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A New Sustainability City Index Based on Intellectual Capital Approach

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Abstract: Urban sustainability is a key factor that must be considered at the local level, however, there are few studies that consider sustainability using the triple bottom line approach and apply it to a large number of cities. In this paper, we develop a sustainability city index based on the triple bottom line using an intellectual capital approach that attempts to solve the negative aspects identified in the main indices proposed in the existing literature, such as the use of: subjective weightings, an arithmetic average or index that is not comparable. Here, we have used information available in the Urban Audit database for 2009. The results for 158 cities in 24 European countries show that the cities with the best positions are in the northern European countries. German cities occupied the best positions in the three dimensions of sustainability, albeit with a slightly worse performance in the social dimension. Moreover, the proposal index is consistent, without redundancy among the variables considered in the three dimensions.

Keywords: sustainability; city index; triple bottom line; intellectual capital; Europe

1. Introduction

Considering the prediction made by the United Nations in the study "the state of the world's cities 2008/2009" that 60% of the world's population would live in cities by the year 2030 [1], urban sustainable development has taken on a much more significant role in recent years. This dominance of cities means that their development and management must be better understood if global sustainability is the objective. This situation, which has been accepted ever since the 1992 Rio Earth Summit, has resulted in a growing number of experts recognizing local initiatives (at municipal, city or metropolitan regional level) as pivotal elements in the transition towards sustainability [2]. Knowledge of wealth creation is critical for cities and one of the aims of these knowledge cities must be to achieve sustainability [3,4].

Since cities are defined in terms of certain standards related to their population and land use [1], we must take into account the limit of available sustainability data at local scales. There is even talk of "green cities" that is, cities that look to generate economic growth and reduce greenhouse gas emissions and pollution, safeguarding the environment and biodiversity [5–7]. Moreover, social and environmental sustainability is a major strategic component of smart cities [8].

City sustainability must not only consider quality of life, but it must also reconcile the conflict between being part of a competitive global city network and satisfying the day to day requirements of their own inhabitants. Therefore, to measure and evaluate city sustainability, complex tools are needed. Much of the works are focused on developing indicators that provide measures of progress towards achieving sustainable development [9]. These indicators are a tool to inform policy makers and help formulate developmental policies. In the context of sustainability, decision making has focused on composite indicators to support policy formulation because aggregated indicators are valued as communication and political tools [10]. However, in practice, most of the indicators used to measure and/or evaluate sustainability focus on one or two SD dimensions and consider small geographical areas, whilst fewer use integrated tools of measurement and fewer still use composite indicator models. Considering these limitations in the existing indices, we use the data available in the Urban Audit database from Eurostat to consider the triple bottom line approach considered by [11]. This triple line approach considers environmental, economic and social dimensions, although cities mainly contribute to economic and social aspects of sustainability rather than to environmental aspects due to environmental externalities [12,13].

Thus, we propose a composite indicator that considers the three sustainability dimensions, for a total of 158 European cities and that uses a principal component analysis as the tool with which to integrate the information of the all the considered indicators. An Intellectual Capital approach is considered to classify the information and the composite index (scales, comparison, and generator method [14–16]). The reference year is 2009 because the Urban Audit database for this year has information with sufficient detail of the variables to be considered. However, in the last version, the spectrum of cities has been expanded in exchange for restricting the system of indicators, so the research group has worked with the structural information from 2009, to develop the method and draw conclusions for Europe on growing sustainable cities.

Thus, this paper is structured as follows: in the second section; we show a recompilation of sustainability indices developed for cities distinguished between indices developed for general application and for certain geographical scopes. In Section 2, we find that the main shortcomings of these indices are our motivation to develop this proposal. Subsequently, in Section 3 we describe how the methodology of the proposal in this paper is based on the intellectual capital approach. In Section 4, we show the main results obtained considering the global sustainability index along with some of these components to favor a clearer interpretation of the results. Finally, in Section 5 we present the main conclusions and propose future research lines.

2. Materials

Although the analysis of the performance of cities is a novel subject, there are many studies which make a concerted effort toward capturing the sustainability of cities. Therefore, in this section we outline the main sustainability indices for cities, although a more detailed analysis has been developed in previous papers [17–19].

Firstly, we discuss the main indices developed from a general perspective which have been applied to several geographical scopes, emphasizing the main advantages and disadvantages of each index to clarify the motivation for developing a new index that aims to solve the identified deficiencies.

The Green City Index was developed by The Economist Intelligence Unit and it considers 30 indicators across eight to nine categories, depending on the region. This index includes 120 cities and the results are presented in a detailed numerical ranking or in five performance bands depending on the levels of data quality and comparability. The main problem of this index is that it only considers environmental indicators.

The City Development Index of the Second United Nations Conference on Human Settlements (Habitat II) is based on five sub-indices that consider the city product, infrastructure, waste, health and education. These sub-indices have the same weightings in the final index, however, the indicators in each sub-index have weightings calculated using a Principal Component Analysis. This index was calculated for 162 countries with values between 0 and 100. The main disadvantages of this index are that it does not consider the economic dimension, it uses an arithmetic average instead of a geometric average and it uses the same weighting for all dimensions considered in the final index [20].

The City Prosperity Index was proposed in the "State of the World Cities 2012/2013" report of UN-Habitat and it evaluates 82 cities in terms of prosperity, reporting the values in six brackets from cities with 'very solid' to 'very weak' prosperity factors. It considers aspects related to economy, quality of life, adequate infrastructures, equity, environmental sustainability and government actions and policies in pursuit of prosperity. This index is possibly the most complete in that it covers all of the sustainability dimensions; however, it has only been developed for a limited number of cities. A previous study developed a multiscalar urban sustainability assessment approach that is particularly suitable for the environmental sustainability dimension of the City Prosperity Index [21].

The Ecological Footprint for cities is measured in global hectares and it compares the human demands on nature with the biosphere's ability to regenerate resources. This index was developed by [22] for nations and adapted for cities by [23]. Now it is used by 100 cities around the world. The main limitation of this index is that it does not consider the triple bottom line of sustainability

In addition to these indices developed from a general perspective, other proposals have been developed for certain geographical areas that have been applied to cities with certain characteristics but which are very difficult to generalize for wider use. The review of these indices allows us to obtain some ideas to develop a new general index that will help solve the insufficiency of general sustainability city indices shown in the previous sub-section.

The Urban Sustainability Index was calculated in 2010 and 2011 and it ranked 112 Chinese cities in terms of overall sustainability, which is considered economic growth that improves the lives of the people. The index considers four components to measure this sustainability: Social, Economic, Environmental and Resource, and it uses 17 individual indicators selected based on experts consults. The city index is calculated based on a weighted average of normalized scores of each indicator on a scale of 1 to 10 where the weightings are based on the analytical hierarchy process (AHP) method and the expert's consultation with values from 0 to 1.

The Sustainability Index for Taipei was proposed by and used Odum's energy diagram as a conceptual model [24] . Based on this, they used 80 policy making indicators grouped into 10 public indicators: ecological sustainability, water resources utilization, economic efficiency, resource self-sufficiency, environmental loading, living comfort, transport efficiency, environmental management, social welfare and public safety and education. The index is calculated using the equal weight method to integrate and analyze the overall sustainability trend from 1994 to 2004, with values between 0 and 1. The signal lighting system considers three colors: green, yellow and red, to provide an overview of the current situation and the trend of the 10 public indicators.

The Compass Index of Sustainability was developed originally for Orlando in 2000 by AtKisson Inc., although later it was applied to other US cities. This index considers four categories—Nature, Economy, Society and Well Being, corresponding to the four points on a compass [25]. The values for each category are on scale 0–100 and the four indices, with the same weight, are aggregated into one indicator.

The development of cities was ranked considering four perspectives: economy, societal, environmental and governance using the Knowledge-Based Urban Development Assessment Model (KBUD/AM). These authors analyse nine global cities using eight dimensions (two for each perspective), and 31 indicators. In the index construction, they use an average with equal weights for each dimension, once normalized [4] .

The Sustainability Cities Index was developed for 20 cities in The United Kingdom between 2007 and 2010. It is based on 13 indicators that are grouped into three dimensions: environmental impact of the city, quality of life for residents, and future proofing. To calculate an index in each dimension, all the indicators have equal weighting; similarly, in the calculation of the overall city index, all of the dimensions have the same weight.

The Sustainability composite indicator for North Aegean Region (Greece) was proposed by and calculated for 1991 and 2001 to make a comparison over time [26]. He considered 20 indicators of the three sustainable development dimensions, specifically, 3 for the economic dimension, 11 for the social dimension and 6 for the environmental dimension. In the composite indicator, all the indicators have equal importance, they are measured in a scale 0–100 and in the case of missing data he used a replacement with the mean.

Developed a sustainability indicator for the Reggio Emilia in Italy with the help of Legambiente. The authors used 25 indicators, focusing on those aspects for which sufficient data were available for all 45 municipalities of the province selected, using a Multiple Criteria. To obtain an index, quantitative weights were assigned based on the relative importance of the criteria using a panel of experts who were asked to rank the criteria in order of importance from 1 to 7 [27].

Developed a sustainability score scale between 0 and 1; and a ranking for 27 cities in the U.S. and Canada. They used a four-step hierarchical fuzzy multi-criteria decision-making approach that used data collected for a total of 16 sustainability indicators, a multi-criteria decision model and weighting for the indicators established by experts of U.S. government agencies and the industry [28]. Proposed key performance indicators based on the Gross Social Feel-Good Index to evaluate a smart sustainable city for a field trial in a city located almost at the center of the Tokyo Metropolitan Area [29].

Used 12 indicators for 18 cities with a population of at least 10 million to propose a model to visualize in 3-D a city sustainability index that considered the sustainability as one that maximizes socio-economic benefits while meeting constraint conditions of the environment and socio-economic equity on a permanent basis. This proposal used the triple bottom line but only considered cities with a lot of people where the sustainability problem is different for the other cities, and they only consider one European city (Moscow) [30].

Established a sustainability index for 15 cities in northeast China based on three layer: comprehensive, systematic and variable using 22 indicators that the authors considered the triple bottom line with economic, social and environmental subsystems. Finally, using a multiple criteria decision method they measured and ranked the sustainability of these cities and with a geographical information system they mapped the sustainability in terms of the spatial effects among these cities [31]. In the same geographical area but with 15 different Sub-Provincial Cities in China, proposed a novel urban green economy evaluation model [32].

Considering the main deficiencies that appear in the general sustainability indices shown in this section and considering several ideas established in the indices developed for certain geographical areas, we have developed a new city sustainability index. This proposal is based on the triple bottom line using the intellectual capital of a city approach and the main characteristics of this are: it considers the triple bottom line of sustainability (environmental, economic and social); it is developed for a large number of cities (all European cities for which information is available); it used objective weighting in the elaboration of a composite indicator based on a principal component analysis and it establishes one composite indicator with a geometric average which is more accurate for this kind of index, as is shown in [20]. Thus, we have addressed the main deficiencies in the development and use of sustainability indicators that we have found in the literature review. In the next section, we explain this proposal in more detail.

3. Methods

Intellectual Capital theory appears as a new management approach at the business level to measure and value the assets capable of generating future profits in the organization [33–35]. The model supported on a scoreboard includes a multiplicative scheme for the calculation of value of such intangible assets. Subsequently, the focus moves to the macro level to identify the intangible capital or hidden wealth of a nation, region or city. In this sense, the use of intellectual capital at city level is not new although there are few authors that analyze this [15,36–38]. Moreover, we would emphasize the papers of [16,39] for an excellent review of the different approach developed to analyze the cities' intellectual capital. In this sense, the research of [40] is interesting, where they show a method to construct an index of urban efficiency supported in metabolic and ecological systems. The intellectual capital of a city is formed for all sources of knowledge in different areas: human resources, infrastructure efficiency, mobility, accessibility, business, image, quality of life, tourism, innovation and sustainability of environment, which allows for smart and sustainable growth and wealth capacity.

Following the intellectual capital approach (IC), two large groups of capital are usually identified as intangibles: human (HC) and structural (SC) or 'non human' capitals. We also include residual capital (RC) as a measurement error or specification of capitals:

$$IC = HC + SC + RC \quad (1)$$

Human capital has two resources: individuals (in) and social (sc). On the other hand, structural capital comprises: process (PC), commercial (CC), image (IC), R & D + I (RDC) and environmental (EC) capitals [14–16].

We use several intangible capitals proposed by [15] to establish a sustainability indicator of European cities that considers the triple bottom line approach. In this sense, we could develop a Sustainability City Index (SCI) that would be based on three dimensions: economic, social and environmental from intangible capitals. Concretely, the environmental structural capital to measure the environmental dimension (ED); the Gross Domestic Product (GDP) and the labor market situation to measure the economic dimension (EcD); and the social human capital to measure the social dimensions (SD).

Using a geometric average and considering that we are averaging indicators in percentage, we can define SCI as [20]:

$$SCI_c = \sqrt[\alpha+\beta+\delta]{ED_c^{\alpha} \cdot EcD_c^{\beta} \cdot SD_c^{\delta}} \quad (2)$$

where, SCI is defined to 'c' cities, and α, β and δ are different weights of each components estimated objectively according to statistical methods (principal component analysis (PCA)) that allow us to consider the relationships between components since PCA considers the variance and covariance matrix in their calculation. The PCA methodology has been used for other authors such as [41].

The environmental dimension (ED) considers four components: pollution; water consumption; waste management and land uses, each measured by a set of indicators (Table 1). The economic dimension (EcD) has been measured using the Gross Domestic Product (GDP) and the labor market indicators (Table 1). Finally, the social dimension (SD) has been disaggregated into four components: health; safety; education; and culture conditions, each measured by a set of indicators (Table 1). The cities and indicators used have been selected based on the literature review developed and the data available in the Urban Audit database from Eurostat. Specifically, we use 17 environmental indicators, 8 economic indicators and 15 indicators for the social dimension.

The different dimensions consider in their construction two kinds of scales of indicators: absolute, normalized in per capita terms; and efficiency, on a percentage scale. To normalize, when the indicator does not have a percentage scale, variables have been rescaled assigning 100 to the highest value and 0 to the lowest. Thus, all the variables generated by the indicators have values ranging from 0 to 100 (minimum to maximum).

Table 1. Sustainability City Index (SCI) components and indicators.

Environmental Dimension	
Component	**Indicators**
Pollution	Rainfall, index of Summer Smog, hours per year that NO_2 exceed 200 mcg/m^3, days particulate matter PM_{10} exceed 50 mg/m^3, accumulated ozone in excess 70 mcg/m^3, annual average concentration of NO_2 and PM_{10}.
Water consumption	Total consumption of water and price of a m^3.
Wastes and recycling	Annual amount of solid waste and solid waste recycled.
Land uses	Total land area, Green space area. Land used for agricultural purpose and commercial activities. Land area in residential use.
Economic Dimension	

Component	Indicators
Labor market	Total economically active population, unemployed, employment: self, paid, full-time and part-time.
GDP	Gross Domestic Product per inhabitant in PPS of NUTS 3 regions
Social Dimension	
Component	**Indicators**
Health	Number of live births and deaths per year, number of hospital beds.
Safety	Number of deaths per year due to suicide, murders and violent deaths, car thefts, domestic burglary and deaths in road accidents.
Education	Number of residents (aged 15–64) with ISCED level as the highest level of education: A (0, 1 or 2), B (3 or 4) and C (5 or 6).
Culture	Number of cinema seats, museums, theatre seats and public libraries.

Note: PPS: Purchasing Power Standards; NUTS: Nomenclature of Territorial Units for Statistics; source: [11].

Using these components, we have constructed an indicator for each of the dimensions considered in the SCI. We must not forget that [15] used these aspects and dimensions together with others to measure cities' intellectual capital through their knowledge city index. The structure of the indicator (SCI) is supported in a multiplicative scheme, according to Equation (2), from Intellectual Capital theory and provides a robust indicator for each component. This method allows for comparison between cities; the addition of new indicators; analyses the capitals capable of obtaining future profits, and provides an interesting objective to make new political decisions.

The cities and indicators used have been selected based on the literature review developed and the data available in the Urban Audit database from Eurostat [4,42–47]. Specifically, we use 17 environmental indicators, 8 economic indicators and 15 indicators for the social dimension.

We use PCA to obtain objective weightings in the construction of the SCI construction. First, we transform the indicators into the same number of principal components because it is impossible to directly assign weights to each index. Once these components have been obtained, we proceed to build one index of each dimension using a weighting of the percentage of variance retained (α_i in environmental; β_i in economic; and δ_i in social), but in accordance with a geometric mean proposed as a requirement of formal consistency in aggregation of indicators non comparables by [20]. Usually, researchers apply subjective weights in the construction of an efficiency indicator. This definitely does not happen in the methodology proposed. In this line, another objective method in the calculation of weights of the variables is the fuzzy logic applied by [40,48,49].

$$ED = \sqrt[\sum_1^h \alpha_i]{\prod_{i=1}^{h} P_{EDn}{}^{\alpha_i}} \quad (3)$$

$$EcD = \sqrt[\sum_1^t \beta_i]{\prod_{i=1}^{t} P_{EcDn}{}^{\beta_i}} \quad (4)$$

$$SD = \sqrt[\sum_1^s \delta_i]{\prod_{i=1}^{s} P_{SDn}{}^{\delta_i}} \quad (5)$$

By changing these components in Equation (2), we can determine the sustainability city index for each of the 158 cities considered. Where, α, β and δ in Equation (2) are the percentage of variance retained by each component.

4. Results and Discussion

After exhaustive analysis and considering the methodology proposed in the previous section and with the limit of the available information, we calculate the sustainability index using 40 indicators for 158 cities in 24 European countries (see Appendix A) with data from 2009. Following the recommendations of [19], we have determined the index as a percentage to provide comparable results between cities and to facilitate the disaggregation for each component considering the differing sub-dimensions.

As we have shown in the previous section, we have followed the main recommendations (four) for obtaining an adequate sustainability index proposed in [26]. First, we have selected the variables available, and in the case of unavailable data we have used proxy variables, these variables are in Table 1. Second, for missing values we have used the simple imputation techniques on the basis of the constant structure assumption. Third, the normalization method used to convert different units of measurement to a common measurement unit is the distance from the best and worst performers, as described in the previous section. Finally, the weighting and aggregation scheme used is based on an objective method (PCA), using the percentage of variance retained by each component and the characteristic vectors, respectively.

The results, which are presented in appendix A, show the index value for sustainability and each dimension (environmental, economic and social). Considering the global sustainability index, the 10 best positions are occupied by Aarhus (Denmark), Dresden (Germany), Mainz (Germany), Hamburg (Germany), Kiel (Germany), Copenhagen (Denmark), Frankfurt (Germany), Bratislava (Slovakia), Nijmegen (Netherlands) and Schwerin (Germany), while Miskolc (Hungary), Palermo (Italy), Lisbon (Portugal), Oviedo (Spain), Cagliari (Italy), Bucharest (Romania), Setúbal (Portugal), Napoli (Italy), Catania (Italy) and Porto (Portugal) are the 10 worst. Therefore, the main conclusion considering the sustainability index proposal in this paper is that the cities with the best values in terms of sustainable development belong to countries in north-eastern Europe, while the cities in countries in south-western Europe have the worst values. Considering the information that we now have with regard to the impact of the economic crisis in different countries and the value obtained for this index, we observe that countries in which the cities have greater sustainable development have been less affected by the crisis. Therefore, we have empirical proof for the necessity of using sustainable development as the basis for growth in different cities.

The situation is similar when we only consider the environmental dimension, because the best 10 positions are occupied by cities belonging to the same set of countries, the only changes being Mönchengladbach (Germany) and Erfurt (Germany) replacing Nijmegen (The Netherlands) and Frankfurt (Germany), respectively. Similarly, changes to the worst 10 positions are Sevilla (Spain), Zaragoza (Spain), Plovdiv (Bulgary), Budapest (Hungary) and Paris (France) replacing Miskolc (Hungary), Palermo (Italy), Cagliari (Italy), Setúbal (Portugal) and Napoli (Italy). These results, in comparison with the results of the global index, show that the German cities are the best in environmental terms while the three Spanish cities occupy the worst positions. We should also emphasize the poor position held by Paris in this environmental ranking.

With respect to the economic dimension, the situation in relation to the countries with a greater number of cities in the best positions is similar with seven German cities and three Dutch cities among the top 10. Cities of countries that were incorporated into the European Union in 2004 and 2007 to make the EU-25 and EU-27, respectively appear in the worst positions. Specifically, the lowest ranked cities include: Pecs, Nyiregyhaza and Miskolc in Hungary; Vilnius and Panevezys in Lithuania; Riga in Latvia; Bucharest in Romania; and Trencín in Slovakia, in addition to Napoli in Italy and Setúbal in Portugal.

Finally, from the social dimension there is greater difference and diversity than is the case with the aforementioned dimensions. In first position is Paris (France), which was one of the worst performers in the environmental dimension. The French cities of Lyon and Grenoble also appear in the best 10, with the remaining positions being occupied by: Stockholm (Sweden), Oslo (Norway), Aarhus and Kobenhavn (Denmark), Utrecht (The Netherlands), Göteborg (Sweden) and London (UK). Meanwhile, 7 Italian and 3 Portuguese cities occupy the worst positions: Palermo, Napoli, Genova, Cremona, Cagliari, Catania and Venezia in Italy; and Lisbon, Setúbal and Porto in Portugal.

Although it is impossible to compare the cities one by one because in each index is different, we have seen that the results obtained with SCI are similar to the results of indices in the Green City

Index, the City Prosperity Index and the City Development Index. Thus, the results obtained with these indices show that the Swedish, the Norwegian, the Dutch, the Swiss, the Danish and the German cities occupy the best positions while the cities of Italy, Portugal and the countries that have recently joined the European Union are in the worst positions. In this sense, considering the 23 common cities with information available for the proposal and the Green City Index, the Spearman's rank correlation for both rankings show a result of 0.612 and therefore, the result shows concordance with the Green City Index and the SCI proposed in this paper.

In summary, it is clear that the countries of northern Europe have betted by a development form that takes a sustainable perspective into account, a situation that it is demonstrated by the best positions being occupied by the cities of these countries in all of the indices calculated, both the global index and the sub-dimensions indices. However, the development that it is powered in the southern European countries does not demonstrate that sustainability concerns play an important role.

We have also calculated the different correlation coefficients for the three dimensions considered in the triple bottom line, with two objectives:

(a) To analyse the relationships between the dimensions to test if the final indicators are robust and therefore they do not contain redundancies in their composition. In this sense, the results verify the inexistence of redundancies because the correlation coefficient between ED and EcD dimensions is 0.454, between EcD and SD dimensions is 0.257 and finally, between ED and SD dimensions is 0.233.
(b) To know the dimension more closely related with SCI. The correlation coefficients between SCI and the different dimensions are: with ED 0.858; with EcD 0.701; and with SD 0.619, so the ranking in SCI is closely related to city environmental management, followed by city wealth and finally the citizens' conditions of well-being.

5. Conclusions

This paper proposes a model with which to establish a sustainability index based on the triple bottom line using the intellectual capital of cities approach. This proposal allows us to consider the triple bottom line of sustainable development and takes into account several deficiencies evident in the more common indices presented in the literature, such as: using objective weightings based on a principal component analysis, calculating the global index with a geometric average and obtaining the index as a percentage to facilitate an easier comparison of the cities. Moreover, the results are shown by components to simplify the task of comparing cities in each dimension. This makes it much easier to identify where each city can or should improve.

The results show that German and Danish cities are the best positioned, while the Italian, Portuguese and Spanish cities are the worst. If we take the evolution of the economic situation into account when analyzing these results, we can see that the cities that are better positioned in terms of sustainable development have been less affected by the economic crisis.

The SCI includes three independent dimensions, where the environmental management is decisive in positioning the city. Therefore, the political decisions for improvement should be taken towards the management of pollutants, although usually this management in the cities is related to their economic and social development and sustainable efficiency is more successfully applied in the wealthiest cities.

The main limitations of this proposal are a consequence of the availability of information and because it is difficult or almost impossible to isolate cities because some cities will extract wealth from others and transfer pollution; it is impossible to delete these synergies. Thus, in some cases we have used proxy variables due to insufficient information on the desired variable. We have used information from 2009 as this is the most recent information available. Finally, information availability has determined which cities we have considered in this paper. Moreover, it must be considered that there is a lack of information for essential aspects of sustainability such as renewable energy or carbon and other important environmental and socio economic aspects. Therefore, we have conducted a partial analysis due to missing information; the main goal of this paper is to develop a comparison between cities.

These limitations open new research lines into applying this model to other non-European cities, and furthermore, this index could be evolved through the calculation and comparison of the index for different years. The analysis was structural and comparative, if the database would have allowed it, we could have included time effects by comparing different moments to evaluate dynamic effects or panel data. Unfortunately, a change in the Urban Audit database has resulted in a lower number of published indicators and we do not have more current information available. Consequently, we are now investigating two ways of solving this problem: a new source of world-wide data from the World Bank Group or the compatibility between the Urban Audit 2013 indicators towards the previous editions of this database.

Appendix A

Table A1. Sustainability City Index (SCI) by Country and Dimensions.

Country	City	SCI	ED	EcD	SD
Belgium	Bruxelles	46.15	37.71	48.24	51.11
	Antwerpen	48.30	45.94	46.68	50.19
	Gent	49.12	49.64	47.44	48.25
	Charleroi	45.88	42.64	42.45	46.80
	Liège	47.04	42.18	51.59	46.82
Bulgary	Sofia	46.05	40.09	38.11	53.65
	Plovdiv	43.35	33.11	41.77	49.22
	Burgas	43.60	35.19	38.89	49.23
	Ruse	43.15	34.50	40.45	47.27
Denmark	Copenhagen	51.17	50.39	48.05	55.73
	Aarhus	54.31	61.22	46.05	55.84
Germany	Berlin	48.31	44.85	50.52	49.34
	Hamburg	52.57	57.00	55.47	48.24
	München	49.25	44.17	54.22	52.05
	Köln	47.44	41.12	53.54	48.79
	Frankfurt	50.84	49.44	56.73	50.27
	Essen	47.84	45.55	53.03	44.83
	Stuttgart	49.13	45.66	55.10	48.99
	Leipzig	48.95	45.59	49.13	51.97
	Dresden	52.94	57.25	49.20	53.37
	Dortmund	47.89	46.17	52.40	44.60
	Düsseldorf	47.38	40.23	55.49	48.54
	Bremen	46.75	40.03	56.21	45.65
	Hannover	48.80	45.91	53.21	48.37
	Nürnberg	49.18	48.48	53.71	46.24
	Bochum	48.08	45.85	53.71	45.03
	Bielefeld	46.31	38.64	54.43	46.75
	Halle (Saale)	46.19	39.94	47.71	48.60
	Magdeburg	46.04	38.40	48.79	49.34
	Wiesbaden	47.02	39.72	54.34	48.37
	Göttingen	49.28	45.48	57.01	48.71
	Mülheim a.d.Ruhr	45.11	36.23	53.60	45.33
	Moers	47.71	45.39	52.28	44.92
	Darmstadt	48.92	43.97	56.90	49.26
	Trier	46.64	37.61	57.43	47.70
	Freiburg im Breisgau	47.69	37.60	58.02	51.91
	Regensburg	49.12	44.58	58.75	48.17
	Frankfurt (Oder)	47.29	43.30	49.46	47.71

	Weimar	47.61	41.55	49.37	51.53
	Schwerin	50.41	53.32	48.99	47.88
	Erfurt	50.10	50.20	48.61	51.00
	Augsburg	47.96	43.53	54.43	47.23
	Bonn	48.70	43.85	54.40	50.00
	Karlsruhe	50.24	49.07	55.41	48.99
	Mönchengladbach	49.88	52.92	52.53	43.96
	Mainz	52.78	56.82	55.68	49.27
	Kiel	52.12	55.32	55.50	48.55
	Saarbrucken	47.19	44.26	53.33	43.59
	Potsdam	47.29	38.68	50.32	53.44
	Koblenz	46.55	39.74	55.15	45.85
Estonia	Tallinn	46.13	38.93	40.16	54.31
	Tartu	46.24	40.23	40.07	53.08
Spain	Madrid	44.00	37.55	40.69	46.65
	Barcelona	42.97	35.43	41.19	44.79
	Valencia	43.24	35.55	41.94	45.31
	Sevilla	42.15	34.22	39.42	43.94
	Zaragoza	42.53	34.22	41.30	44.42
	Málaga	41.99	34.75	39.39	42.56
	Murcia	43.63	37.68	39.99	45.32
	Valladolid	42.93	35.92	41.92	43.50
	Palma de Mallorca	43.42	37.71	41.75	43.29
	Santiago de Compostela	41.96	34.85	40.93	41.36
	Vitoria	43.64	36.35	43.70	44.86
	Oviedo	41.29	33.04	38.53	42.40
	Pamplona	43.73	36.05	42.67	46.32
	Santander	41.75	34.55	39.10	41.98
	Toledo	42.88	35.58	39.19	45.40
	Badajoz	43.52	37.95	39.84	44.58
	Logroño	43.12	36.35	39.11	45.47
	Bilbao	42.35	34.93	41.37	42.67
	Córdoba	42.25	34.85	38.72	43.99
	Alicante	43.61	37.00	41.31	45.36
France	Paris	46.48	32.40	50.31	58.47
	Lyon	46.45	36.92	45.32	55.28
	Strasbourg	46.04	37.43	43.96	53.63
	Bordeaux	46.51	39.09	44.24	53.25
	Nantes	47.74	41.26	46.33	54.34
	Lille	46.55	39.64	43.26	53.27
	Saint-Etienne	46.89	42.46	45.04	49.85
	Le Havre	45.91	39.53	43.93	50.26
	Nancy	46.37	38.82	44.59	52.80
	Metz	46.32	39.56	43.46	52.28
	Orléans	48.05	44.00	42.81	54.11
	Dijon	46.41	38.64	44.40	53.32
	Clermont-Ferrand	46.54	40.49	44.57	51.28
	Grenoble	47.64	40.10	46.03	55.69
	Toulon	44.95	37.92	43.87	48.29
	Aix-en-Provence	46.57	38.81	45.28	53.24
	Marseille	45.94	40.22	43.49	49.71
	Nice	45.60	38.89	45.01	49.12

Italy	Roma	43.10	34.54	45.19	44.06
	Milano	44.08	37.40	47.79	42.84
	Napoli	40.80	34.47	38.04	38.61
	Torino	43.90	40.25	44.37	40.31
	Palermo	41.70	37.05	38.55	38.70
	Genova	41.98	35.26	45.06	38.34
	Firenze	43.72	37.14	46.18	42.64
	Bologna	42.86	34.91	47.03	41.44
	Catania	40.09	32.68	39.26	37.24
	Venezia	42.12	36.25	46.14	36.95
	Verona	43.05	36.04	47.33	40.51
	Cremona	43.52	40.30	45.22	38.07
	Trento	44.72	39.66	45.39	44.01
	Ancona	44.14	39.53	45.62	41.55
	Cagliari	41.23	34.68	42.32	37.56
Latvia	Riga	43.80	35.77	37.81	49.99
Lithuania	Vilnius	44.61	35.79	37.94	53.37
	Panevezys	43.81	36.77	35.05	50.35
Luxemburg	Luxembourg (city)	48.53	45.93	48.15	50.28
Hungary	Budapest	42.69	32.91	39.71	47.90
	Miskolc	41.72	34.44	35.34	44.31
	Nyiregyhaza	45.21	42.85	36.86	47.06
	Pecs	43.92	39.09	37.70	46.06
The Netherlands	's-Gravenhage	46.84	37.56	54.18	50.62
	Amsterdam	48.09	36.99	57.42	54.83
	Rotterdam	46.37	38.38	53.09	48.18
	Utrecht	49.22	41.04	55.69	55.29
	Groningen	49.86	44.62	60.72	50.11
	Nijmegen	50.53	47.61	58.03	50.60
Austria	Wien	47.23	40.85	47.22	52.16
Poland	Warszawa	45.04	35.82	43.32	51.89
	Lodz	43.40	36.51	40.04	45.87
	Krakow	44.67	35.97	40.91	51.54
	Wroclaw	45.40	38.97	40.53	50.89
	Poznan	45.27	36.82	42.40	52.09
	Gdansk	44.84	36.72	40.85	51.30
	Szczecin	44.27	36.17	41.35	49.30
	Bydgoszcz	44.41	37.23	39.73	49.44
	Lublin	44.70	37.44	39.15	50.79
	Katowice	44.31	37.40	41.00	48.01
Portugal	Lisbon	41.49	33.96	42.51	39.54
	Porto	40.08	34.33	40.55	34.15
	Setúbal	41.12	36.19	36.83	38.41
Romania	Bucharest	41.22	31.35	37.33	45.09
Slovenia	Ljubljana	44.92	35.69	42.03	52.35
	Maribor	45.11	39.89	39.10	49.27
Slovaquia	Bratislava	50.70	55.74	40.10	51.31
	Trencín	44.51	40.45	34.10	49.00
Finland	Helsinki	46.49	40.17	44.98	51.24
	Tampere	47.53	42.24	42.92	54.21
	Turku	47.10	42.70	43.64	51.25
Sweden	Stockholm	47.96	36.29	53.32	57.74

	Göteborg	47.20	37.22	50.44	54.98
	Malmö	47.81	39.56	50.96	54.11
UK	London	46.91	36.21	50.68	54.91
	Birmingham	45.85	36.24	48.33	51.75
	Leeds	46.49	37.87	50.62	50.89
	Bradford	46.29	38.27	47.57	51.35
	Liverpool	45.19	36.34	48.48	48.66
	Manchester	46.03	36.34	47.65	52.82
	Sheffield	46.90	39.09	52.09	50.13
	Bristol	47.16	36.41	53.98	53.71
	Newcastle upon Tyne	46.22	37.78	51.22	49.50
	Leicester	45.22	36.05	48.17	49.39
	Portsmouth	46.16	35.32	50.92	52.76
Norway	Oslo	47.57	36.60	51.17	56.96
	Bergen	47.85	39.89	52.68	52.79
Switzerland	Zürich	45.72	34.88	53.20	50.03

Source: Own elaboration using information of urban audit database from Eurostat.

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