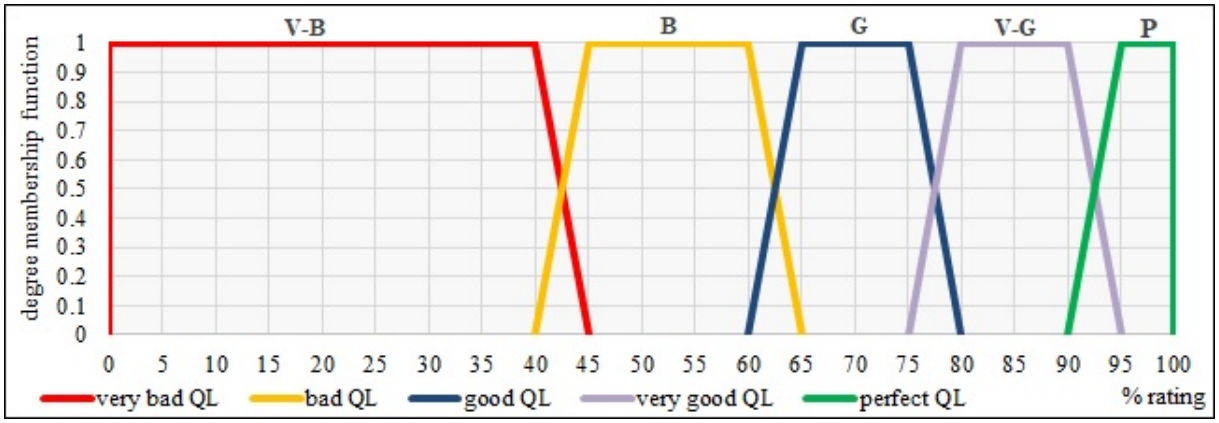
Source: Authors

In the previous text the complexity of the QL evaluation was described, including data sources and selected indicators. Further there shall be described methods used for dealing with the problem – "the core" of the model. For QL evaluation were used software application MS Excel, MATLAB and myCBR in the model.

2.2 Fuzzy sets

Fuzzy logic was also used for the solution and FSs were defined for QL evaluation. Based on previous work (Šanda and Křupka, 2017) there were defined 4 FSs for area evaluation and 5 FSs for the total QL evaluation. In this article the intervals of FS were specified and there were used FS of trapezoidal shape of MF in the form [a b c d] (Chen et al., 1999). A graphical image of the defined FS is in the Fig. 2.

Fig. 2: Fuzzy sets for evaluation



Source: Authors

Defined FSs and their linguistic variables for total evaluation: very bad [0 0 0.4 0.45], bad [0.4 0.45 0.6 0.65], good [0.6 0.65 0.75 0.8], very good [0.75 0.8 0.9 0.95] and perfect [0.9 0.95 1 1]. This approach to QL evaluation and the defined FSs is based on the publication *QLIFEX - a rule-based expert system for quality of life evaluation*" (Atanasová, 2014). It is also based on the article " *A Novel Approach for*

Quality of Life Evaluation: Rule-Based Expert System“ (Atanasová a Karashtranová). Atanasová (2014) also works with linguistic variables and a general assumption that the QL function is approaching the exponential shape (the better the results, the fewer subjects it achieves).

2.3 Methods Used in the Model

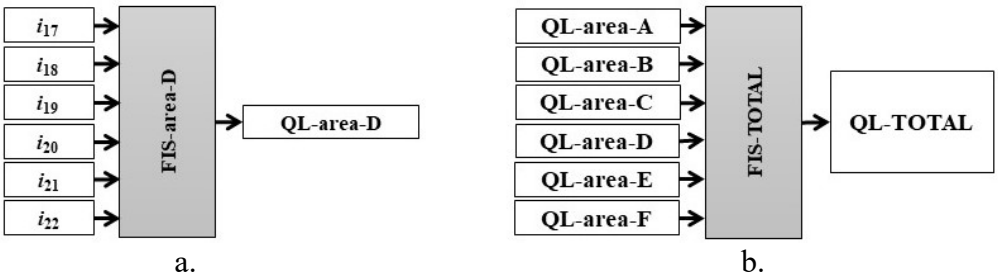
This model works with fuzzy modification TOPSIS, with FIS and CBR that shall be described in detail in the following text.

The method TOPSIS is one of Multi Attribute Decision Making algorithms, which is widely adopted. TOPSIS method is presented by Chen and Hwang (1992) and it is a multiple criteria method to recognize solutions from a limited set of alternatives. TOPSIS ranks the available networks based on their scores, with the highest being the best solution. In the created model there was used the extension of TOPSIS - fuzzy TOPSIS, where defined FSs were used. FSs were in TOPSIS method used thanks to publication (Chen, 2000). As stated by this author utilization of the fuzzy approach makes the method more realistic in the human beings decision-making environment where individuals' preferences are often ambiguous and thus they cannot be easily defined by concrete numeric values. On the contrary it is suitable to strive for verbal evaluation of alternatives and criteria. Weights of individual indicators were solved with share (1/30). Concrete description of the method's algorithm and an example of another problem being solved by the authors by means of TOPSIS method is in (Šanda, Křupka, 2016).

General structure of FIS is used for the resolution according to Zadeh (2015); Hu, et al. (2017) and Bělohlávek et al. (2002). Prior to its own QL evaluation with FIS usage, it is necessary to resolve: normalized matrix, define the rules and FSs for the QL evaluation, Mamdani type of FIS was used. Based on experimental FIS settings (Šanda, Křupka, 2017) as the optimal solution in defuzzification were selected the trapezoidal shape of membership function (MF) and the Centre of Gravity method.

Hierarchy structure of FIS for QL area and for total evaluation see in Fig. 3b.).

Fig. 3: Hierarchy structure of FIS for QL area D (3a.) and Total evaluation (3b.)



a. b.

Source: Authors

The number of rules depends on the number of indicators in the relevant individual area and the number of defined FSs Examples of rules of area A: Rule$_{54}$: If (i_1 is very-bad) and (i_2 is very-bad) and (i_3 is bad) and (i_4 is very-good) and (i_5 is bad) and (i_6 is bad) then (QL-area-A is bad); Rule$_{907}$: If (i_1 is very-good) and (i_2 is good) and (i_3 is very-bad) and (i_4 is good) and (i_5 is good) and (i_6 is good) then (QL-area-A is good).

CBR is according to (Aamodt, Plaza, 1994; Watson, 1997; Lopez de Mantaras et al., 2005; Zehraoui et al., 2003) based on previous experiences that serve as the basis

for the evaluation of a given problem. CBR can be, according to described in the following steps: Retrieve (finding as much as possible similar cases to the input case), Reuse (use again the solution for the most similar case), Revise (repair of correction of the proposed solution) Retain (keeping this input problem and its solution). It is a learning process that solves problems based on the already solved problems. CBR differs from other models also by its increasing permanent learning – when there is yet another problem solved it immediately becomes available for dealing with further future problems. CRB is thus utilized for dealing with a new problem via remembering previous similar situations and re-utilization of these information and knowledge for the actual situation. CBR works on similarity basis- distance of the nearest neighbour.

2.4 Extension of the Model

One of the objectives of this article is to provide a recommendation regarding the allocation of the region development grant (for instance for a region with long-term bad result) and also the recommendation on the percentage level of the grant for any selected region. This recommendation is based on the EIU (2015), which is in the Tab. 1. In this article this approach is modified namely by the percentage (per cent amount) from the "development" operational program (which would be specially created). It is then possible to specifically define the area for the grant allocation from the partial results of the QL evaluation of the single areas.

Tab. 1: Suggestion for Allowance (in %)

QL evaluation – rating	80 – 100	70 – 80	60 – 70	50 – 60	50 or less
Suggested allowance	0	5	10	15	20

Source: (EIU, 2015)

3 Quality of Life Evaluation Results

Results achieved by the individual methods are stated in Tab. 2, 3, 4 and Tab. 5. The last column “Suggested allowance” illustrates the areas to which the grant should be directed – based on partial results in areas A – E. The result can be the recommendation for one or more areas, for more than one area, or also “alternatively area” (the area has below average results however not the worst results).

As one of the advantages of the utilization of this model can be seen the suppression of any “extreme values” both in the positive and the negative sense – where, for instance, GDP of capital cities did not play any important part.

From Tab. 2 it can be generally stated that the most problematic is the area Economy and Labour Market (based on the evaluation in the CZ in year 2015).

Tab. 2: Results of Individual Methods – CZ (in %)

Region	fTOPSIS	FIS	CBR	Suggested allowance
CZ01	41.54	68.30	51.39	area F, alternatively area A
CZ02	56.97	71.28	63.44	area C, alternatively area D
CZ03	60.97	73.38	63.61	area A, alternatively area D
CZ04	62.41	53.36	59.16	area F, area B
CZ05	61.52	69.31	64.32	area A, area B, alternatively area D
CZ06	65.54	80.38	67.56	area A, alternatively area D
CZ07	62.19	67.28	61.95	area A, area B
CZ08	61.11	56.28	60.27	area A, area F

Source: Authors

There arises the question of how shall this evaluation look like in the following years when we can see from the macroeconomic data that economy is on the rise. The NUTS2 region CZ06 has the best evaluation within the CZ. This region also belongs among the best regions under the V4 evaluation with about 70%. On the other hand CZ01 is among the worst regions due to, to a large extent, Agriculture area results.

As it is clear from Tab. 3 in PL the areas that need the most support are the following areas: Economy, Labour Market, Transport and Tourism.

Tab. 3: Results of Individual Methods - PL (in %)

Region	fTOPSIS	FIS	CBR	Suggested allowance
PL11	59.51	61.67	59.73	area A, alternatively area D
PL12	54.93	60.77	58.22	area E, alternatively area D
PL21	71.98	57.10	64.92	area A, area F
PL22	60.08	49.18	59.69	area A, area F
PL31	58.29	51.16	56.20	area A, area E
PL32	61.01	45.91	56.98	area E, area F
PL33	56.56	48.82	54.55	area A, area E
PL34	53.54	54.57	54.97	area E
PL41	64.06	66.52	62.48	partly to areas A, D and E
PL42	63.65	58.33	59.46	partly to areas A, B, D and F
PL43	58.73	42.09	55.24	area E, area F
PL51	64.91	56.00	59.94	area F
PL52	51.21	47.47	50.58	area A, area C
PL61	63.02	65.65	62.34	partly to areas A, D and E
PL62	57.37	54.57	58.26	area E
PL63	68.67	62.58	66.21	area A, alternatively area D

Source: Authors

The worst regions within PL, as well as in total, are NUTS2 regions Opolskie - PL52, Świętokrzyskie - PL33 and Lubuskie - PL43 with evaluation 50 – 53.5 %. The best NUTS 2 Polish region is Pomorskie - PL63 with value over 65%.

In HU, the following areas are the areas with the worst evaluation: Economy, Labour Market, Education, Science and Technology.

Tab. 4: Results of Individual Methods - HU (in %)

Region	fTOPSIS	FIS	CBR	Suggested allowance
HU10	59.49	61.00	56.22	area F, alternatively area A and B
HU21	59.61	59.31	59.10	area A, area B
HU22	59.84	63.97	59.51	area B, alternatively area A
HU23	58.28	57.63	58.48	area A, area B
HU31	56.96	53.18	55.14	area A, area F
HU32	56.54	54.22	56.17	area A, area B
HU33	55.43	53.88	55.29	area A

Source: Authors

NUTS 2 HU regions evaluation can be described as average (or even bellow average). The regions rank approximately in the middle of the total ranking. Neither of the regions is exceptionally good or bad.

As it can be seen in Tab. 5 Slovak regions are evaluated as from average to above-average. For SK there were generally worse results (that means potential areas for grants funding) composed from more average results. Thereby it can be recommended to distribute grants funding into more areas.

Tab. 5: Results of Individual Methods - SK (in %)

Region	fTOPSIS	FIS	CBR	Suggested allowance
SK01	57.40	67.78	51.69	partly to areas A, C and D
SK02	60.95	63.90	62.55	area F, alternatively area A
SK03	65.00	57.88	59.52	partly to areas A, B and C
SK04	66.09	60.32	62.27	partly to areas A, B, C and F

Source: Authors

When looking at the results for all regions we can see approximately 20% difference between the best and the worst regions. In average results for the entire countries there is difference smaller than 5%. This verifies the hypothesis that V4 countries are very similar to each other, however, within V4 there are regions that are worse off. Under the concept of achieving fairness it is essential to support the development of such regions. The results of the proposed model for QL evaluation NUTS2 regions were compared with Melecký and Staníčková (2014), which provide the most comprehensive view of the comparison. The other listed comparisons only deal with the partial evaluation results. The average deviation of the overall results of Melecký and Staníčková (2014) is 3.63% (for CZ 5.2%; HU 1.13%; PL 2.57% and SK 6.3%) a median 2.56% (for CZ 6.53%; HU 2.46%; PL 1.73% and SK 5.56%) compared to the results of this model.

To determine the influence of the individual parameters in the model (the indicators), a one-at-a-time sensitivity analysis (Hamby, 1994; Degasperi and Gilmore 2008) was performed on the overall results. It was examined how the overall results change if each indicator decrease by 1%. For a total of 20 out of 30 indicators, the change (decrease) S was less than 0.05%. Based on the sensitivity analysis, the biggest influence was present for the i_2 and i_{23} indicators, where S_{i12} is 1.35% and S_{i23} is 1.34%. Results of other indicators: Si_{I3} is 0.78%; $S_{i4} \in$ [0.63%; 1.19%]; S_{i5} is 0.92%; $S_{i10} \in$ [0.54%; 0.79%]; S_{i12} is 0.67%; S_{i14} is 0.65%; $S_{i17} \in$ [0.60%; 0.63%]. As an extreme value can be seen the improvement of the CZ01 by 3.2% with a 1% decrease for the indicator i_{24}. This result is probably due to the nature of the indicator and the specific region CZ01 - the Prague region is a very popular region in the area of tourism. Based on the above, the results can be classified as robust.

4 Discussion - Suggestion for Allowance

Based on the above-stated evaluation results there are compiled recommendations for amounts to be allocated for the suggested grants funding (the area for grants funding has been already stated). The highest recommendation is 16.67% for the above-mentioned Polish regions. The lowest recommendation (that means best results) is for the Czech Regions Jihozápad - CZ03 a Jihovýchod - CZ06. The CZ results overall can be seen as very good results with the exception of Praha CZ01 and Severozápad - CZ04. On general terms the CZ ranks among the better parts of the V4.

The total results - Suggestion for Allowance are as follows: I) 16.67%: PL33. PL43 and PL52; II) 15%: CZ01. HU21. HU23. HU31. HU32. HU33. PL22. PL32. PL31. PL34 and PL62; III) 13.3%: CZ04. HU10. HU22. PL11. PL12. PL42. PL51. SK01 and SK03; IV) 11.67%: CZ0; V) 10%: CZ02. CZ05. CZ07. PL21. PL41. PL61. PL63. SK02 and SK04; VI) 8.33%: CZ03; VII) 6.67%: CZ06.

As an example we can state the operation program “Rural Development Programme” implemented, in the CZ, by Ministry of Agriculture. This program allocated the amount of 2.3 billion CZK. The thematic objectives of this program are also Investment in research, development and innovations for practice, Support for SMEs, Reducing energy intensity of economy, Reducing natural hazards, floods and environmental burden, Protection of the environment and use of natural resources, Increasing employment and high-quality workforce, Functioning social system and combating poverty, Improving the educational system. For instance for region Střední Čechy - CZ02, Severovýchod - CZ05 any recommendation for providing grants funding in the amount of 10% would represent 230 million CZK. In case of region CZ05 any recommendation for grants funding would go into the following areas: Economy, Labour Market, Education, Science and Technology (EU funds, 2012).

The whole process can then be described in more detail in several basic steps: the government or the ministry has set up a framework for the Operational Program (such as the Rural Development Program 2014-2020) approved by the European Commission; for the achievement of fairness between NUTS 2 regions, this model will be used; the outcome of the model will be suggestion for allowance (including areas such as infrastructure); under the principle of subsidiarity, the Regional Council of the Cohesion Region decides to grant a subsidy or contribution to the region's development. The model will ensure greater efficiency of redistribution of subsidies provided that all levels of public administration work properly. Of course, there are risks that can not affect the model and which can make the entire process "skewed" (for example, corruption). The suggestion for allowance will thus serve as a support for decision-making in public administration (Regional Council of the Cohesion Region, government). Thanks to a fairer redistribution (based on this model of QL evaluation), underdeveloped or backward regions will be continuously developed (similarly with Austrian Bundesland of Burgenland). As a result, disparities between regions will be reduced and the overall QL will increase.

Conclusion

Any QL evaluation is a fairly complex issue and its practical implementation is usually challenging. However, tools like rule-based systems, expert systems, multi-criteria decision-making systems, systems engineering methods may simplify this process. Despite this drawback, the concept of the QL has one big advantage. This concept looks on QL from many facets. Thus, this concept allows a complex QL evaluation. The created model for QL evaluation can be thus adopted to meet the number of available criteria, to meet extension by more (available) years and to allow for application on further regions, states or group of states. The model for QL evaluation can be used for QL evaluation for EU countries, evaluation development, trend description and similar and thus support the strive for fairness (justness) where the attention is given to the fact that under the same conditions there are, in various cases, achieved different results.

The authors are aware of the handicap in relation to the meta-theory, but they do not have this ambition. It is an empirical research with a pragmatic and purposeful goal. The article deals with the solution of practical issues in the relation of comparability to life. The article verifies and confirms the suitability of using and

retrieving existing data. The article also confirms the suitability of QL evaluation based on these data using selected methods. If new methodologies and theories were defined all the time, it would hurt the possibility of comparison. It would not be possible to compare the QL and its development over time, and it would not be possible to compare the individual states or regions that measure their QL "on their own". Therefore, the authors proceeded on the basis of Eurostat's official methodology, indicators and data, and did not create a new set of indicators or even new indicators. The benefits of this model and the whole approach can be found in the use of uncertainty methods for evaluating a complex variable, i.e. the QL. As Zadeh (1965) states, working with uncertainty is more appropriate for describing reality. The contribution of the model was confirmed in this paper by comparison (average deviation of 3.63% and median 2.56%) and one-at-a-time sensitivity analysis, from which the results can be classified as robust.

Recommendations for further work and development of the model include the use of multiple methods of system engineering, their synthesis and analysis; using more criteria; the inclusion of indicators for weights and areas; availability of data (current disadvantage).

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