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INDEX OF ECONOMIC DEVELOPMENT – CASE STUDY OF THE EUROPEAN REGIONS

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Abstract:

The economic aspect is an essential part of perceiving the issue of quality of life and standard of living. Analysis of these aspects is part of many studies focusing on regional development and living standards. This article aims to propose a method for the evaluation of economic development using available statistical data. The subject of the assessment is the European regions at the NUTS 2 administrative level. Five economic indicators are selected for the analysis, and their aggregation with the use of principal component analysis is examined. The resulting components are evaluated separately, followed by an experiment combining them into the one index. This result is supplemented with a classification describing the uncertainty of the detected values. The outputs are evaluated and visualised with emphasis on the geographical aspect. Finally, all the study steps and identified problems are critically discussed. This exemplary application of multidimensional statistics has proven to be a useful objective tool for designing a composite index, but the results need to be viewed critically, and subtler results correctly interpreted before further processing.

Key words:

Spationomy, multidimensional statistics, spatial analysis, quality of life

JEL: C38, O1, I3

1 Introduction:

One of the frequently discussed topics in connection with the development of society and the standard of living is the quality of life. The quality of life is a very complex topic, which can be approached from many points of view – medicine, psychology, economics or environmentalism. This presence of many attitudes caused the absence of a clear consensus on the definition of quality of life in a long-term perspective (Andrews, 1986). Since the 1980s, this topic has been a great deal of attention for scientists, but also from non-academic institutions, such as government agencies or international institutions. The analysis of the quality of life is a subject of great importance in the design, application and evaluation of social and economic policies (Pena & Somarriba, 2008). In their next paper, Somarriba & Pena (2009) state that the analysis of quality of life and social welfare is considered one of the main challenges of economic science because of its important role in political, social and economic areas. Also, the European Union has devoted more attention to this topic since 2007, when the "Beyond the GDP – Measuring progress in changing world" initiative was launched. Its main idea is to shift the issue of quality of life beyond the single economic indicator – the Gross Domestic Product (Stiglitz, Sen, & Fitoussi, 2009). GDP has been considered as an appropriate and the only instrument for measuring the level of human society and well-being for a long time; the topic of quality of life has therefore been closely associated with only economic indicators. This attitude was established in the 1920s by economist C. Pigou, who distinguished between economic welfare and a broader concept of social welfare (Sirgy et al., 2006). This approach has already been overcome, and many authors agree that the quality of life is necessary to be perceived as a complex that describes our life from many points of

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view. For different conceptual definitions of quality of life, see work of Liu (1976), Meeberg (1993) or Cummins (1997).

Although the quality of life is currently understood as a subject that needs to be evaluated in a comprehensive way (not only as an economic issue), there is no doubt that the economic indicators reflect on the overall living standard, and hence the quality of life. The economic indicators are part of almost all composite quality of life indexes or rating methodologies. The economic strength of the region influences the financial possibilities of every person living in the location, and then it can be transformed into elements that make the person satisfied – whether it is housing, personal property, the ability to travel or to pursue its interests. These ideas are formed in Sen's concept of commodities and capabilities (Sen, 1985). These possibilities of individual gains are likely to depend on the overall economic situation in the region where the person lives. It can be expected that if the region is economically strong, there will be attractive and well-valued employment opportunities that will ensure the economic satisfaction of the individual and thereby increase his overall quality of life. In the case of a satisfied employee, there is a chance that he/she does his job well and thus contributes to the economic development of his/her region in the cycle. Interesting comparison between self-reported happiness and the income has been examined by (Easterlin, 1974). Simple relations between the satisfaction of the population and the basic economic indicators have already been examined within the author's research on the quality of life (Macku, 2018). The next challenge is the elaboration of a detailed analysis of the economic aspects of quality of life.

Regarding the research of complex themes, whether economic, social or other, the use of aggregated numerical indicators – indexes has been well-established. Generally, an index is a dimensionless measure that can contain complex information consisting of a number of input indicators. For this reason, it is appropriate to use an index(es) for a comprehensive assessment of economic indicators. There are already indexes measuring the economic situation or development. The Index of Economic Well-being was designed in 1985 as a tool competing with GDP for economic development assessment. The index consists of 4 dimensions: Effective per capita consumption flows, Net societal accumulation of stocks of productive resources, Income distribution and Economic security. These dimensions include in a total of 14 indicators, such as income inequality, risk of unemployment or government spending per capita (Osberg, 1985). The final index is obtained as a weighted sum of indicators. Its main drawback is the lack of standardised data for use outside the original area of interest (the index was designed for evaluation of the economic situation in Canada). Economic aspects play a role in a number of other indicators - the most well-known Human Development Index uses gross national income as one third of its composition (Salin, Nevin, & Lever, 2018), Regional Human Development Index (Hardeman & Dijkstra, 2014) takes into account net adjusted household income and employment rate; OECD Regional Wellbeing Initiative uses household disposable income per capita, employment and unemployment rates (OECD, 2016) and finally in the European initiative on quality of life, the dimension of Material and Living Condition is the first issue (Eurostat, 2015).

The main issue of these particular indexes may be their applicability only to certain territories, where the necessary data is available. When applying to a different area in another part of the world or at a more detailed level than a national level, such data may no longer be available. Then the idea of creation of own index from freely available objective statistical indicators is encouraged. Based on the above considerations, this article aims to propose an alternative process for the evaluation of the economic aspects of quality of life. The main objectives of this article are, therefore:

- to collect a dataset of simple economic indicators
- to aggregate indicators into a composite index of economic development
- to evaluate the regional dissimilarities from the geographical point of view

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2 Methods

2.1 Data

The data affects the success and result of the research and the availability of different dataset influences the selection of indicators. In this paper, the intention is to analyze the economic development of the region on the basis of freely available objective statistical data. The required data should have as much spatial (i.e. administrative) detail as possible in order to be also used for a spatial evaluation of results. The geographical extent of this study is driven by the unit of analysis based on European NUTS 2 or NUTS 3 classification. Finally, due to the (un)availability of data, NUTS 2 was chosen. Based on the theoretical review of existing approaches and indexes in combination with the availability of statistical indicators in public databases, 5 indicators were selected for economic analysis: *GDP per capita* (at current prices in PPS), *Net disposable household income* (at current prices in PPS per capita), *long-term employment rate* as a percentage of economically active population, 5-year average of *growth rate of gross value added* (average calculated from percentage changes in previous years) and *economic dependency index* (calculated as a ratio of population in age 0-14 and population over 65 year to number of economically active population).

There are two available main resources of pan-European statistical data: the Eurostat database and the OECD Regional Database. None of these is fully sufficient since the OECD database covers only OECD member countries, Eurostat Database provides data primarily for EU member countries plus some of the non-EU countries. Some of the indicators are not up-to-date. Although this paper is made at the beginning of 2019, the latest record for some indicators is from 2015. For this reason, the complete dataset is referenced to the year 2015. By combining the OECD and Eurostat data, most of the European regions are covered at the level of NUTS 2 units. The data is lacking for most of the Balkan countries, thus Montenegro, Macedonia, Albania, Serbia, Bosnia and Herzegovina, Kosovo have been dropped from the analysis. In Iceland and Switzerland, data about income in 2015 were not available; therefore, values from 2013 were used. In Croatia and Norway, detailed regional data about growth rate is missing, and it was thus replaced with the national average.

2.2 Composite index design

For the design of the composite index of economic development, the principal component analysis (PCA) was used. It offers a way to build a synthetic index using objective and multidimensional statistics. The use of PCA as a data aggregation tool describes e.g. Li & Weng (2007), Lo & Faber (1997) and Ram (1982). The principal component analysis is one of the basic methods of multidimensional data processing for the extraction of variables (Jolliffe, 2002). It can reduce the dimension of the processed dataset and reveal new, hidden properties depending on input data (the so-called component), without losing more information from the input data. It works with the assumption that input data is somehow related and correlated, which also means a certain redundancy in the data. This is removed by the PCA, creating new, uncorrelated variables (components). With this feature, PCA can be an appropriate tool for aggregating multidimensional data into a one-dimensional index. The new component represents the newly constructed synthetic dimension, which does not arise from the decision of the authors but results from mathematical procedures defined from the original data. The components are dimensionless, and their interpretation is possible at the level of the higher value = better score in the given dimension.

Each component can be interpreted as a new, independent index. If components describe the same topic, but each focuses on its sub-section, its values can be processed by a simple arithmetic addition. The result is a composite index, which is based on a simple equation:

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$$IED = \sum_{1}^{n} F_i W_i \quad (1)$$

IED – a value of a new composite index of economic development
F_i – component score
W_i – component weight
n – number of components
i – component order

In many cases of our study, there was a situation in which the value of the first component for a certain area/region (let's call it region A) was high and the value of the second was low – then the resulting sum was an average. At the same time, average values of IDE value were calculated in a different region (region B) but having both inputs around the average value. Therefore, it is clear that such region A and B are not entirely comparable. For this reason, a simple classification was designed, considering 1) the value of the calculated index and 2) the variation of the input values of the two components. It was possible to identify regions whose index value is significantly influenced by the extensive difference between the individual components. The classification is summarised in the table below. For the low/high category determination, the value of the index of economic development and the value of the difference between components in every region was compared with the median. The median value of the index of economic development was 0.44, median of components difference was 0.28, both scales were standardised to 0-1 interval.

Table 1 Region types based on differences between components

Type	Index value	Difference in components	Description
HH	high	High	developed with uncertainty
HL	high	Low	developed regions
LH	low	High	weak with uncertainty
LL	low	Low	weak regions

2.3 Spatial analysis & visualisation

Almost every phenomenon occurs in relation to geographical space. This fact is sometimes neglected, and the results of various analyses are often presented only in the form of tables and charts. By adding a spatial view of the subject, the analysis is enriched with a geographic aspect. Through the use of geospatial technologies, the result will be not only in the declaration "how" is the quality of life, but also "where" these values are. Spatial analysis can explore hidden patterns in the behaviour of the phenomenon and its spatial differentiation, identify spatial clusters of problematic areas or vice versa prosperous regions, or perform aggregation to higher administrative units. The great strength also lies in visualisation tools (e.g. epidemiological data visualisation (Marek, 2013)), which allow to display information much faster and more efficiently than, for example, using tables or word assessment. For that reason, the created index was related to the NUTS 2 units and visualised to support the final interpretation.

In the last step, a spatial clustering (Hot Spot analysis uses the Getis-Ord Gi * indicator, for more information see Ord & Getis (2010) or Getis & Ord (2010)) was evaluated in the area of interest. This analysis is an example of spatial statistics - a set of exploratory techniques for describing and modelling spatial distributions, patterns, processes and relationships (Bennett, Vale, & D'Acosta, 2017). Hot Spot analysis allows to spatially define (significant) areas with similar values (hot spots or cold spots), not

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according to the author's expert estimate, but on the basis of a statistical test evaluating spatial autocorrelation of the observed phenomenon.

3 Results

The composite index of economic development of the region was compiled by the PCA. Five input attributes were reduced to two components (the Kaiser criterion (Kaiser, 1960) determines that only those components whose eigenvalue is larger than 1 are considered for further work). These two components together explained 73% of the original data variance. A high percentage of explained variance is recommended (ideally around 80-90%), but in many cases, especially dealing with soft data, this level cannot be reached. Considering the Kaiser criterion, the first two components are sufficient. The other would describe rather a noise than relevant information.

Table 2 PCA component loadings

	PC1	PC2	PC3	PC4	PC5
GDP per capita	0.493	-0.441	0.183	0.427	0.587
net disposable household income	0.494	-0.438	0.284	-0.265	-0.641
long-term employment rate	-0.379	0.009	0.895	-0.162	0.164
5-year average of *growth rate of gross value added*	0.362	0.671	0.288	0.514	-0.264
economic dependency index	0.485	0.402	0.009	-0.674	0.383

Using the calculated component loading (Table 2), a correlation within the input indicators and the new components can be analyzed. This information is beneficial and necessary for further component interpretation. As an output from PCA, the biplot graph (see Figure 1) consists of the correlation within the input indicators and the components (the vector lines) and the component score of every single NUTS 2 region (grey dots). The biplot can be interpreted as follow: positively correlated variables have similar orientation, negatively correlated variables are positioned on opposite sides of the plot origin and the distance between variables and the origin of coordinates measures the quality of the representation of the variable in the PCA model - variables that are remoted from the origin are well represented. A very strong correlation is evident between GDP per capita and net disposable household income. According to the orientation of the vectors, two groups of variables can be observed: GDP per capita and net disposable household income form the first group which describe the pure economic performance in terms of capital. This is proved by the position of the Inner London – West region (the economically most dominant region in Europe), which is situated straight in the direction of these two vectors (Figure 1). The second group consists of the growth rate of gross value added and long-term employment rate. This direction could be characterized as economic growth. Regarding the first component, all of the indicators have a similar positive contribution (including the economic dependency index, whose vector is opposite since the higher values of the index mean greater economic and social burden). Disunity appears when evaluating the second component, all four indicators with the same positive interpretation are divided into the above described opposing groups.

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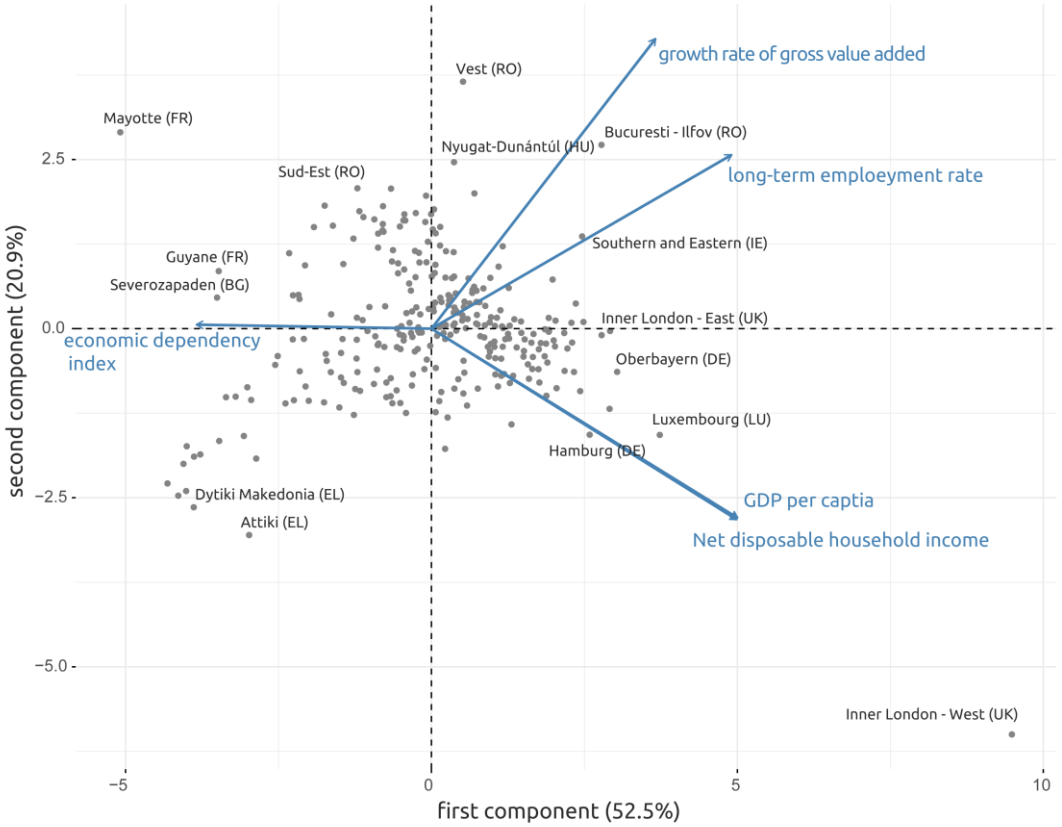
Figure 1 Component score of NUTS 2 projected on the first two components, with the loadings of input indicators



The nature of the components can be described as follows: GDP per capita, net disposable household income, long-term employment rate, 5-year average of growth rate of gross value added contributes positively to the first component, the index of economic dependency has a negative influence on this component (which is logically correct since the higher values of the index mean greater economic and social burden). The first component generally describes the economic development on the basis of input indicators and could itself serve as an index of economic development. If the Kaiser criterion is taken into account, the second component should also be included in the analysis. Here, the average rate of growth contributes positively along with the employment rate; on the other hand, GDP and income have a negative loading. The component, therefore, describes regions that are rapidly developing (average growth rate), but they are worse in other economic indicators. Regions that are "strong" regarding GDP and income, even with average values of employment and development rates, will have the worst score here. This results in the question of whether it is appropriate to evaluate the components separately as follows or to aggregate the two components into a composite index.

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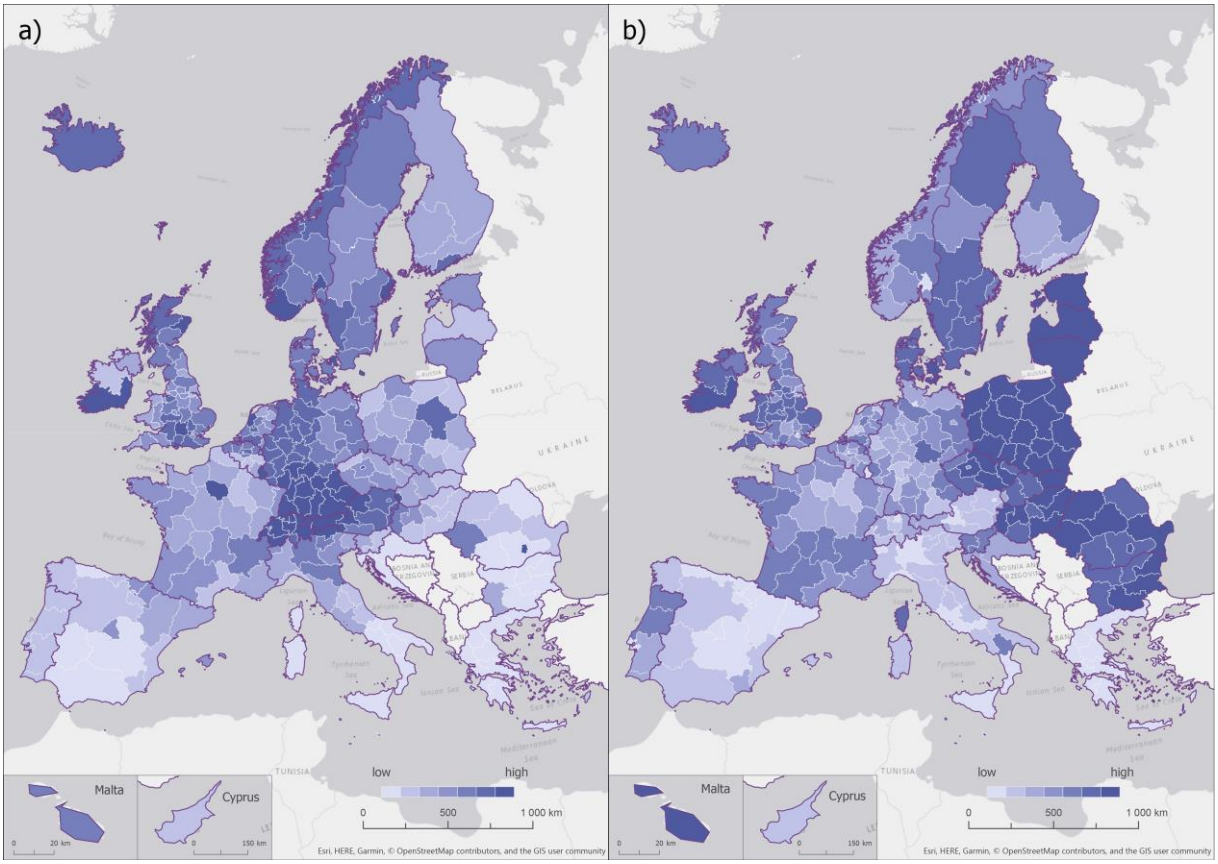
Figure 2 Visualisation of the first (a) and the second component (b)



The visualisation of individual components (Figure 2a, b) revealed spatial patterns of the phenomenon. The first component represents economically developed areas in line with the current overall perception of the situation in Europe: the high values are especially in central Europe – the southern part of Germany, part of Austria and Switzerland. Regions of Greece, Spain and southern Italy are on the opposite end of the ranking. On an overall scale, the capital cities are generally distinguished, indicating that the capitals are always important economic centres.

The visualisation of the second component brings greater contrasts. The border between the countries of the former Eastern Block and the rest of Europe is still well visible on this component, but it reveals the information that the eastern regions, though they have lower economic performance, are significantly growing.

Each component explains a portion of the variance in the original data. This information can define its significance, which can be used as the weight for the final sum. The weights have been modified to make up 100%. The resulting index is thus obtained according to the equation in Chapter 2.2., with a weight of first component 0.72 and the weight of the second component is 0.28. Based on the description and interpretation, both components are evaluated as positive for the index summarisation.

$$IED = \sum_{1}^{n} F_i W_i = PC1 \times 0.72 + PC2 \times 0.28 \quad (2)$$

Separate components well describe the situation from two perspectives; the synthetic index brings a complex result, however harder to interpret (Figure 3a) – especially in case of shattered values due to the slightly contradictory nature of the components. Since the composite index of economic development is more affected by the first component, spatial visualisation is closer to the first

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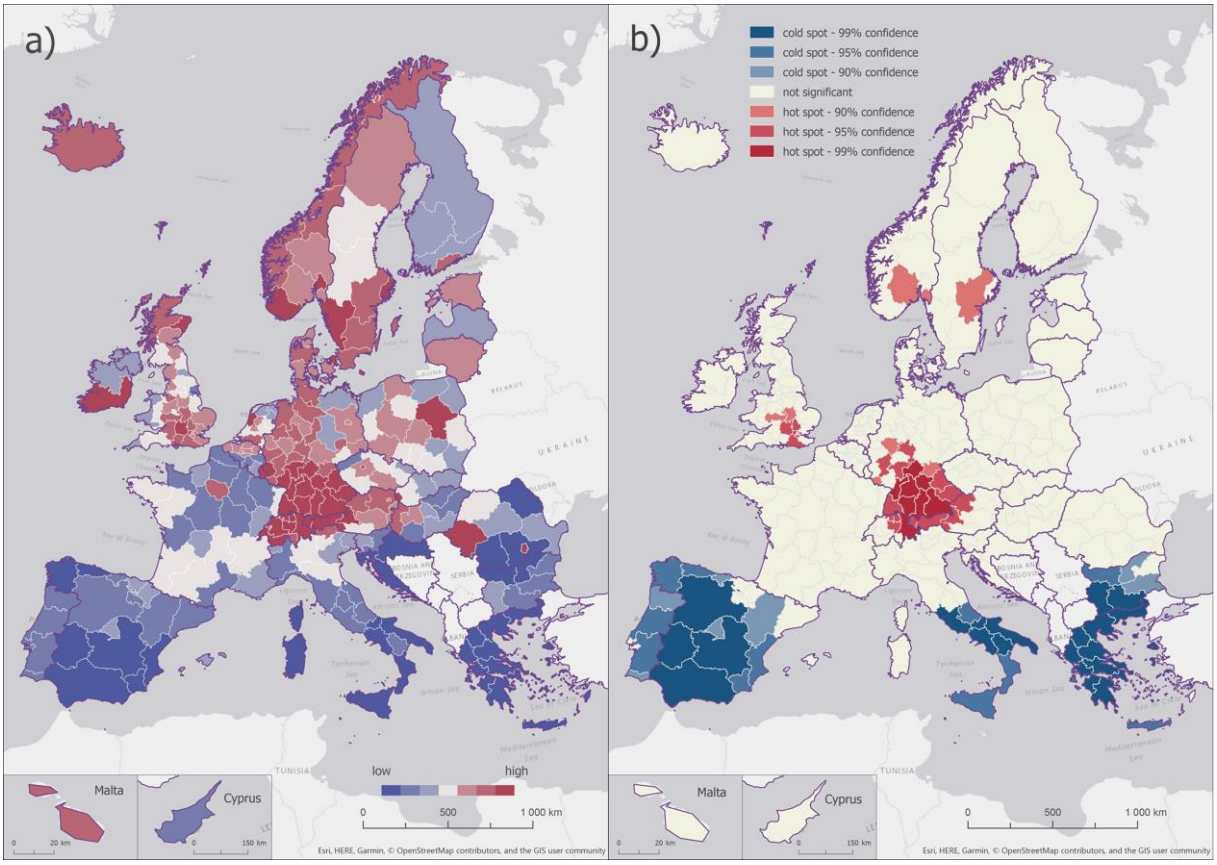
component. There are three major economically strong regions, central Europe (south of Germany, Switzerland and Austria), the western part of Scandinavia and the United Kingdom, with the strong influence of Inner London – West region, which is the business core of the whole United Kingdom. On the other hand, the worst-ranked areas are south-eastern Europe, Spain and southern Italy, regions that are known for economic problems, especially high unemployment. It is evident (from Figures 2, 3, and 4) that the northern part of Italy differs from the southern part. Higher values of IED (Figure 3a) are caused by the weights of input components; therefore, interpretation based on IED and typology map (Figure 4) might seem counterintuitive.

Figure 3 The composite index of economic development (a), the result of Hot Spot analysis (b)



In the area of interest, we find several outliers – values that do not fit into the overall trend. Most visible are the Romanian regions Bucharest and Vest, and the Irish Southern and Eastern, which rank in the top ten in the total index score. In the case of Ireland, this result can be explained by very high GDP and average growth. Bucharest is the capital region, and it is understandable that the overall score is out of the low average around, the Vest region is strongly influenced by high-value economic growth. In the overall index, surprisingly good are the regions of northeastern Europe, as well as in Romania, the result is influenced by the second component. To support the spatial interpretation of the results, a Hot Spot analysis (Getis – Ord Gi *) was run with the conceptualization of spatial relationship set to Contiguity edges corners. This setting considers for analysis only neighbouring regions, which touch by an edge or by only single points. The obtained result is reasonable for regions with variable units size. Hot Spot analysis (Figure 3b) has revealed several significant areas with high and low performance in the economic development index. These locations correspond to the verbal description as mentioned above. The advantage of the hot spot analysis lies in its ability to estimate the significance of the index value in the region in a geographical context (a defined surrounding area). Therefore, as a hot spot, only

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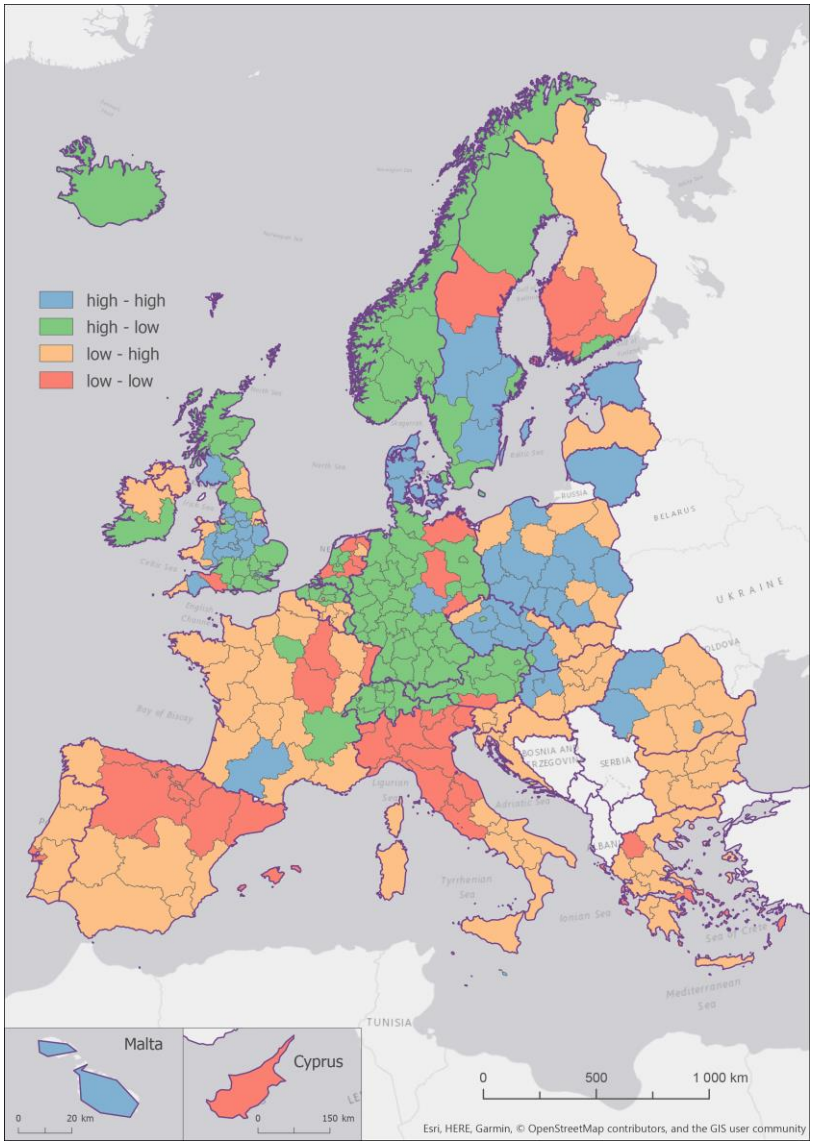
the places where high values are concentrated are delimited, rather than those where the high value occur at random (for example, high ranked regions in Poland alternating with average and low ranking)

The typology described in Table 1 (Chapter 2.2) divided the European regions into four groups (Figure 4), which can be considered as a confidence indicator of the calculated index. Regions labelled as high-low (developed regions) are high in both components and are most likely to be economically strong areas. The spatial location of this type approximately corresponds with the strongest areas identified by the Hot Spot analysis. Similarly, low-low (weak regions) is at the opposite end of the ranking, weak in both components. The inclusion of north-Italian regions (which are in general considered as economically significant) in this category is quite surprising. Regions classified as low-high (weak with uncertainty) or high-high (developed with uncertainty) need more attention, as there is a more significant difference between input components. Eastern Europe, as a whole, was classified into these types. For this reason, it is more appropriate to investigate these areas at a separate level of individual components and not only to follow the overall index.

Figure 4 Classification of European regions based on the difference between components



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The occurrence of those types might be explained primarily by a high score of the second component. All of the regions located in eastern Europe are highly ranked in the first component. The key role is played by the high growth rate of gross value added values and by the lowes values of GDP per capita and net disposable household income at the same time. If the region is evaluated as s HH – the high value of IED score is probably caused by the very high score at the second component. On the other hand, regions marked as LH also have a high score on the second component, but the score at first is significantly low, and it influences the total value index more because of the greater importance in the weighted sum. Taking into account the first component as the more important in terms of economic development, the HH regions are those with a better economic situation.

4 Discussion and conclusion

The analysis of the quality of life has great importance due to their implications in the political, economic and social matter. An example of the evaluation of individual aspects of quality of life is introduced in this paper, which deals with the regional analysis of economic indicators. To the authors' knowledge, there is a limited number of studies dealing with a similar topic at a regional level. Thus, the authors perceive the presented study to be contributing to the general discussion (and official political agendas – mentioned in the introduction) about development policies in Europe. Despite the fact that social development and quality of life is understood as a complex issue, this paper offers detailed analyses on a particular domain focused on economic evaluation. This convenes with a “traditional” concepts of regional policies that grasp mainly economic matters.

The analysis has encountered some issues. The entire authors’ research notes the lack of sufficient regional data. It is the advantage to have central databases (Eurostat, OECD) where statistics are freely available. Unfortunately, at the regional level, there are often missing values, and the up-to-dateness of data is unsatisfactory. When looking for alternative sources to substitute missing data, there is a problem of conceptual compatibility. In various sources, data is, for example, in other units, or the topic which data represents is differently defined. Unfortunately, at the regional level, there are often missing values, and the up-to-dateness of data is unsatisfactory. Caused by these data issues, at a deeper administrative level (NUTS 3) is not such an analysis possible. This issue has also been discussed with Eurostat representative; the problem is primarily the inability to force individual member states to provide high-quality data to the central database.

The intention was rather to present the possibilities of aggregating data into indexes than to process accurate econometric analysis. Caused by this approach, economists may have objections to the selection of indicators. Selection was strongly influenced by the offer of available data. If analysis is processed at the national level, the data offer is much broader. But as Hardeman & Dijkstra (2014) state, disparities across regions within the same country might well be more extensive than disparities across countries at large. For this fact, authors decided to perform the evaluation at the regional level, even with the presence of a reduction of available data. Same as dozens of other studies, this paper points to the fact, that there is a still lack of the data on the regional level, which could be used for a broad-area (such as Europe) analysis.

There are many simple methods of data aggregation, like a simple arithmetics of standardised data. Simple approaches do not catch the data character regarding, e.g. its variance or variation. Importance of particular indicators can be controlled by, e.g. weighted summarisation. Without the expert knowledge of all input data, which could help to define a set of weight for a weighted summarisation, an alternative solution can be found in multidimensional statistics. The PCA itself has proven to be a useful data aggregation method, especially for its objectivity that seeks the most significant variation in input data. Using one component to describe one topic is an ideal situation. One component is usually easy to explain and interpret. However, if this component does not cover a sufficient variation of data, it is also necessary to consider other components (second, third etc.). Based on the experience in this article, the authors recommend that each component should be evaluated

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separately. In the case where one thematic phenomenon, i.e. economic development, is analysed by PCA, component arithmetics as a method for obtaining the aggregate index is questionable. Since all input indicators are thematically and numerically correlated, the PCA's essence is to look for a difference between the new components, which may also result in a certain contradiction affecting the results. This is the case of the second component in this paper, which was influenced by two groups of indicators, one group with positive influence, the second one with negative. In case when all of these indicators are considered as positive in terms of economic development, it is a demanding task to interpret such a component properly. For this reason, it seems to be more appropriate to use the first component as a composite index and add more components to the index if each one represents the thematically different but homogeneous phenomena (e.g. economic development and environmental conditions).

Adding the spatial aspect to the analysis enables to see relationships and spatial patterns in the results, which are not clear when using only tabular or graphic outputs. Spatial visualisation is always helpful in terms of the easy delivery of the information. The Hot Spot analysis reveals the most significant areas with high/low values of the composite index. In the case of region's classification based on components differences, trends within the regions of particular countries are visible. For this benefit of easy perception, the author recommends using a spatial approach to data visualisation, whenever working with any space-located information.

For further research, several topics and questions arose. There are other methods of index construction, and it would be needed to analyse, how results of different approaches differ. The authors believe that there would be significant differences between statistical aggregation methods. Subsequently, it would be necessary to verify the results. Currently, authors negotiate with Eurostat on the matter of obtaining microdata on Material and Living Conditions in European regions. With such data, the topic of subjective satisfaction with financial situation and development can be used as reference data for the index validation.

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