## ERES 2012

**Title:** Determining Indicators of Quality of Life Differences in European Cities

**Authors**: Wolfgang Breuer and Dominique Schaeling from RWTH Aachen University

**Abstract:** The comparison of cities by indicators covering several topics of urban life is crucial for policy decisions such as the funding allocation for urban development. Simply adding up a high number of indicators to one single index evokes reasonable criticism due to opacity and very limited interpretation possibilities. Nevertheless, the same arguments can be made against using large sets of disaggregated indicators for city comparison. This paper helps to steer a middle course by identifying a small number of relevant indicators to determine quality of life differences. The basis of this analysis is the Urban Audit Key Indicator Set which is provided by the Eurostat database and consists of 46 indicators covering different aspects of urban life. Principal component analysis reveals a small number of indicators which have a high impact on the overall differences between the selected cities of each of the ten countries and five time frames that were analysed. This study extends the general application of principal component analysis for regional clustering by the combination of 244 partial analyses to identify determining indicators of urban differences. The results show that a small set of nine indicators, which are often among the most relevant determinants, can be identified. Those selected indicators are spread over the initial groups representing environmental, human, manufactured and social urban capital as well as demographic aspects. They cover current political debates on environmental, infrastructural and migration difficulties in cities, safety and especially security impairment due to anonymity and poverty in densely populated areas as well as population changes leading to space shortage in larger cities, but also abandonment in small cities. Applying this method to wider data sets seems promising as it might lead to important insights which could impact policy measures on urban development and its funding allocation processes.

**Key words:** urban differences, indicators, policy measures

**JEL- Classifications**: Q01, R5

# 1 Introduction

Urbanization is one of the most challenging aspects of our modern society. Nowadays, cities are both the engine of economic growth and the venue of social problems. As approximately 80 % of the European Union's population lives and works in urban areas, recreation of cities is an important issue to ensure economic and social stability of this union. Therefore, policy measures in the field of urban development to improve the quality of life in european cities have become more and more important over the last years. With the start of the current programming period of the European Structural Funds the topic of urban development has reached a new dimension with the JESSICA Initiative for the promotion of sustainable development in urban areas through financial engineering instruments (see European Union, 2006). The general need for urban quality of life assessments as a basis for urban comparisons has thus steadily grown to build a sound foundation for policy decisions.

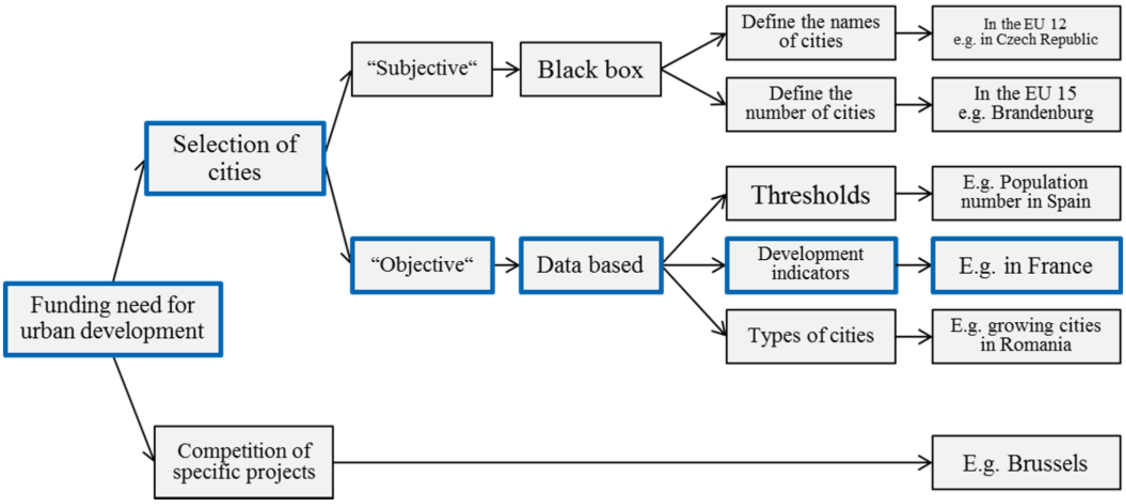


**Figure 1: Funding target determination in the ERDF Operational Programmes of the current Programming Period 2007-2013**

The European Regional Development Fund (ERDF) Operational Programmes enforce european policy decisions for urban development. Thus, urban or regional comparisons are partly included for the determination of funding targets. Figure 1 gives an overview of applied methods to urban funding targets. This figure is an extended version of the findings of European Commission (2008).

The most interesting way of funding determination is the highlighted one, which defines cities eligible for funding through objective data based criteria including development indicators. This study adapts the general idea of employing indicators, but identifies only a small number of indicators for quality of life comparisons of cities as the basis for policy decisions. In addition, the results can serve as basis for an efficiency analysis of funding as well.


Figure 2: City comparison for funding target determination (left) and funding efficiency analysis (right).

Figure 2 reveals one possibility for the assessment of nonmonetary aspects like the quality of life trough indicators (left plot). Changes in these indicators then give insights into funding efficiency (right plot).

However, the assessment of nonmonetary aspects always poses a problem. In the case of Figure 1, the definition of the two considered indicators is crucial for the results and their interpretation. The same holds true when applying other techniques for urban comparisons like the definition of one highly aggregated index or the proposal of large indicator sets. These two extremes have their advantages and disadvantages. With respect to the first one, difficult interpretations arise with single indexes (Mayer, 2008) when they cover multiple aspects like e.g. environment, manufacture, or demography. An aggregated approach for city comparison produces neat results and reflects extremes in the differences, but values which do not clearly belong to the top or to the bottom, do not allow a solid statement, since the differences in the values of medium ranked cities are comparatively small due to neutralisation effects in the aggregation. Due to these consequences, there is no possibility to interpret the influencing indicators and initial data, which are responsible for the differences among the compared cities. In the practice of regional development within the European Structural Funds, the main indicator for regional allocation of funding is not even very aggregated, it simply is the Gross Domestic Product (European Council, 2006). The latter approach, the definition of whole indicator sets, is a tedious task and results in a large number of indicators to measure the quality of life in cities. Therefore, it is impossible to handle all enclosed information objectively when maintaining all items of the initial description and funding efficiency measurement would not be possible by common methods. Hence, a trade-off between loss of information and interpretability is necessary. In the practice of European regional development policies, the targets for urban areas are defined in the ERDF Operational Programmes (see Figure 1). These documents include a broad analysis of regional differences where often hundreds of indicators are considered, but the final decision on funding targets to support neglected areas is often opaque due to information overflow or to only a small number of diverse indicators selected without justification (see e.g. Operational Programme Brandenburg ERDF 2007-2013, 2007 and Operational Programme South-East ERDF 2007-2013, 2007). Finally, as a middle way, there are framework approaches that apply more sophisticated methods like the multidimensional scaling or the principal component analysis to reduce the complexity of the initial indicator sets to a smaller dimension which is higher than one by defining synthetic compressed indicators. Hence, these methods combine lower complexity with better clarification of the cities' relative positioning. But practitioners often tend to avoid such reduced framework approaches based on advanced mathematical methods, because the interpretation of the resulting compressed indicators is difficult. This study reveals those indicators of an initial large set which are good representatives for the overall differences among cities by the use of principal component analysis without the use of synthetic indicators. The application of principal component analysis to reveal clusters and uncover disparities among nations or one nation's regions is not new. But this study analyses the influences of the initial indicators on the new composites in a broader way in order to reveal determinants of urban quality of life differences over a large sample of several countries, with its cities, and time frames. Thereby, we contribute to bridge the gap between the existing approaches of comparing cities by only one index on the one hand or by only considering some aspects of development on the other hand. In addition, our approach is also superior to those that apply large sets of indicators without any specific methodology to reduce their complexity.

The structure of this paper is as follows. A literature review is given in the next section. Section 3 introduces the principal component analysis and the applied rotation technique. Section 4 presents the data and its selection criteria. Afterwards, the general structure of the analysis is shown in Section 5. Section 6 offers insights into the results of the analyses. Finally, the paper concludes by summarizing the results in Section 7.

## 2 Literature review

This section aims at providing a general overview of existing literature related to urban quality of life differences. However, to get an idea about current research approaches, this review covers the slightly more general but strongly interconnected case of urban and regional development discrepancies.

First, there are very specific approaches including only limited aspects of development for the comparison of cities and regions as Nijkamp (1986), who only concentrates on infrastructural influences. Another example is Callais and Aubert (2007). They analyse the impact of social capital on regional development empirically. A great advantage of such approaches is the limited number of variables included in the analyses. Hence, interpretation of the results is directly possible without the need for strong compressions.

The second type of literature related to this study consists of comparisons by indexes for quality of life and more general for sustainability. Singh et al. (2009) give an overview of sustainable development indexes which shows that the application of principal component analysis for the definition of indexes is not unusual. Li et al. (2006) and Soler Rovira (2009) each develop a synthetic index without interpreting the results in the context of sustainability aspects. Representatives for the missing interpretation of quality of life indexes are Slottje (1991) as well as Somarriba and Pena (2009). The strength of indexing is the clear ranking of items, but there is no possibility of in–depth interpretation. Mayer (2008) concludes that one index cannot cover the multidimensionality of sustainability. Parris and Kates (2003) state that the plurality nature of sustainable development inhibits the clear definition of one appropriate and interpretable index. Of course, both issues are equally true for the measurement of quality of life, as the topics are strongly connected (see Mitchel et al., 1995).

The third group consists of specific studies in the context of regional disparities uncovered by principal component analysis. This is e.g. done for Portuguese regions by Oliveira et al. (2003), for Greek regions by Monastiriotis (2007), for Turkish regions by Özaslan et al. (2006) and on a higher level for European countries by Tausch et al. (2007). In these studies indexing problems still arise as proper interpretation of the new components often lacks and the defined clusters by topics are vague.

In the first group the input for comparison is very limited, whereas in the other two groups of literature the output is very compressed and thus in–depth interpretation is problematic. This study will help to steer the middle way by identifying a small number of determining indicators for the differences among cities. The input is a large indicator set and thus not limited whereas the output is a small set of indicators which are not compressed and thus interpretation is easily possible.

# 3 Method

## 3.1 Principal component analysis for urban comparison

The principal component analysis (PCA) transforms differences that are originally defined in a complex, multidimensional manner in the form of a large set of indicators into quite a small number of dimensions. Hence, it neatly arranges the objectives of comparison in a smaller dimensional space without any assumption on the indicators' distributions or their patterns of causality (Morrison, 1990).

The PCA reduces the dimensions by a variance maximising technique. This means that the method tries to keep as much of the data's original variability as possible by reducing the complexity simultaneously. It generates a new set of variables by combining the initial indicators linearly. The new variables are determined step by step under the condition of preserving the maximal possible information defined by the variability. A useful feature of the PCA is that the newly generated variables are ordered by the amount of variance in the data which they describe (thus by their informational contents). By only considering the variables that capture the most part of the information, it reduces the number of variables which are further analysed.

For example, a comparison of cities by the two standardised indicators “highly educated proportion female” and “highly educated proportion” leads to the following figure:

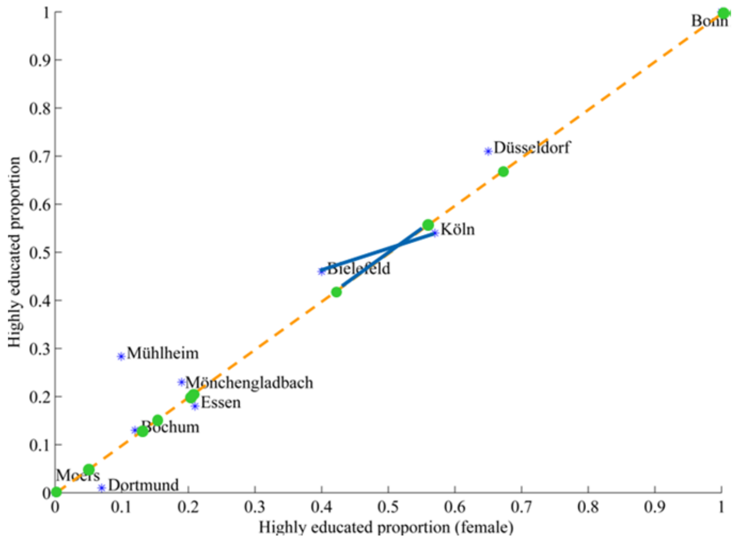


Figure 3: PCA with two education indicators.

The data points of the cities (printed as stars) nearly lie on the dashed line, representing the angle bisector. In this example, the PCA determines a new variable, which is represented by the angle bisector – that expresses almost completely all the differences between cities in their relative positioning. The new data points for the compressed variable all lie on the angle bisector (printed as points in Figure 3). In this case, 99 % of the original overall variance are captured by the new variable. Comparing Cologne – named Köln – and Bielefeld, the plot reveals that the distance of the original data points is the same as the distance of the new points corresponding to these cities, as shown by the two bold lines of nearly the same length. In this special case, the new value for each city is calculated by the equally weighted sum of the two initial indicators. It is not necessary to separately analyse the two indicators for the relative comparison of the cities here, because the PCA condenses this information in the new value with hardly any loss of information.

If considering more indicators, one new variable normally does not explain enough overall variance of the dataset. Then, additional new variables are determined in the same way as described above with the further condition of being orthogonal – thus uncorrelated – to the previous ones. This results in a set of new variables – principal components – that explains the differences between the cities in lower dimensions. The number of principal components necessary to reproduce the differences of the cities depends on the desired accuracy. There are several criteria for the definition of boundaries to determine the new number of axes.

Finally, the influences of the original indicators – called factor loadings – can be reconstructed to allow for analyses of the final positioning of cities and interpretation of the obtained principal components (Marques de Sá, 2007). As the factor loadings are often widely spread among the principal components, rotation methods help to overcome the resulting interpretation difficulties.

## 3.2 Rotation of the principal components for the determining indicators' identification

The aim of rotation techniques for obtained principal components is to find new axes that maintain the mathematical fit of the method and exhibit better interpretation opportunities. Each rotated principal component thus should have high factor loadings of some initial indicators while at the same time the loadings of the other indicators are small. The result of a rotation is a set of new variables (like the axes in the right plot of Figure 4) that have a high variation across the influences of the underlying indicators.

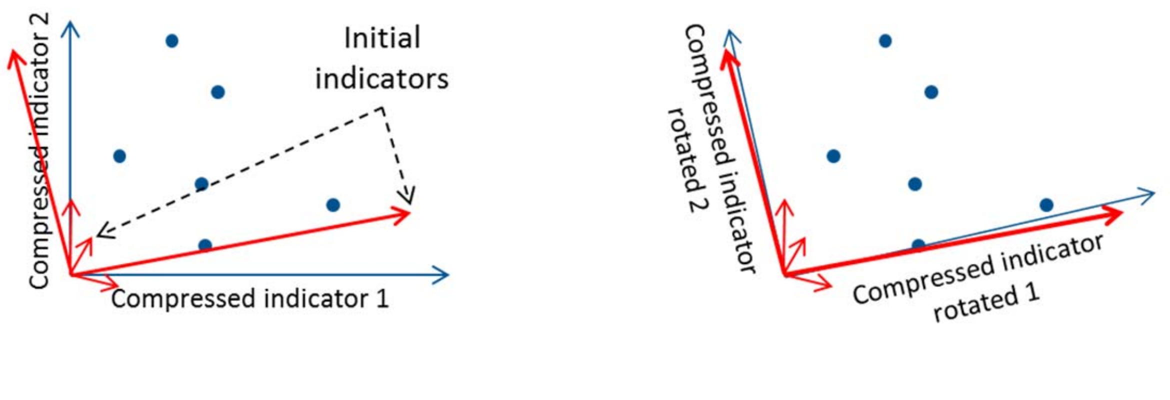


Figure 4: Influence of the initial indicators on the compressed indicators before (left) and after (right) rotation.

Figure 4 reveals this by the almost perfectly given identity of the new axes and the two bold initial indicators while the others are unimportant for the differences among the compared cities. Hence, the factor loadings of these rotated principal components indicate the explanatory power of the urban audit indicators for the differences among cities so that the positioning of the cities can be explained for each new dimension by only a few initial indicators (see Figure 4 where only one indicator explains each new dimension). The rotation method employed in this paper is called varimax rotation. It keeps the orthogonality of the axes and maximises the sum over all components' variance of the squared loadings (Mulaik, 1972).

# 4 Data

## 4.1 General data structure and categorisation

The data basis for this research study is the Urban Audit Key Indicator Set for core cities – the administrative unit of a city –, which is available as part of the Eurostat database. Urban Audit in general is a data collection of indicators to measure the quality of life in cities of the European Union and candidate or neighbouring nations. With this data collection the DG Regio and Eurostat initiated a basis for a comparison necessary for policy measures on the urban level, which is exactly this study's approach. Therefore, they defined criteria for one nation's Urban Audit city selection which include e.g. a 20 % proportion of inhabitants living in Urban Audit cities as well as geographic and size distributions (European Commission, 2009). The data set for the analyses of this paper (downloaded on February 7th 2012) consists of 30 nations – the EU 27 together with Turkey, Switzerland, and Norway – with 372 urban units (counting some metropolitan areas as double units: one for the city and the other includes the broader urban area). Table 1 shows the number of cities taking part in the Urban Audit for each nation.

| Nation | # Units | Nation | # Units | Nation | # Units |
|---|---|---|---|---|---|
| Germany | 40 | Portugal | 10 | Austria | 5 |
| France | 36 | Switzerland | 10 | Denmark | 5 |
| Italy | 32 | Greece | 9 | Finland | 5 |
| United Kingdom | 31 | Hungary | 9 | Lithuania | 3 |
| Poland | 28 | Sweden | 9 | Estonia | 2 |
| Spain | 26 | Bulgaria | 8 | Latvia | 2 |
| Turkey | 26 | Slovakia | 8 | Malta | 2 |

| | | | | | |
|---|---|---|---|---|---|
| Netherlands | 15 | Belgium | 7 | Slovenia | 2 |
| Czech Republic | 14 | Ireland | 6 | Cyprus | 1 |
| Romania | 14 | Norway | 6 | Luxembourg | 1 |

**Table 1: Number of Urban Audit cities for each available nation.**

The data for each urban unit is available for different time frames. One time frame thereby defines only one data point. Its calculation differs depending on the original data availability (European Commission, 2009). The considered time frames here are: 1989–1993, 1994–1998, 1999–2002, 2003–2006, 2007–2009. For more details on slight country specific definition differences and variations of reference years see European Commission (2007b) and for general clarification of the definition see European Commission (2004).

The key indicators cover several aspects of urban life quality. For our analyses, the indicators are newly categorised to maintain a more general and broader structure. Table 2 shows all indicators arranged by their categories.

| Category | Indicators |
|---|---|
| Demographic | Population density in Urban Audit cities |
| Demographic | Total annual population change over approximately 5 years |
| Demographic | Total population change over 1 year |
| Demographic | Total Population at working age |
| Demographic | Total population in Urban Audit cities |
| Environmental | Registered cars in Urban Audit cities as number of cars per 1000 inhabitants |
| Environmental | Share of journeys to work by car in Urban Audit cities as % |
| Environmental | Total land area ($km^2$) according to cadastral register |
| Environmental | Proportion of solid waste arising within the boundary processed by landfill |
| Environmental | Collected solid waste in Urban Audit cities as tonnes per inhabitant and year |
| Environmental | Consumption of water (as cubic metres per annum) per inhabitant |
| Environmental | Number of days particulate matter concentrations exceeds 50 $\mu g/m^3$ in Urban Audit cities as days per year |
| Environmental | Number of days ozone concentration exceeds 120 $\mu g/m^3$ in Urban Audit cities as days per year |
| Human | Number of deaths in road accidents per 10000 population |
| Human | Proportion of working age population qualified at level 5 or 6 ISCED – female |
| Human | Proportion of population aged 15-64 qualified at tertiary level (ISCED 5-6) living in Urban Audit cities as % |
| Human | Proportion of working age population at level 1 or 2 ISCED – female |
| Human | Proportion of working age population qualified at level 1 or 2 ISCED |
| Human | Proportion of female students in higher education (ISCED level 5-6) |
| Human | Proportion in part-time employment |
| Human | Employment/Population (of working age) ratio |
| Human | Self-employment rate |
| Human | Unemployment rate in Urban Audit cities as % |
| Manufactured | Number of stops of public transport per $km^2$ |
| Social | Cost of a monthly ticket for public transport (for 5-10 km) |
| Social | Average time of journey to work |
| Social | Children 0-2 in day care (public and private) per 1000 children |
| Social | Number of domestic burglary per 1000 population |
| Social | Car thefts in Urban Audit cities as number per 1000 inhabitants |
| Social | Available hospital beds in Urban Audit cities per 1000 inhabitants |
| Social | Average living area in Urban Audit cities as $m^2$ per person |
| Social | Proportion of households living in owned dwellings in Urban Audit cities as % |
| Social | Price of a $m^3$ of domestic water |
| Social | Percentage of households receiving less than half of the national average household income |
| Social | Proportion of households with children aged 0-17 in Urban Audit cities as % |

| | |
|---|---|
| Social | Average household size in Urban Audit cities as number of persons per household |
| Social | Proportion of one-person households in Urban Audit cities as % |
| Social | Nationals born abroad as a proportion of total population |
| Social | Non-EU nationals as a proportion of total population |
| Social | EU nationals as a proportion of total population |
| Social | Nationals as a proportion of total population |
| Social | Number of tourist overnight stays in registered accommodation per year per resident population |
| Social | Tourist overnight stays in registered accommodation in Urban Audit cities as number of nights per year |
| Social | Annual visitors to museums per resident |
| Social | Cinema seats in Urban Audit cities as seats per 1000 inhabitants |
| Social | Percentage of elected city representatives who are men |

**Table 2: Urban Audit Key Indicators arranged by general categories.**

The demographic category covers all indicators of population size, changes, and distribution. The other four categories represent Ekins and Medhurst's (2006) concept of capital. Environmental (or natural) capital covers all natural aspects linked in a smaller or broader sense to human welfare, whereas manufactured capital describes produced assets which then help to produce goods and services. The last two categories are human and social capital. They refer to the well-being on an individual or societal level, respectively. Table 2 already reveals that the indicators are not equally distributed among the categories. Especially manufactured and social capital have highly different extents. This abnormality does not only occur for the general category structure applied in this study, but also for Eurostat's own more detailed and differently arranged categorisation which divides the indicators into demography, social aspects, economic aspects, civic involvement, training and education, environment, travel and transport, information society as well as culture and recreation.

## 4.2 Data selection and final data availability for the study

Unfortunately, there are high variations on data availability across different cities and time frames which is revealed by an analysis for every combination of a nation's cities and time frames. Therefore, a reduction of cities and time frames under consideration is necessary to take data gaps into account. We do so in a way that remaining numbers of cities and time frames are as large as possible.

| Nation | Time frame | # Units | # Indicators | Nation | Time frame | # Units | # Indicators |
|---|---|---|---|---|---|---|---|
| France | 1989-1993 | 35 | 11 | Poland | 2007-2009 | 28 | 24 |
| France | 1999-2002 | 28 | 24 | Romania | 1989-1993 | 14 | 13 |
| France | 2003-2006 | 34 | 28 | Romania | 1994-1998 | 14 | 5 |
| Germany | 1989-1993 | 30 | 15 | Romania | 1999-2002 | 13 | 23 |
| Germany | 1994-1998 | 31 | 23 | Romania | 2003-2006 | 14 | 14 |
| Germany | 1999-2002 | 38 | 26 | Romania | 2007-2009 | 14 | 11 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Germany | 2003-2006 | 40 | 34 | Spain | 1989-1993 | 16 | 11 |
| Germany | 2007-2009 | 39 | 32 | Spain | 1994-1998 | 17 | 13 |
| Italy | 1989-1993 | 27 | 17 | Spain | 1999-2002 | 14 | 23 |
| Italy | 1994-1998 | 27 | 11 | Spain | 2003-2006 | 25 | 28 |
| Italy | 1999-2002 | 27 | 32 | Spain | 2007-2009 | 25 | 28 |
| Italy | 2003-2006 | 32 | 20 | CR | 1989-1993 | 5 | 19 |
| Italy | 2007-2009 | 32 | 19 | CR | 1994-1998 | 5 | 18 |
| Netherlands | 1994-1998 | 10 | 5 | CR | 1999-2002 | 5 | 31 |
| Netherlands | 1999-2002 | 10 | 25 | CR | 2003-2006 | 4 | 20 |
| Netherlands | 2003-2006 | 15 | 30 | CR | 2007-2009 | 14 | 17 |
| Netherlands | 2007-2009 | 15 | 14 | Turkey | 1999-2002 | 26 | 12 |
| Poland | 1989-1993 | 23 | 10 | Turkey | 2003-2006 | 22 | 6 |
| Poland | 1994-1998 | 23 | 10 | UK | 1999-2002 | 25 | 11 |
| Poland | 1999-2002 | 22 | 37 | UK | 2003-2006 | 31 | 10 |
| Poland | 2003-2006 | 27 | 21 | UK | 2007-2009 | 31 | 9 |

**Table 3: Remaining data after selection by number of cities – units – and indicators.**

Table 3 presents the resulting data set. The abbreviation UK stands for United Kingdom and CR for Czech Republic.

Furthermore, a minimum maximum standardisation technique adapts the data scales as a second step. Hence, any original data point $x_i$ – with $i = 1, \ldots, n$, while n represents the number of cities – for one indicator is transformed into

$$y_i = \frac{x_i - min_j\, x_j}{max_j\, x_j - min_j\, x_j}, \text{ with } i, j = 1, \ldots, n.$$

Then, the data is well prepared for the following analyses.

## 5 Analysis

The program MATLAB R2011b offers all main procedures necessary for the overall computation of this study which combines the mentioned standardization with the principal component analysis and the varimax rotation method afterwards. Hence, it is an appropriate basis for the following analyses.

The aim of this study is to identify a small number of indicators which have a high impact on the overall differences between the selected cities of each of the analysed nations and time frames. Therefore, three decisions arise in each partial analysis: first, the definition of accuracy limits. Second, there is the choice of a nation and, third, the selection of a time frame. Here, the study covers six accuracy limits, ten nations and five time frames resulting after elimination of some data sets due to availability problems in 244 partial analyses. The six accuracy limits consist of two preset limits. First, principal components need to explain at least 70 %, 80 %, or 90 % of overall variation in the data by inclusion of all principal components with explanatory power of at least 10 %. Second, the loadings after rotation should have at least a value of 0.3 or 0.4, respectively. Thus, the indicator loadings fulfil the condition of being significant for small samples (Kline, 2002).

The results of each partial analysis are the selected indicators with a sufficiently high explanatory power regarding the differences between the cities under consideration. Afterwards, for each indicator the percentage of situations (characterized by a certain accuracy limit, a certain country and a certain time frame) is calculated in which the respective indicator has been chosen. Those indicators with the 20 % highest proportion are then selected as determinants for urban differences as a result of the overall analysis.

In addition, we conduct robustness and adaptability checks by analysing the results for each nation and each time frame separately in a partial analysis. By doing so, we test for nation and time specific variations.

# 6 Results

## 6.1 Overall analysis

This part of the study reveals the overall explanatory power of indicators for urban quality of life differences by Urban Audit data for cities of ten nations and five time frames. See Table 4 for the results.

| | | Accuracy limits | | | | | | Result |
|---|---|---|---|---|---|---|---|---|
| Category | Indicators | 70 0.3 | 70 0.4 | 80 0.3 | 80 0.4 | 90 0.3 | 90 0.4 | |
| Manufactured | Number of stops of public transport per km2 | 0.67 | 0.67 | 1.00 | 1.00 | 1.00 | 1.00 | 0.89 |
| Environmental | Proportion of solid waste arising within the boundary processed by landfill | 0.75 | 0.38 | 1.00 | 0.75 | 1.00 | 1.00 | 0.81 |
| Environmental | Number of days ozone concentration exceeds 120 µg/m³ in Urban Audit cities as days per year | 0.83 | 0.67 | 0.83 | 0.83 | 0.83 | 0.83 | 0.81 |
| Social | Nationals born abroad as a proportion of total population | 0.81 | 0.63 | 0.93 | 0.57 | 1.00 | 0.71 | 0.78 |
| Demographic | Total population change over 1 year | 0.78 | 0.47 | 0.93 | 0.67 | 0.93 | 0.77 | 0.76 |
| Human | Proportion of working age population qualified at level 5 or 6 ISCED – female | 0.67 | 0.44 | 1.00 | 0.63 | 1.00 | 0.75 | 0.75 |
| Demographic | Total annual population change over approximately 5 years | 0.69 | 0.45 | 0.93 | 0.63 | 0.93 | 0.78 | 0.73 |
| Social | Number of domestic burglary per 1000 population | 0.69 | 0.46 | 0.77 | 0.69 | 0.85 | 0.85 | 0.72 |
| Social | Car thefts in Urban Audit cities as number per 1000 inhabitants | 0.68 | 0.47 | 0.79 | 0.68 | 0.89 | 0.74 | 0.71 |
| Demographic | Total population in Urban Audit cities | 0.76 | 0.34 | 0.90 | 0.49 | 0.95 | 0.77 | 0.70 |
| Human | Number of deaths in road accidents per 10000 population | 0.41 | 0.41 | 0.81 | 0.63 | 1.00 | 0.94 | 0.70 |
| Demographic | Total Population at working age | 0.74 | 0.36 | 0.89 | 0.49 | 0.92 | 0.76 | 0.69 |
| Human | Proportion of population aged 15-64 qualified at tertiary level (ISCED 5-6) living in Urban Audit cities as % | 0.78 | 0.22 | 1.00 | 0.50 | 1.00 | 0.63 | 0.69 |
| Human | Unemployment rate in Urban Audit cities as % | 0.88 | 0.48 | 0.88 | 0.50 | 0.83 | 0.50 | 0.68 |
| Environmental | Number of days particulate matter concentrations exceeds 50 µg/m³ in Urban Audit cities as days per year | 1.00 | 0.25 | 1.00 | 0.25 | 1.00 | 0.50 | 0.67 |
| Human | Employment/Population (of working age) ratio | 0.71 | 0.48 | 0.75 | 0.60 | 0.85 | 0.55 | 0.66 |
| Social | Cinema seats in Urban Audit cities as seats per 1000 inhabitants | 0.58 | 0.42 | 0.82 | 0.45 | 1.00 | 0.64 | 0.65 |
| Social | Proportion of households living in owned dwellings in Urban Audit cities as % | 0.62 | 0.29 | 0.89 | 0.53 | 0.89 | 0.63 | 0.64 |
| Social | Nationals as a proportion of total population | 0.70 | 0.33 | 0.76 | 0.52 | 0.84 | 0.68 | 0.64 |
| Social | Percentage of elected city representatives who are men | 0.67 | 0.11 | 0.89 | 0.44 | 1.00 | 0.67 | 0.63 |
| Social | Non-EU nationals as a proportion of total population | 0.74 | 0.30 | 0.76 | 0.43 | 0.81 | 0.67 | 0.62 |
| Social | Average living area in Urban Audit cities as m² per person | 0.76 | 0.38 | 0.80 | 0.40 | 0.80 | 0.55 | 0.62 |
| Environmental | Total land area (km2) according to cadastral register | 0.64 | 0.24 | 0.83 | 0.42 | 0.88 | 0.67 | 0.61 |
| Environmental | Consumption of water (as cubic metres per annum) per inhabitant | 0.63 | 0.31 | 0.73 | 0.53 | 0.87 | 0.60 | 0.61 |
| Social | Cost of a monthly ticket for public transport (for 5-10 km) | 0.71 | 0.29 | 0.83 | 0.33 | 0.83 | 0.67 | 0.61 |
| Human | Proportion of working age population at level 1 or 2 ISCED – female | 0.50 | 0.25 | 0.86 | 0.43 | 1.00 | 0.57 | 0.60 |
| Social | Number of tourist overnight stays in registered accommodation per year per resident population | 0.45 | 0.30 | 0.75 | 0.55 | 0.85 | 0.70 | 0.60 |
| Environmental | Collected solid waste in Urban Audit cities as tonnes per inhabitant and year | 0.44 | 0.22 | 0.67 | 0.56 | 0.89 | 0.67 | 0.57 |
| Social | Available hospital beds in Urban Audit cities per 1000 inhabitants | 0.56 | 0.32 | 0.76 | 0.32 | 0.88 | 0.60 | 0.57 |
| Social | Proportion of one-person households in Urban Audit cities as % | 0.64 | 0.32 | 0.70 | 0.35 | 0.87 | 0.57 | 0.57 |
| Human | Proportion of female students in higher education (ISCED level 5-6) | 0.57 | 0.29 | 0.69 | 0.38 | 0.92 | 0.54 | 0.57 |
| Social | Average household size in Urban Audit cities as number of persons per household | 0.50 | 0.25 | 0.60 | 0.50 | 0.80 | 0.70 | 0.56 |
| Social | Tourist overnight stays in registered accommodation in Urban Audit cities as number of nights per year | 0.70 | 0.25 | 0.85 | 0.35 | 0.90 | 0.30 | 0.56 |
| Human | Self-employment rate | 0.58 | 0.38 | 0.74 | 0.35 | 0.74 | 0.57 | 0.56 |
| Environmental | Registered cars in Urban Audit cities as number of cars per 1000 inhabitants | 0.53 | 0.16 | 0.78 | 0.39 | 0.83 | 0.61 | 0.55 |
| Demographic | Population density in Urban Audit cities | 0.58 | 0.35 | 0.68 | 0.48 | 0.72 | 0.48 | 0.55 |
| Human | Proportion in part-time employment | 0.58 | 0.21 | 0.74 | 0.35 | 0.78 | 0.52 | 0.53 |
| Human | Proportion of working age population qualified at level 1 or 2 ISCED | 0.67 | 0.11 | 0.75 | 0.38 | 0.88 | 0.38 | 0.53 |
| Social | Proportion of households with children aged 0-17 in Urban Audit cities as % | 0.60 | 0.20 | 0.68 | 0.32 | 0.79 | 0.53 | 0.52 |
| Social | Children 0-2 in day care (public and private) per 1000 children | 0.75 | 0.38 | 0.57 | 0.43 | 0.57 | 0.29 | 0.50 |
| Social | Annual visitors to museums per resident | 0.31 | 0.08 | 0.58 | 0.33 | 0.83 | 0.58 | 0.45 |
| Social | Average time of journey to work | 0.71 | 0.14 | 0.69 | 0.15 | 0.77 | 0.23 | 0.45 |
| Social | EU nationals as a proportion of total population | 0.48 | 0.17 | 0.76 | 0.19 | 0.71 | 0.38 | 0.45 |
| Social | Percentage of the households receiving less than half of the national average household income | 0.20 | 0.20 | 0.67 | 0.00 | 1.00 | 0.33 | 0.40 |
| Social | Price of a m3 of domestic water | 0.40 | 0.20 | 0.50 | 0.50 | 0.50 | 0.25 | 0.39 |
| Environmental | Share of journeys to work by car in Urban Audit cities as % | 0.50 | 0.08 | 0.36 | 0.09 | 0.73 | 0.36 | 0.35 |

**Table 4: Results of the overall analysis: Explanatory power of the initial indicators on urban quality of life differences.**

The indicators and their category describe the second and first column. Then, the following columns contain the results of the calculations for all cities and time frames for the accuracy limits of 70 % variance explained and 0.3 loadings after rotation, 70 % and 0.4, 80 % and 0.3, 80 % and 0.4, 90 % and 0.3 as well as 90 % and 0.4, respectively. Finally, the last column shows the overall proportion of the indicator selection to its availability as mean over the different accuracy levels. The 20 % highest column values are highlighted in colour. Thereby, revealing a good general alignment of the results for the different levels with only some outliers. However, outliers mainly occur for the lower boundary of 0.3 for the principal component loadings. The 0.4 boundary better reflects the overall results in general with the selection of the following indicators in decreasing order: number public transport stops per km$^2$, proportion of solid waste arising within the boundary processed by landfill, number of days where ozone concentration exceeds 120 µg/m³ in Urban Audit cities as days per year, nationals born abroad as a proportion of total population, total population change over one year, proportion of working age population qualified at level 5 or 6 ISCED – female, total annual population change over approximately five years, number of domestic burglary per 1,000 inhabitants as well as car thefts in Urban Audit cities as number per 1,000 inhabitants. They thus cover the fields of manufactured capital with public transport infrastructure, environmental capital with waste management and air quality, social capital with migration, safety and security, human capital with female education as well as demographic aspects with population changes (for the interpretation of indicators see European Commission (2007a)). Hence, the nine selected indicators are more or less equally spread among all aspects of urban quality of life as covered by the initial set of 46 indicators. It is thus not necessary to compare cities by all initial indicators, instead the set of nine indicators can be chosen as representatives.

Some indicators seem to be missing among the selection, for example employment and poverty indicators, as they are always mentioned in political debates. But this study reveals that problems in these fields have quite a similar extension in one nation's cities. Therefore, studies like this one might question political focuses. Nevertheless, the nine indicators fit well to a high number of current and currently returning political debates on environmental and infrastructural problems caused by urbanisation, migration difficulties in cities, safety, and especially security impairment due to anonymity and poverty in densely populated areas as well as population changes leading to space shortage in large cities, but also abandonment in small cities and rural regions. In addition, gender equality is always a topic of policies and forms part of the selected indicators. Hence, the nine chosen indicators do not only satisfy analytical criteria, but they do also fit to the practical perception as well.

## 6.2 Partial analysis

### 6.2.1 Time frame variation

In order to apply robustness checks, we first analyse the time dependence of indicator selection based on the rotated principal component analysis. Table 5 shows the results of the 70 % and 0.4 boundaries. The first column presents the indicators in the same order as above and the following columns describe the proportion of selected indicators by the rotation loadings over data availability for the different time frames. The highlighted cells represent the 20 % highest values of the respective column and fonts in italics imply absence of any data.

This immediately reveals data availability problems for the first two time frames. Especially in the first nine rows, the bundled absence of data strikes and reinforces the overall assumption that these indicators would also have been selected as there is only one case where data is available but not selected. Hence, better data availability is an unconditional requirement for the continuing use of Eurostat data for policy decisions.

Besides the aforementioned problems, the results show a number of 12 consistencies in selected indicators for two subsequent time frames. In addition, five indicators are selected again after an interruption of only one period. Seven of the 17 mentioned consistencies are represented by the selected nine indicators in the first rows. This is a good result compared to the large overall time frame of 20 years where development naturally influences quality of life determinants over time. Therefore, an application to policy decisions needs to maintain the possibility to analyse the influence changes continuously and adapt for time specific structures.

| Indicators | 1989-1993 | 1994-1998 | 1999-2002 | 2003-2006 | 2007-2009 |
|---|---|---|---|---|---|
| Number of stops of public transport per km2 | *0.00* | *0.00* | 1.00 | 0.50 | 0.67 |
| Proportion of solid waste arising within the boundary processed by landfill | *0.00* | *0.00* | 0.00 | 0.67 | 0.33 |
| Number of days ozone concentration exceeds 120 µg/m³ in Urban Audit cities as days per year | *0.00* | 1.00 | 0.33 | 1.00 | *0.00* |
| Nationals born abroad as a proportion of total population | *0.00* | *0.00* | 0.71 | 0.75 | 0.67 |
| Total population change over 1 year | 0.33 | 0.67 | 0.29 | 0.50 | 0.50 |
| Proportion of working age population qualified at level 5 or 6 ISCED – female | *0.00* | *0.00* | 0.25 | 0.75 | 0.00 |
| Total annual population change over approximately 5 years | *0.00* | 0.71 | 0.14 | 0.14 | 0.75 |
| Number of domestic burglary per 1000 population | *0.00* | *0.00* | 0.50 | 0.50 | 0.40 |
| Car thefts in Urban Audit cities as number per 1000 inhabitants | *0.00* | 1.00 | 0.50 | 0.29 | 0.60 |
| Total population in Urban Audit cities | 0.43 | 0.43 | 0.20 | 0.33 | 0.38 |
| Number of deaths in road accidents per 10000 population | *0.00* | *0.00* | 0.00 | 0.38 | 0.57 |
| Total Population at working age | 0.50 | 0.50 | 0.11 | 0.40 | 0.38 |
| Proportion of population aged 15-64 qualified at tertiary level (ISCED 5-6) living in Urban Audit cities as % | *0.00* | *0.00* | 0.00 | 0.50 | 0.00 |
| Unemployment rate in Urban Audit cities as % | 0.50 | 0.33 | 0.50 | 0.60 | 0.00 |
| Number of days particulate matter concentrations exceeds 50 µg/m³ in Urban Audit cities as days per year | *0.00* | 1.00 | 0.00 | 0.00 | *0.00* |
| Employment/Population (of working age) ratio | 0.33 | 0.67 | 0.25 | 0.60 | 1.00 |
| Cinema seats in Urban Audit cities as seats per 1000 inhabitants | *0.00* | *0.00* | 0.20 | 0.60 | 0.50 |
| Proportion of households living in owned dwellings in Urban Audit cities as % | 0.80 | 0.00 | 0.20 | 0.00 | 0.00 |
| Nationals as a proportion of total population | 0.40 | 0.80 | 0.11 | 0.00 | 0.50 |
| Percentage of elected city representatives who are men | *0.00* | *0.00* | 0.00 | 0.20 | 0.00 |
| Non-EU nationals as a proportion of total population | 0.50 | 1.00 | 0.11 | 0.20 | 0.40 |
| Average living area in Urban Audit cities as m² per person | 0.40 | 0.50 | 0.29 | 0.50 | 0.33 |
| Total land area (km2) according to cadastral register | 0.60 | 0.20 | 0.00 | 0.25 | 0.20 |
| Consumption of water (as cubic metres per annum) per inhabitant | 1.00 | 0.33 | 0.33 | 0.20 | 0.00 |
| Cost of a monthly ticket for public transport (for 5-10 km) | *0.00* | *0.00* | 0.00 | 0.33 | 0.33 |
| Proportion of working age population at level 1 or 2 ISCED – female | *0.00* | *0.00* | 0.25 | 0.33 | 0.00 |
| Number of tourist overnight stays in registered accommodation per year per resident population | 1.00 | 0.67 | 0.00 | 0.20 | 0.40 |
| Collected solid waste in Urban Audit cities as tonnes per inhabitant and year | *0.00* | *0.00* | 0.00 | 0.67 | 0.00 |
| Available hospital beds in Urban Audit cities per 1000 inhabitants | 0.00 | 0.60 | 0.00 | 0.50 | 0.50 |
| Proportion of one-person households in Urban Audit cities as % | 0.29 | 0.50 | 0.33 | 0.25 | 0.33 |
| Proportion of female students in higher education (ISCED level 5-6) | *0.00* | *0.00* | 0.20 | 0.33 | 0.33 |
| Average household size in Urban Audit cities as number of persons per household | *0.00* | 0.00 | 0.00 | 0.50 | 0.33 |
| Tourist overnight stays in registered accommodation in Urban Audit cities as number of nights per year | 1.00 | 0.33 | 0.00 | 0.20 | 0.40 |
| Self-employment rate | 0.40 | 0.00 | 0.44 | 0.43 | 0.00 |
| Registered cars in Urban Audit cities as number of cars per 1000 inhabitants | 0.50 | 0.00 | 0.25 | 0.20 | 0.00 |
| Population density in Urban Audit cities | 0.60 | 0.60 | 0.00 | 0.25 | 0.40 |
| Proportion in part-time employment | 0.50 | 0.33 | 0.00 | 0.17 | 0.50 |
| Proportion of working age population qualified at level 1 or 2 ISCED | *0.00* | *0.00* | 0.25 | 0.00 | 0.00 |
| Proportion of households with children aged 0-17 in Urban Audit cities as % | 0.17 | 0.00 | 0.13 | 0.33 | 0.50 |
| Children 0-2 in day care (public and private) per 1000 children | *0.00* | *0.00* | 0.00 | 0.67 | 0.50 |
| Annual visitors to museums per resident | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 |
| Average time of journey to work | 0.33 | 0.00 | 0.20 | 0.00 | 0.00 |
| EU nationals as a proportion of total population | 0.67 | 1.00 | 0.00 | 0.00 | 0.00 |
| Percentage of the households receiving less than half of the national average household income | *0.00* | *0.00* | 0.00 | 0.00 | 0.50 |
| Price of a m3 of domestic water | *0.00* | *0.00* | 0.00 | 0.25 | 0.00 |
| Share of journeys to work by car in Urban Audit cities as % | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 5: Results of the time frame analysis: Explanatory power of the initial indicators on urban quality of life differences.**

### 6.2.2 Country variation

Now, a distribution analysis among the ten countries constitutes the second robustness check. The structure, boundaries and the following table are the same as in the previous section, but this time the back columns describe the countries' results instead of time variations.

| Indicators | Germany | Romania | Netherlands | Italy | Turkey | UK | Spain | France | Poland | CR |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of stops of public transport per km2 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |
| Proportion of solid waste arising within the boundary processed by landfill | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 |
| Number of days ozone concentration exceeds 120 µg/m³ in Urban Audit cities as days per year | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 1.00 | 0.67 |
| Nationals born abroad as a proportion of total population | 0.00 | 0.50 | 0.67 | 0.00 | 1.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| Total population change over 1 year | 0.00 | 0.80 | 0.50 | 0.40 | 0.00 | 1.00 | 0.67 | 0.00 | 0.25 | 0.20 |
| Proportion of working age population qualified at level 5 or 6 ISCED – female | 0.33 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| Total annual population change over approximately 5 years | 0.00 | 0.75 | 0.50 | 0.75 | 0.00 | 0.50 | 0.50 | 0.00 | 0.25 | 0.25 |
| Number of domestic burglary per 1000 population | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.50 | 0.00 | 1.00 | 0.00 |
| Car thefts in Urban Audit cities as number per 1000 inhabitants | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.50 | 1.00 | 0.00 | 0.33 |
| Total population in Urban Audit cities | 0.00 | 0.80 | 0.25 | 0.40 | 1.00 | 1.00 | 0.40 | 0.00 | 0.20 | 0.00 |
| Number of deaths in road accidents per 10000 population | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 1.00 |
| Total Population at working age | 0.00 | 0.80 | 0.25 | 0.40 | 1.00 | 1.00 | 0.40 | 0.00 | 0.25 | 0.00 |
| Proportion of population aged 15-64 qualified at tertiary level (ISCED 5-6) living in Urban Audit cities as % | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Unemployment rate in Urban Audit cities as % | 0.00 | 0.50 | 1.00 | 0.50 | 1.00 | 1.00 | 0.75 | 0.50 | 0.50 | 0.25 |
| Number of days particulate matter concentrations exceeds 50 µg/m³ in Urban Audit cities as days per year | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 |
| Employment/Population (of working age) ratio | 0.25 | 0.50 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.33 |
| Cinema seats in Urban Audit cities as seats per 1000 inhabitants | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 1.00 | 0.67 | 0.00 |
| Proportion of households living in owned dwellings in Urban Audit cities as % | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 1.00 | 0.50 | 0.33 | 1.00 | 0.50 |
| Nationals as a proportion of total population | 0.00 | 0.00 | 0.25 | 0.40 | 1.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.67 |
| Percentage of elected city representatives who are men | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Non-EU nationals as a proportion of total population | 0.00 | 0.50 | 0.33 | 0.20 | 1.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.00 |
| Average living area in Urban Audit cities as m² per person | 0.00 | 0.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.80 | 0.00 |
| Total land area (km2) according to cadastral register | 0.20 | 0.00 | 0.00 | 0.40 | 0.00 | 0.00 | 0.33 | 0.00 | 0.50 | 0.00 |
| Consumption of water (as cubic metres per annum) per inhabitant | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.33 |
| Cost of a monthly ticket for public transport (for 5-10 km) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.00 |
| Proportion of working age population at level 1 or 2 ISCED – female | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Number of tourist overnight stays in registered accommodation per year per resident population | 0.50 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.25 |
| Collected solid waste in Urban Audit cities as tonnes per inhabitant and year | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 |
| Available hospital beds in Urban Audit cities per 1000 inhabitants | 0.00 | 0.60 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.20 |
| Proportion of one-person households in Urban Audit cities as % | 0.00 | 0.50 | 0.67 | 1.00 | 1.00 | 1.00 | 0.25 | 0.00 | 0.00 | 0.00 |
| Proportion of female students in higher education (ISCED level 5-6) | 0.00 | 0.00 | 0.50 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 |
| Average household size in Urban Audit cities as number of persons per household | 0.33 | 0.00 | 0.33 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tourist overnight stays in registered accommodation in Urban Audit cities as number of nights per year | 0.25 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 0.25 | 0.00 |
| Self-employment rate | 0.20 | 0.67 | 0.00 | 0.00 | 1.00 | 1.00 | 0.00 | 0.67 | 0.00 | 0.25 |
| Registered cars in Urban Audit cities as number of cars per 1000 inhabitants | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.33 |
| Population density in Urban Audit cities | 0.00 | 0.00 | 0.00 | 0.80 | 0.00 | 0.00 | 0.67 | 0.00 | 0.50 | 0.20 |
| Proportion in part-time employment | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 | 0.25 | 0.33 | 0.00 | 0.25 |
| Proportion of working age population qualified at level 1 or 2 ISCED | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Proportion of households with children aged 0-17 in Urban Audit cities as % | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.50 | 0.00 |
| Children 0-2 in day care (public and private) per 1000 children | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 0.67 | 0.00 |
| Annual visitors to museums per resident | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Average time of journey to work | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 |
| EU nationals as a proportion of total population | 0.00 | 0.50 | 0.00 | 0.20 | 0.00 | 0.00 | 0.25 | 0.33 | 0.00 | 0.00 |
| Percentage of the households receiving less than half of the national average household income | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Price of a m3 of domestic water | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Share of journeys to work by car in Urban Audit cities as % | 0.00 | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 6: Results of the countries' analysis: Explanatory power of the initial indicators on urban quality of life differences.**

Table 6 indicates that there are some countries with quite a high number of identical indicator selections among the 20 % highest values. The group of Spain, Turkey, and the UK have each six selected indicators in common. Another group consists of Poland, France, and Spain with five consistencies. Furthermore, Spain has five selections in common with Italy and the UK with Romania. In addition, there are 14 further consistencies of four selected indicators. A cluster analysis with correlations as the distance metric and the unweighted average algorithm for the determination of distances between clusters now helps to objectively define groups of countries with similar indicators chosen among all values.

Allowing for five clusters, the results are: a group of Netherlands, Romania, Spain, Turkey, UK, and a second group of France and Poland, whereas all other countries define groups by themselves. Hence, the objectively conducted clusters correspond more or less to those obtained by a first sight on only the 20 % highest values.

The results reveal the need for country specific indicator sets for subsequent more detailed analyses which can then be applied to clusters like the group of France and Poland.

Again, the table indicates the high absence of data for the nine generally selected indicators, represented by the first rows, for some countries. This underpins the need for reliable data as mentioned above. This analysis again suggests that the first indicators would be highly determining for those countries' cities without data as well, because there are comparably few cases where data is available and the indicators are not chosen.

## 7 Conclusion

This study used a principal component analysis with a subsequent rotation technique to identify a small number of indicators that adequately represent urban quality of life differences among one nation's cities. Furthermore, it considered parts of the general analysis in order to check for robustness and derive application conditions as well as data requirements.

The overall analysis points out that a small indicator set of nine items determines the differences among one nation's cities for several boundaries, nations, and time frames. The results are plausible in the context of current political debates, as the set covers nearly all policy aspects of urban life, and in the context of methodology, as the selections do not vary much by changing the boundaries.

However, the more detailed analyses reveal that the general application of a small indicator set needs to be controlled over time and space. It should be used to get a broader overview of the cities' state on a supranational level and is therefore much better than a simple index from an interpretational perspective. Nevertheless, it is advisable to conduct a second comparison on the basis of newly selected indicators especially suitable for the respective country. Those should result from only this country's principal component analysis with rotation. A general approach should always be adaptable for time and space specific structural differences.

The idea of this paper was thus covered by the overall analysis. The more detailed parts of the study revealed the problems arising from data availability that disturb the robustness. However, the results are plausible from a methodological and practical point of view and applying this method to wider data sets with more time frames and units seems promising. It might lead to important insights which could impact policy measures on urban development and its funding allocation processes as well as funding efficiency analysis.

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