Annex B: Statistical Assessment of the Cultural and Creative Cities Index 2017

The Cultural and Creative Cities Monitor aims to capture and express complex and indeterminate concepts related to the 'Cultural Vibrancy', 'Creative Economy' and 'Enabling Environment' of 168 cities in Europe. This statistical annex analyses and comments on the methodological choices made in the selection of 29 indicators and their organisation into nine dimensions, three sub-indices and an overall index (the C3 Index). The analysis was performed and is reported here in order to maximise the reliability and transparency of the model (the C3 model). It should enable users to draw more relevant, meaningful and useful conclusions from the results presented in the report or in the online version of the Cultural and Creative Cities Monitor[1].

The statistical assessment of the C3 Index 2017 focuses on two main aspects:

- The statistical coherence of the structure, and;
- The impact of key modelling assumptions on the C3 scores and ranks.[2]

This analysis complements the rankings in the C3 Index with confidence intervals, including for the three sub-indices ('Cultural Vibrancy', 'Creative Economy', and 'Enabling Environment'), in order to demonstrate the robustness of these rankings to the computation methodology.

(a) Statistical Coherence in the Cultural and Creative Cities Framework

Almost 200 variables were initially considered for their relevance to the dimensions of the C3 Index on the basis of a literature review and expert consultation at a first workshop that took place at the JRC in Ispra on 17–18 September 2015. After screening for data coverage and subsequently testing for statistical coherence, 29 indicators were selected. Given that the validity of the C3 Index relies on the combination of both statistical and conceptual soundness, the C3 model was developed in an iterative process involving rounds of exchange between theoretical perspectives on culture and creativity on the one hand and empirical observation on the other. For instance, during the second and final workshop that took place in Brussels on 9 November 2016, experts agreed that 'Cultural Vibrancy' should capture more than 'formal' cultural institutions; it should include, among others, informal cultural venues such as multidisciplinary arts spaces, clubs or voluntary associations. Indeed, the statistical analysis shows that the underlying indicators currently used capture only 45% of the cities' 'Cultural Vibrancy'. However, comparable, comprehensive and reliable observations on informal cultural venues could not be found at this stage for such a large and diverse sample of cities. It was therefore agreed that only major cultural facilities would be counted in the first edition.

Subsequent to this process, the assessment of the statistical coherence of the final version of the C3 Index 2017 had four main steps, described hereafter.

Step 1: Relevance

29 variables were selected with respect to statistical coherence, country coverage and timeliness. To take into account differences between cities, variables were scaled, either at source or by the JRC as appropriate and where needed. Most variables have been expressed in per capita terms (see Table A1 in the Appendix for more details).

Step 2: Data checks

The most recently released data were used for each city. The cut-off year was set at 2010. Cities were included if data availability was at least 45% at the main index level[3] and at least 33% for the 'Cultural Vibrancy' and 'Creative Economy' sub-indices (see Table A2 in the Appendix for more detail on cities' data coverage). Although the data availability requirements were set at relatively low levels in order to allow more cities to enter into the analysis, data coverage is very good for 75% of the 155 cities included in the calculation of the C3 Index (at least 81% at the main index level, at least 89% for Cultural Vibrancy, 100% for Creative Economy, and at least 75% for the Enabling Environment).

The dataset is characterised by satisfactory data coverage (74% in a matrix of 29 variables × 168 cities). Missing data for each city were estimated using a three-step approach. In the first step, missing values on two perception-related indicators under D3.2, Openness, Tolerance & Trust (Tolerance of foreigners and Integration of foreigners), were replaced by the average of the cities within a given country. This first step made it possible to fill in 18% of the 1284 values missing in the dataset. In a second step, the peer-group average based on the trio of GDP, population size and the employment rate was used. This second step made it possible to fill in 64% of the 1284 values missing in the dataset. In a third step, the remaining missing values (18% of the 1284 values) were estimated using the nearest neighbour approach. This three-step approach for estimating missing values in the Cultural and Creative Cities framework was adopted as it resulted in lower cross-validation error compared to the other method tested, the expectation maximisation method.[4]

Potentially problematic variables that could bias the overall results were identified as those having absolute skewness greater than 2 and kurtosis greater than 3.5[5], and were treated by winsorisation. A total of 27 values in 14 indicators were treated by winsorisation: values distorting the indicator distribution were assigned the next highest value, up to the level where skewness and/or kurtosis entered within the ranges specified above (see Table A3 in the Appendix for more details).

Step 3: Statistical coherence

The statistical coherence of the Cultural and Creative Cities Monitor 2017 consists of a correlation and cross-correlation analysis to analyse the structure of the data and the grouping of indicators into nine dimensions and a comparison of the expert-based weights assigned to the key components of C3 Index (the nine dimensions and three sub-indices) with the respective implicit weights.

Correlation and cross-correlation analysis

Correlation analysis shows that within each C3 dimension all correlations of the underlying indicators with the respective dimension are strong and positive (greater than 0.5 in all but two cases)[6]. Furthermore, a more detailed analysis of the cross-correlations of the indicators with the C3 dimensions confirms the expectation that the indicators are more strongly correlated with their own dimension than with any other (see Table 1).

These results suggest that the conceptual grouping of indicators into dimensions in the C3 framework is statistically sound and that all the indicators influence the variation in the city scores in their respective dimension.

Table 1.

Statistical coherence in the Cultural and Creative Cities Framework: Pearson correlation coefficients between indicators and dimensions

Dimensions	Indicators	D1.1	D1.2	D2.1	D2.2	D2.3	D3.1	D3.2	D3.3	D3.4
D1.1 Cultural Venues & Facilities	1. Sights & landmarks	0.63	0.12	0.00	-0.14	-0.18	0.05	-0.01	-0.13	-0.03
	2. Museums	0.71	0.35	0.15	-0.04	-0.08	0.05	0.07	-0.03	0.11
	3. Cinema seats	0.56	0.39	0.22	-0.01	-0.05	0.04	0.16	0.15	0.16
	4. Concerts & shows	0.71	0.38	0.22	0.06	0.09	0.35	0.24	0.07	0.21
	5. Theatres	0.71	0.23	0.24	0.10	-0.02	-0.11	0.03	0.01	0.08
D1.2 Cultural Participation & Attractiveness	6. Tourist overnight stays	0.35	0.53	0.27	0.13	0.13	0.21	0.07	0.21	0.22
	7. Museum visitors	0.32	0.70	0.41	0.35	0.08	0.25	0.04	0.32	0.27
	8. Cinema attendance	0.50	0.59	0.31	0.17	0.05	0.09	0.20	0.28	0.34
	9. Satisfaction with cultural facilities	-0.01	0.62	0.31	0.35	0.10	0.15	0.33	0.29	0.44
D2.1 Creative & Knowledge-based Jobs	10. Jobs in arts, culture & entertainment	0.37	0.49	0.85	0.41	0.10	0.16	0.17	0.32	0.27
	11. Jobs in media & communication	0.19	0.46	0.90	0.55	0.35	0.28	0.33	0.36	0.34
	12. Jobs in other creative sectors	0.20	0.48	0.91	0.51	0.25	0.29	0.27	0.52	0.48
D2.2 Intellectual Property & Innovation	13. ICT patent applications	-0.02	0.39	0.49	0.90	0.09	0.25	0.28	0.46	0.52
	14. Community design applications	0.09	0.36	0.48	0.84	0.23	0.07	0.16	0.37	0.34
D2.3 New Jobs in Creative Sectors	15. Jobs in new arts, culture & entertainment enterprises	-0.07	0.10	0.12	0.08	0.84	0.12	0.13	0.16	0.11
	16. Jobs in new media & communication enterprises	-0.09	0.13	0.29	0.23	0.92	0.11	0.24	0.17	0.02
	17. Jobs in new enterprises in other creative sectors	0.06	0.14	0.26	0.13	0.93	0.14	0.12	0.12	0.01
D3.1 Human Capital & Education	18. Graduates in arts and humanities	0.19	0.14	-0.03	-0.05	-0.05	0.73	-0.02	0.08	0.04
	19. Graduates in ICT	-0.12	-0.03	-0.04	-0.01	0.07	0.66	-0.04	0.12	0.08
	20. Average appearances in university rankings	0.14	0.41	0.55	0.40	0.23	0.60	0.21	0.35	0.34
D3.2 Openness, Tolerance & Trust	21. Foreign graduates	0.18	0.17	0.13	0.12	0.07	-0.04	0.46	-0.03	0.23
	22. Foreign-born population	0.26	0.37	0.64	0.41	0.27	0.19	0.44	0.50	0.41
	23. Tolerance of foreigners	0.00	0.13	0.09	0.16	0.23	0.06	0.72	-0.09	0.16
	24. Integration of foreigners	-0.01	-0.18	-0.23	-0.24	0.03	0.05	0.57	-0.16	-0.17
	25. People trust	0.08	0.30	0.29	0.34	-0.04	0.02	0.59	0.06	0.40
D3.3 Local & International Connections	26. Passenger flights	0.06	0.39	0.46	0.46	0.19	0.28	0.11	0.85	0.46
	27. Potential road accessibility	-0.05	0.31	0.33	0.33	0.17	0.22	-0.03	0.80	0.24
	28. Direct trains to other cities	0.12	0.44	0.31	0.40	0.04	0.22	0.10	0.82	0.52
D3.4 Quality of Governance	29. Quality of governance	0.18	0.52	0.41	0.50	0.05	0.25	0.35	0.49	1.00

Importance of the dimensions and sub-indices in the C3 framework

The C3 Index is calculated as a weighted average of its three sub-indices (namely 40% each for 'Cultural Vibrancy' and the 'Creative Economy' and 20% for the 'Enabling Environment') whilst the three sub-indices are calculated as weighted averages of the respective underlying dimensions: the 'Cultural Vibrancy' sub-index is the weighted average of D1.1 Cultural Venues & Facilities (50%) and D1.2 Cultural Participation & Attractiveness (50%); the 'Creative Economy' sub-index is the weighted average of D2.1 Creative and Knowledge-based Jobs (40%), 2.2 Intellectual Property & Innovation (20%), and 2.3 New Jobs in Creative Sectors (40%); the 'Enabling Environment' sub-index is the weighted average of D3.1 Human Capital & Education (40%), D3.2 Openness, Tolerance & Trust (40%), D3.3 Local & International Connections (15%) and D3.4 Quality of Governance (5%).

The weights for the C3 Index were elicited, using the budget allocation method[7], by around fifteen international experts during the second participatory workshop of the C3 Monitor in November 2016. While weights are often assigned to the components of an index to reflect the components' effective importance in the index, in practice, the data correlation structure and the data variances do not always allow the weights assigned to the variables to match their importance.

This section compares the expert-based weights assigned to the nine dimensions and the three sub-indices with their 'implicit weights'. The implicit weights are calculated here with the squared Pearson correlation coefficient, otherwise known as the coefficient of determination. Table 2 shows that the coefficients of determination ('importance' measures) of the C3 Index components are in general similar to the expert-based weights. For example, city variations in scores on D1.1 Cultural Venues & Facilities can capture 77% of the variance in the 'Cultural Vibrancy' scores, just slightly more than the 69% captured by variations in D1.2 Cultural Participation & Attractiveness. Hence, the implicit weights for the two components of 'Cultural Vibrancy' are very similar to the 50-50% weights assigned by the experts to these two dimensions. The most notable divergence between an expert-based weight and an implicit weight in the C3 framework is observed for D3.4 Quality of Governance; despite the modest 5% weight assigned by the experts, this dimension captures 34% of the variation in city scores in the 'Enabling Environment' sub-index. This can be explained by the good correlation (Pearson correlation coefficient 0.5) between D3.4 Quality of Governance and three of the dimensions in the C3 framework, namely D1.2 Cultural Participation & Attractiveness, D2.1 Intellectual Property & Innovation and D3.3 Local & International Connections. Nevertheless, within 'Enabling Environment', D3.4, Quality of Governance, is less important than D3.1, Human Capital & Education, and D3.2, Openness, Tolerance & Trust, as foreseen by the experts. At the main index level, 'Cultural Vibrancy' and 'Creative Economy' are more important than the 'Enabling Environment', although the 'Creative Economy' seems to capture somewhat more variation (71%) than 'Cultural Vibrancy' (59%), despite the expert-based weights putting these two sub-indices on a par.

Table 2.

Expert-based weights and importance measures for the main components of the C3 Index

	1. Cultural Vibrancy	2. Creative Economy	3. Enabling Environment	C3 Index	Expert-based Weights	Implicit weights (rescaled to sum 100%)
D1.1 Cultural Venues & Facilities	77%	2%	4%	30%	**50%**	53%
D1.2 Cultural Participation & Attractiveness	69%	23%	24%	61%	**50%**	47%
D2.1 Creative & Knowledge-based Jobs	22%	67%	23%	64%	**40%**	41%
D2.2 Intellectual Property & Innovation	6%	45%	19%	36%	**20%**	28%
D2.3 New Jobs in Creative Sectors	0%	52%	5%	24%	**40%**	32%
D3.1 Human Capital & Education	5%	7%	56%	18%	**40%**	32%
D3.2 Openness, Tolerance & Trust	6%	11%	41%	19%	**40%**	23%
D3.3 Local & International Connections	8%	21%	29%	26%	**15%**	17%
D3.4 Quality of Governance	16%	14%	34%	28%	**5%**	19%
1. Cultural Vibrancy	100%	12%	15%	59%	**40%**	33%
2. Creative Economy	12%	100%	25%	71%	**40%**	40%
3. Enabling Environment	15%	25%	100%	46%	**20%**	26%

Note: The first four columns are the squared Pearson correlation coefficients. The 'implicit weights' are the squared Pearson correlation coefficients rescaled to 100% sum.

Step 4: Qualitative review

Finally, the C3 Index results, including city classifications and relative performances in terms of the three sub-indices and within the four population groups[8], were evaluated by the development team and the experts to verify that the overall results were consistent with current evidence, existing research and prevailing theory on culture and creativity.

Notwithstanding the positive outcomes of these statistical tests regarding the soundness of the C3 model, it is important to note that the C3 model will be susceptible of improvement as better data become available, in particular on cultural provision, cultural demand and funding for culture and creativity.

(b) Impact of Modelling Assumptions on the C3 Index Results

Every score on the overall C3 Index and its three sub-indices depends on modelling choices. These choices were based on literature review (e.g. for the selection of variables), standard practice (e.g. min-max normalisation in the [0, 100] range) and expert opinion (e.g. for weights assigned to the nine dimensions and the three sub-indices) or were driven by statistical analysis (e.g. treatment of outliers and missing data estimation). The robustness analysis described hereafter is aimed at assessing the combined impact of key modelling choices on the city rankings. This uncertainty analysis is, to some extent, an explicit acknowledgement of and attempt to address the fact that the aggregate city scores are not calculated under conditions of certainty.[9]

Table 3.

Uncertainty analysis for the C3 Index 2017: normalisation and weights

II. Uncertainty in the normalisation formula at the indicator level		
Reference: min-max	Alternative: percentile ranks	
II. Uncertainty in the weights at the dimension level		
Dimension/Sub-index	*Reference value for the weight (within the sub-index)*	*Distribution assigned for robustness analysis (within the sub-index)*
D1.1 Cultural Venues & Facilities	0.5	U[0.38, 0.63]
D1.2 Cultural Participation & Attractiveness	0.5	U[0.38, 0.63]
D2.1 Creative & Knowledge-based Jobs	0.4	U[0.3, 0.5]
D2.2 Intellectual Property & Innovation	0.2	U[0.15, 0.25]
D2.3 New Jobs in Creative Sectors	0.4	U[0.3, 0.5]
D3.1 Human Capital & Education	0.4	U[0.3, 0.5]
D3.2 Openness, Tolerance & Trust	0.4	U[0.3, 0.5]
D3.3 Local & International Connections	0.15	U[0.11, 0.19]
D3.4 Quality of Governance	0.05	U[0.04, 0.06]
1. Cultural Vibrancy sub-index	0.4	U[0.3, 0.5]
2. Creative Economy sub-index	0.4	U[0.3, 0.5]
3. Enabling Environment sub-index	0.2	U[0.15, 0.25]

The robustness assessment of the C3 Index involved running 2,000 simulations. The simulations explored the issue of weighting and involved 1,000 runs, each corresponding to a different set of weights for the nine C3 dimensions, randomly sampled from uniform continuous distributions centred in the reference values provided by the experts. A perturbation of the weights ±25% around the reference values was applied. The limit values of uncertainty intervals for the dimension weights are shown in Table 3. In all simulations sampled weights are rescaled so that they always sum to 1.

The effect of normalising all indicators using percentile ranks was also tested because the use of percentile ranks would make it possible not to have to treat outliers.

The main results of the robustness analysis are shown in Figure 1, with median ranks and 90% confidence intervals computed across the 2,000 Monte Carlo simulations for the C3 Index in the four city-size groups.[10] Cities are categorised into four groups based on their population size and ordered within each group according to their reference rank (black line), the dot being the median rank. Error bars represent, for each city, the 90% interval across all simulations.

All C3 city ranks lie within the simulated intervals, and these are narrow enough for most cities (fewer than ±3 positions) to allow for meaningful inferences to be drawn about a city's positioning in the peer-group classification. If the median rank across the simulated scenarios can be considered representative of these 2,000 scenarios, then the fact that the C3 rank is close to the median rank (fewer than two positions away) for 81% of the cities suggests that the C3 Index is a suitable summary measure for cities' performance within a peer group. Furthermore, the reasonably narrow confidence intervals for the majority of the cities' ranks (fewer than ±3 positions for 78% of the cities) imply that the C3 ranks are also, for most cities, robust to changes in the dimension weights and the normalisation formula.

Results for the three sub-indices – 'Cultural Vibrancy', 'Creative Economy', and 'Enabling Environment' – are also robust and representative of the plurality of scenarios considered. The 'Cultural Vibrancy' rank is close to the median rank (fewer than two positions away) for 79% of the cities and the rank intervals are ±3 positions for 72% of the cities. Similarly, the 'Creative Economy' rank is close to the median rank (fewer than two positions away) for 84% of the cities, and the rank intervals are ±3 positions for 69% of the cities. Finally, the 'Enabling Environment' rank is close to the median rank (fewer than two positions away) for 83% of the cities, and the rank intervals are ±3 positions for 60% of the cities.

Overall, city ranks in the C3 Index and its three sub-indices are fairly robust to changes in the dimension weights and the normalisation method, for the majority of the cities analysed. For full transparency and information, Table 4 reports the C3 city ranks (and those of the sub-indices) together with the simulated intervals (90% of the 2,000 scenarios) for a full appreciation of the robustness of these ranks to the computation methodology.
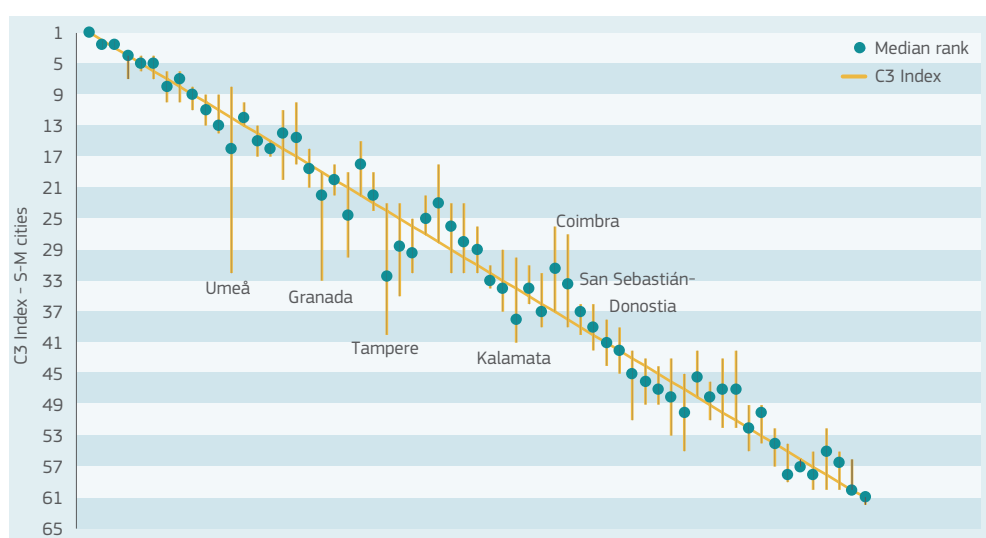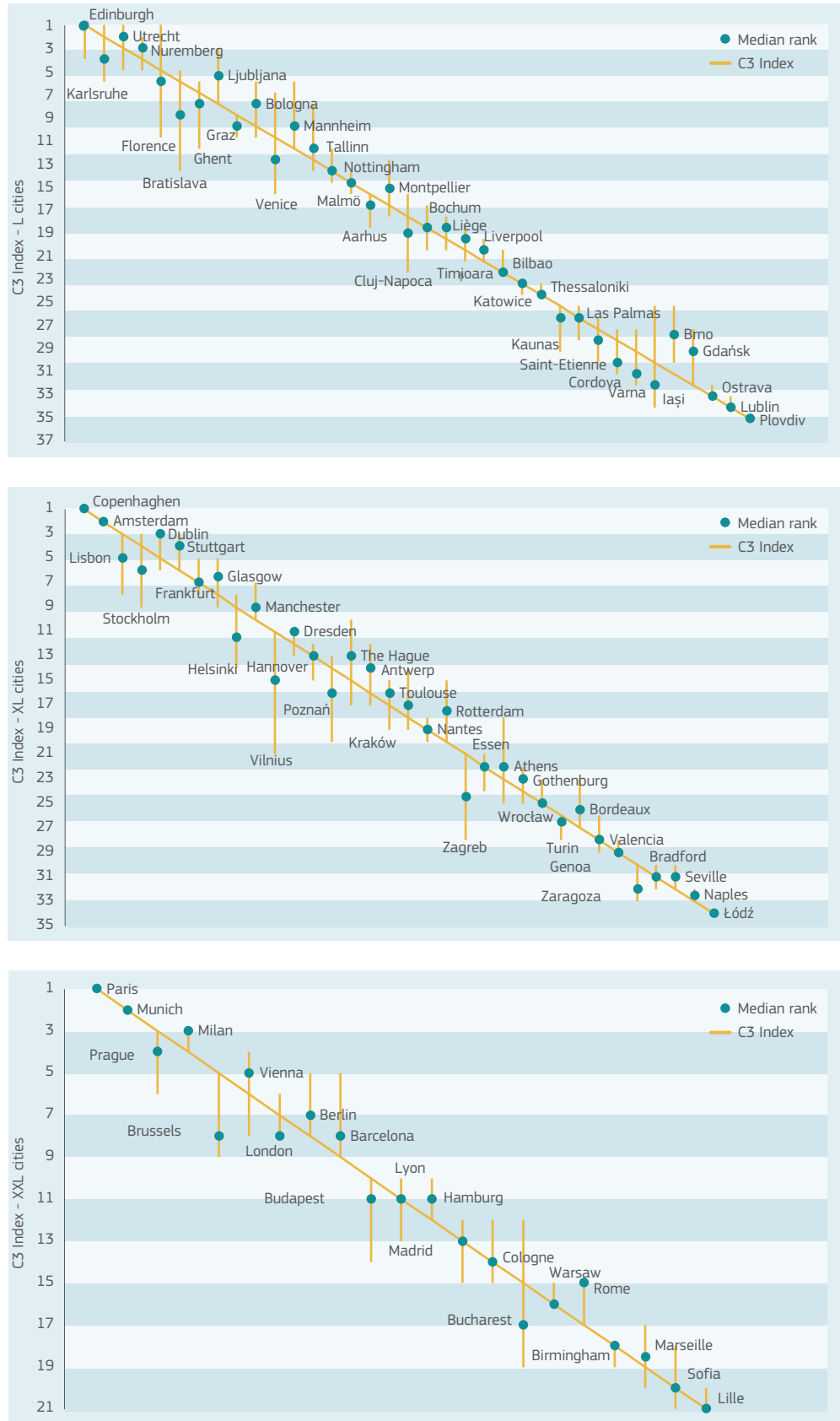
Figure 1.

Robustness analysis (C3 Index rank vs. median rank, 90% confidence intervals, four city-size groups)

Notes: The Spearman rank correlation between the median rank and the C3 Index 2017 rank is 0.993. Median ranks and intervals are calculated over 2,000 simulated scenarios combining perturbed weights (±25% around the nominal weights assigned by experts), and percentile ranks versus min-max normalisation at the indicator level.

Table 4.

City ranks and 90% confidence intervals for C3 Index 2017 and the three sub-indices (for four city-size groups)

XXL Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Paris	1	[1, 1]	1	[1, 1]	1	[1, 1]	2	[1, 4]
Munich	2	[2, 2]	9	[9, 12]	2	[2, 2]	3	[1, 3]
Prague	3	[3, 6]	2	[2, 3]	6	[5, 8]	16	[16, 17]
Milan	4	[3, 4]	3	[3, 5]	11	[8, 12]	8	[7, 11]
Brussels	5	[5, 9]	10	[8, 10]	3	[3, 4]	13	[13, 14]
Vienna	6	[4, 8]	4	[2, 4]	17	[13, 17]	5	[4, 8]
London	7	[6, 8]	11	[11, 13]	8	[6, 9]	1	[1, 2]
Berlin	8	[5, 8]	8	[6, 9]	5	[3, 7]	9	[9, 12]
Barcelona	9	[5, 9]	5	[3, 6]	16	[15, 18]	4	[4, 6]
Budapest	10	[10, 14]	7	[6, 7]	14	[14, 18]	14	[14, 15]
Lyon	11	[10, 13]	6	[5, 8]	18	[14, 18]	11	[7, 12]
Hamburg	12	[10, 12]	14	[14, 16]	9	[5, 10]	10	[7, 10]
Madrid	13	[12, 15]	13	[11, 13]	15	[14, 18]	6	[5, 6]
Cologne	14	[12, 15]	17	[15, 18]	12	[7, 12]	12	[10, 12]
Bucharest	15	[12, 19]	20	[20, 20]	4	[4, 10]	18	[16, 20]
Warsaw	16	[15, 16]	15	[14, 17]	7	[5, 13]	20	[19, 20]
Rome	17	[15, 17]	12	[9, 12]	13	[12, 15]	19	[17, 19]
Birmingham	18	[18, 19]	16	[16, 17]	21	[21, 21]	7	[3, 8]
Marseilles	19	[17, 20]	18	[14, 18]	19	[19, 19]	15	[13, 15]
Sofia	20	[18, 21]	21	[21, 21]	10	[8, 12]	21	[21, 21]
Lille	21	[20, 21]	19	[19, 19]	20	[20, 20]	17	[16, 18]

XL Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Copenhagen	1	[1, 1]	2	[1, 2]	2	[2, 5]	5	[5, 7]
Amsterdam	2	[2, 2]	4	[2, 4]	3	[1, 4]	7	[5, 9]
Lisbon	3	[3, 8]	1	[1, 3]	9	[8, 20]	15	[12, 19]
Stockholm	4	[3, 9]	5	[5, 6]	6	[3, 19]	4	[4, 14]
Dublin	5	[3, 6]	3	[3, 4]	10	[7, 12]	1	[1, 2]
Stuttgart	6	[3, 6]	12	[12, 14]	1	[1, 3]	9	[6, 9]
Frankfurt	7	[5, 8]	17	[15, 18]	5	[3, 6]	6	[4, 7]
Glasgow	8	[5, 9]	6	[6, 8]	14	[9, 15]	2	[2, 3]
Helsinki	9	[8, 14]	18	[13, 19]	8	[6, 22]	10	[9, 11]
Manchester	10	[7, 10]	10	[9, 10]	12	[11, 17]	3	[1, 3]
Vilnius	11	[11, 21]	30	[28, 30]	4	[3, 13]	22	[18, 23]
Dresden	12	[11, 13]	8	[7, 11]	11	[8, 12]	25	[24, 27]
Hannover	13	[12, 15]	31	[30, 32]	7	[2, 8]	17	[10, 17]

XL Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Poznan	14	[13, 20]	16	[14, 19]	13	[10, 21]	19	[17, 23]
The Hague	15	[10, 17]	20	[13, 21]	15	[6, 15]	21	[16, 23]
Antwerp	16	[12, 17]	11	[10, 13]	22	[18, 23]	12	[11, 15]
Toulouse	17	[15, 19]	29	[27, 29]	17	[9, 18]	8	[4, 9]
Krakow	18	[14, 19]	9	[7, 9]	23	[21, 26]	27	[25, 27]
Nantes	19	[18, 20]	15	[13, 17]	24	[22, 25]	11	[10, 14]
Rotterdam	20	[15, 20]	24	[18, 25]	18	[13, 20]	20	[17, 24]
Zagreb	21	[21, 28]	25	[21, 32]	19	[15, 20]	26	[23, 33]
Essen	22	[21, 24]	32	[31, 33]	16	[9, 16]	14	[13, 16]
Athens	23	[18, 25]	7	[5, 8]	28	[28, 30]	28	[24, 30]
Gothenburg	24	[22, 25]	28	[23, 30]	21	[18, 22]	13	[12, 19]
Wroclaw	25	[23, 25]	26	[24, 27]	20	[17, 24]	23	[21, 25]
Turin	26	[26, 28]	13	[12, 22]	25	[25, 26]	31	[29, 31]
Bordeaux	27	[23, 27]	21	[21, 23]	26	[23, 26]	24	[21, 25]
Valencia	28	[26, 29]	22	[15, 24]	29	[28, 29]	18	[14, 21]
Genoa	29	[28, 29]	14	[11, 25]	27	[27, 28]	34	[33, 34]
Zaragoza	30	[30, 33]	19	[15, 29]	33	[31, 33]	30	[29, 31]
Bradford	31	[30, 32]	33	[32, 33]	30	[27, 30]	16	[12, 22]
Seville	32	[30, 32]	23	[15, 24]	32	[32, 33]	29	[27, 29]
Naples	33	[32, 33]	27	[24, 29]	31	[31, 34]	33	[30, 33]
Łódź	34	[34, 34]	34	[34, 34]	34	[32, 34]	32	[32, 34]

L Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Edinburgh	1	[1, 4]	5	[3, 5]	8	[6, 9]	3	[2, 3]
Karlsruhe	2	[1, 6]	21	[15, 23]	2	[1, 2]	4	[4, 5]
Utrecht	3	[1, 5]	11	[10, 12]	4	[3, 5]	1	[1, 3]
Nuremberg	4	[2, 5]	13	[11, 15]	3	[2, 3]	8	[6, 10]
Florence	5	[1, 11]	1	[1, 1]	21	[19, 22]	19	[14, 20]
Bratislava	6	[5, 14]	19	[16, 24]	1	[1, 5]	24	[18, 25]
Ghent	7	[6, 12]	2	[2, 2]	23	[21, 26]	9	[7, 11]
Ljubljana	8	[3, 8]	4	[4, 5]	9	[6, 9]	22	[17, 27]
Graz	9	[9, 11]	6	[6, 7]	12	[11, 14]	5	[5, 12]
Bologna	10	[6, 11]	8	[6, 8]	7	[6, 10]	15	[11, 17]
Venice	11	[7, 16]	3	[3, 7]	20	[17, 21]	21	[15, 22]
Mannheim	12	[6, 12]	24	[19, 24]	5	[4, 5]	11	[8, 12]
Tallinn	13	[8, 14]	7	[5, 8]	10	[8, 11]	18	[16, 28]
Nottingham	14	[12, 15]	10	[9, 10]	19	[16, 21]	2	[1, 2]
Malmö	15	[14, 16]	16	[16, 21]	6	[6, 11]	17	[14, 22]

L Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Aarhus	16	[16, 19]	9	[9, 12]	16	[14, 19]	16	[13, 19]
Montpellier	17	[13, 18]	22	[21, 23]	15	[12, 16]	7	[5, 8]
Cluj-Napoca	18	[16, 23]	25	[25, 26]	13	[11, 21]	13	[11, 23]
Bochum	19	[17, 21]	32	[32, 33]	11	[9, 12]	10	[7, 11]
Liège	20	[18, 21]	23	[14, 24]	17	[15, 19]	14	[12, 20]
Liverpool	21	[19, 22]	17	[17, 24]	25	[22, 26]	6	[5, 7]
Timișoara	22	[20, 22]	29	[28, 29]	14	[13, 15]	12	[10, 20]
Bilbao	23	[21, 23]	12	[11, 16]	24	[22, 26]	29	[24, 30]
Katowice	24	[24, 25]	30	[29, 30]	18	[17, 20]	23	[20, 28]
Thessaloniki	25	[24, 25]	14	[11, 14]	33	[31, 35]	20	[15, 24]
Kaunas	26	[26, 30]	18	[16, 21]	35	[34, 35]	28	[27, 31]
Las Palmas	27	[26, 29]	20	[17, 21]	30	[30, 32]	34	[33, 35]
Saint-Etienne	28	[27, 31]	31	[30, 31]	28	[27, 28]	25	[16, 26]
Cordova	29	[28, 32]	15	[13, 17]	36	[36, 36]	31	[31, 33]
Varna	30	[28, 33]	26	[25, 31]	26	[23, 26]	36	[36, 36]
Iași	31	[26, 35]	36	[36, 36]	22	[19, 30]	26	[23, 29]
Brno	32	[26, 31]	27	[26, 28]	27	[26, 28]	32	[30, 33]
Gdansk	33	[28, 33]	28	[26, 28]	32	[28, 33]	30	[25, 30]
Ostrava	34	[33, 34]	33	[32, 33]	29	[28, 31]	33	[32, 34]
Lublin	35	[34, 35]	35	[34, 35]	34	[30, 35]	27	[24, 27]
Plovdiv	36	[36, 36]	34	[34, 35]	31	[31, 35]	35	[34, 35]

S-M Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Eindhoven	1	[1, 1]	3	[3, 5]	2	[1, 2]	12	[7, 12]
Linz	2	[2, 3]	4	[4, 6]	5	[3, 8]	15	[14, 16]
's-Hertogenbosch	3	[2, 3]	2	[2, 3]	8	[5, 8]	13	[10, 14]
Cork	4	[4, 7]	1	[1, 1]	20	[11, 21]	11	[9, 12]
Heidelberg	5	[4, 6]	16	[12, 33]	6	[3, 7]	3	[1, 3]
Lund	6	[4, 7]	21	[12, 24]	3	[3, 5]	8	[6, 13]
Galway	7	[6, 10]	6	[4, 8]	25	[15, 26]	2	[2, 5]
Leuven	8	[6, 10]	43	[39, 43]	4	[1, 5]	1	[1, 5]
York	9	[8, 11]	25	[23, 31]	7	[6, 8]	4	[2, 5]
Norwich	10	[9, 13]	8	[6, 9]	22	[15, 26]	9	[4, 9]
Weimar	11	[9, 14]	5	[5, 7]	11	[10, 25]	23	[19, 27]
Umeå	12	[8, 32]	49	[48, 57]	1	[1, 8]	37	[34, 44]
Leiden	13	[10, 13]	13	[10, 21]	16	[10, 17]	5	[4, 8]
Limerick	14	[13, 17]	10	[10, 14]	35	[30, 36]	6	[6, 14]
Waterford	15	[15, 17]	11	[11, 16]	23	[15, 25]	20	[16, 26]

S-M Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Groningen	16	[11, 20]	41	[33, 45]	9	[9, 9]	10	[6, 11]
Maastricht	17	[10, 18]	14	[7, 16]	24	[12, 24]	17	[16, 23]
Mons	18	[16, 21]	12	[11, 25]	21	[13, 25]	34	[27, 38]
Granada	19	[19, 33]	9	[9, 11]	47	[45, 53]	27	[23, 30]
Bruges	20	[18, 22]	7	[2, 8]	39	[35, 40]	53	[48, 60]
Porto	21	[19, 30]	23	[23, 36]	13	[10, 36]	25	[19, 28]
Avignon	22	[15, 22]	20	[13, 22]	19	[14, 21]	29	[17, 30]
Parma	23	[19, 24]	19	[13, 20]	18	[15, 22]	45	[38, 48]
Tampere	24	[23, 40]	28	[28, 42]	10	[10, 42]	42	[41, 44]
Tartu	25	[23, 35]	17	[13, 26]	40	[38, 43]	31	[27, 39]
Namur	26	[25, 32]	18	[17, 34]	33	[27, 34]	36	[28, 41]
Ostend	27	[22, 27]	22	[17, 26]	41	[39, 44]	16	[11, 17]
Maribor	28	[18, 28]	32	[19, 33]	28	[20, 30]	21	[15, 26]
Turku	29	[23, 32]	38	[28, 39]	17	[13, 25]	32	[27, 35]
Trieste	30	[23, 32]	24	[15, 25]	27	[21, 30]	52	[45, 54]
Trento	31	[26, 32]	30	[23, 33]	34	[31, 42]	28	[17, 31]
Santiago	32	[31, 34]	33	[27, 35]	31	[28, 36]	33	[28, 35]
Dundee City	33	[29, 37]	44	[42, 45]	46	[37, 46]	7	[6, 8]
Kalamata	34	[30, 41]	15	[15, 23]	36	[29, 42]	63	[63, 64]
Sibiu	35	[31, 36]	34	[32, 37]	29	[15, 34]	38	[36, 51]
Perugia	36	[32, 39]	37	[37, 39]	12	[11, 34]	58	[53, 59]
Coimbra	37	[26, 37]	39	[25, 42]	15	[11, 27]	49	[37, 52]
San Sebastián-Donostia	38	[27, 39]	40	[24, 41]	30	[24, 34]	39	[27, 39]
Cagliari	39	[36, 40]	36	[27, 39]	26	[23, 29]	60	[56, 61]
Ravenna	40	[36, 42]	31	[19, 32]	37	[35, 43]	57	[46, 57]
Salamanca	41	[38, 44]	35	[20, 35]	59	[56, 60]	18	[17, 27]
Brescia	42	[39, 45]	48	[47, 51]	14	[11, 22]	59	[53, 60]
Klaipeda	43	[42, 51]	27	[26, 29]	62	[62, 63]	40	[34, 44]
Matera	44	[43, 49]	26	[22, 40]	45	[39, 50]	64	[63, 64]
Rijeka	45	[44, 49]	50	[46, 52]	43	[42, 47]	30	[23, 41]
Nitra	46	[43, 53]	57	[56, 60]	53	[47, 54]	14	[13, 24]
Karlovy Vary	47	[45, 55]	29	[27, 47]	49	[45, 55]	62	[60, 62]
Lleida	48	[42, 48]	45	[39, 47]	51	[49, 54]	35	[30, 36]
Baia Mare	49	[46, 51]	60	[56, 61]	38	[33, 42]	26	[25, 33]
Guimarães	50	[43, 52]	56	[54, 58]	32	[28, 33]	47	[33, 50]
Torun	51	[42, 52]	52	[44, 53]	42	[33, 50]	46	[45, 51]
Split	52	[49, 55]	51	[48, 52]	60	[58, 60]	24	[21, 35]
Győr	53	[49, 54]	46	[46, 48]	52	[46, 53]	48	[44, 54]
Szeged	54	[52, 57]	61	[60, 61]	50	[47, 50]	22	[19, 23]

S-M Group	C3 Index		1. Cultural Vibrancy		2. Creative Economy		3. Enabling Environment	
Lecce	55	[54, 59]	53	[51, 55]	48	[47, 54]	56	[51, 59]
Burgos	56	[56, 57]	47	[45, 52]	55	[52, 56]	54	[50, 58]
Veliko Turnovo	57	[55, 60]	42	[41, 46]	61	[61, 63]	55	[51, 58]
Pilsen	58	[52, 60]	58	[53, 59]	44	[41, 47]	50	[39, 52]
Pécs	59	[55, 60]	55	[51, 56]	54	[51, 54]	44	[43, 51]
Osijek	60	[56, 60]	54	[54, 60]	64	[64, 64]	19	[18, 31]
Patras	61	[61, 62]	59	[56, 60]	57	[56, 59]	61	[61, 62]
Prešov	62	[61, 62]	62	[62, 62]	58	[57, 60]	51	[45, 55]
Liepāja	63	[63, 64]	63	[63, 63]	63	[61, 63]	41	[38, 60]
Košice	64	[63, 64]	64	[64, 64]	56	[55, 58]	43	[39, 53]

Conclusions

Overall, the analysis of statistical coherence reveals that the statistical structure of the C3 Index 2017 is coherent with its conceptual framework, given that all indicators have good-to-strong correlation with their respective dimensions. Furthermore, all dimensions correlate strongly with the three sub-indices and the C3 Index itself and are fairly in line with the expert-based weights, all of which indicates that the framework is well balanced.

The C3 Index and all three sub-indices are relatively robust to methodological assumptions relating to the normalisation method and the dimension weights. It is reassuring that for over 80% of the cities included in the C3 Index, the overall and sub-index ranks are the result of the underlying data and not of the modelling choices. Consequently, inferences can be drawn for most cities within their peer group (particularly in the XXL group). Nevertheless, some caution may be needed for a few cities, such as Vilnius in the XL group (with 90% confidence interval widths of 10 positions), Florence in the L group (with 90% confidence interval widths of 10 positions), twelve cities in the S-M group – Umeå, Tampere, Granada, Tartu, San Sebastián-Donostia, Porto, Kalamata, Coimbra, Maribor, Nitra, Karlovy Vary and Torun – with 90% confidence interval widths between 10 and 24 positions.

APPENDIX

Table A1.
Indicators

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-Index 1	**Cultural Vibrancy**					
Dimension 1.1	**Cultural Venues & Facilities**					
1. Sights & landmarks	Points of historical, cultural and or artistic interest, such as architectural buildings, religious sites, monuments and statues, churches and cathedrals, bridges, towers and fountains, divided by the total population and then multiplied by 100,000.	City	2016	2016	99%	TripAdvisor
2. Museums	Number of museums that are open to the public divided by the total population and then multiplied by 100,000.	City	2016	2016	100%	TripAdvisor
3. Cinema seats	Number of cinema seats in the city divided by the total population and then multiplied by 1,000.	City	2011-2014	2011	57%	Eurostat (Urban Audit)
4. Concerts & shows	Number of theatres and other music venues (concert halls, clubs, etc.) and current shows divided by the total population and then multiplied by 100,000.	City	2016	2016	94%	TripAdvisor
5.Theatres	Number of theatres in the city divided by the total population and then multiplied by 100,000.	City	2011-2014	2011	64%	Eurostat (Urban Audit)

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-Index 1	**Cultural Vibrancy**					
Dimension 1.2	**Cultural Participation & Attractiveness**					
6. Tourist overnight stays	Total annual number of nights that tourists/guests have spent in tourist accommodation establishments (hotel or similar) in the city divided by the total population.	City	2010-2014	2014	84%	Eurostat (Urban Audit)
7. Museum visitors	Total number of museum tickets sold during the reference year divided by the total population and then multiplied by 1,000.	City	2011-2014	2011	71%	Eurostat (Urban Audit)
8. Cinema attendance	Total number of tickets sold, referring to all films screened during the year, divided by the total population and then multiplied by 1,000.	City	2011-2014	2011	52%	Eurostat (Urban Audit)
9. Satisfaction with cultural facilities	Percentage of population that is very satisfied with cultural facilities in the city.	City	2015	2015	32%	Flash Eurobarometer 366 by TNS/EC (Survey on 'Quality of life in cities')

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-index 2	**Creative Economy**					
Dimension 2.1	**Creative & Knowledge-based Jobs**					
10. Jobs in arts, culture & entertainment	Number of jobs in arts, culture- and entertainment-related activities such as performing arts, museums and libraries, divided by the total population and then multiplied by 1,000.	City	2011-2014	2011	81%	Eurostat (Urban Audit)
11. Jobs in media & communication	Number of jobs in media and communication-related activities such as book and music publishing, film production and TV, divided by the total population and then multiplied by 1,000.	City	2011-2014	2011	70%	Eurostat (Urban Audit)
12. Jobs in other creative sectors	Number of jobs in professional, scientific and technical, administrative and support service activities such as architecture, advertising, design, and photographic activities, divided by the total population and then multiplied by 1,000.	City	2011-2014	2011	70%	Eurostat (Urban Audit)

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-index 2	**Creative Economy**					
Dimension 2.2	**Intellectual Property & Innovation**					
13. ICT patent applications	Three-year average number of ICT patent applications (including: consumer electronics, computers and office machinery, and telecommunications) filed to the European Patent Office (EPO) by priority year divided by the total population and then multiplied by 1 million.	NUTS 3	2010-2012	Average	95%	Eurostat (Regional Statistics)
14. Community design applications	Three-year average number of Community design applications filed to the Office for Harmonization in the Internal Market (OHIM) divided by the total population and then multiplied by 1 million[11].	NUTS 3	2013-2015	Average	82%	Eurostat (Regional Statistics)

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-index 2	**Creative Economy**					
Dimension 2.3	**New Jobs in Creative Sectors**					
15. Jobs in new arts, culture & entertainment enterprises	Number of persons employed in the enterprises established in the reference year in arts, culture and entertainment activities such as performing arts, museums and libraries, divided by the total population and then multiplied by 100,000.	NUTS 3	2010-2013	2013	43%	Eurostat (Regional Statistics)
16. Jobs in new media & communication enterprises	Number of persons employed in the enterprises established in the reference year in in media and communication activities such as book and music publishing, film production and TV, divided by the total population and then multiplied by 100,000.	NUTS 3	2010-2013	2013	42%	Eurostat (Regional Statistics)
17. Jobs in new enterprises in other creative sectors	Number of persons employed in the enterprises established in the reference year in professional, scientific and technical activities such as architecture, advertising, design and photographic activities, divided by the total population and then multiplied by 100,000.	NUTS 3	2010-2013	2013	43%	Eurostat (Regional Statistics)

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-index 3	**Enabling Environment**					
Dimension 3.1	**Human Capital & Education**					
18. Graduates in arts & humanities	Average number of tertiary education students (ISCED 2011 levels 5-8) enrolled in the academic years 2010–2011, 2011–2012 and 2012–2013 in arts and humanities courses divided by the total population and then multiplied by 100,000[12].	City	2010-2013	Average	88%	ETER project
19. Graduates in ICT	Average number of tertiary education graduates (ISCED 2011 levels 5-8[13]) in the academic years 2010–2011, 2011–2012 and 2012–2013 in Information and communication technologies courses divided by the total population and then multiplied by 100,000.	City	2010-2013	Average	88%	ETER project
20. Average appearances in university rankings	Average number of a university's appearances in four different university rankings: QS, Shanghai, Leiden and Times.	City	2014	2014	100%	QS, Shanghai, Leiden, Times rankings

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-index 3	**Enabling Environment**					
Dimension 3.2	**Openness, Tolerance & Trust**					
21. Foreign graduates	Average number of foreign graduates in tertiary education courses in the academic years 2010–2011, 2011–2012 and 2012–2013 as a percentage of the total number of tertiary education graduates (ISCED 2011 levels 5-8[14]) in the same academic years.	City	2012-2013	2012	62%	ETER project
22. Foreign-born population	Percentage of the total population which is foreign-born.	City	2011-2014	2011	73%	Eurostat (Urban Audit)
23. Tolerance of foreigners	Percentage of the population which very strongly agrees with the statement: 'The presence of foreigners is good for this city'.	City	2015	2015	32%	Flash Eurobarometer 366 by TNS/EC (Survey on 'Quality of life in cities')
24. Integration of foreigners	Percentage of the population which very strongly agrees with the statement: 'Foreigners who live in this city are well integrated'.	City	2015	2015	32%	Flash Eurobarometer 366 by TNS/EC (Survey on 'Quality of life in cities')
25. People trust	Percentage of the population which very strongly agrees with the statement: 'Generally speaking, most people in this city can be trusted'.	City	2015	2015	32%	Flash Eurobarometer 366 by TNS/EC (Survey on 'Quality of life in cities')

Variable name	Short explanation	Geo level	Reference period	Mode year	Availability	Source
Sub-index 3	**Enabling Environment**					
Dimension 3.3	**Local & International Connections**					
26. Passenger flights	Number of passenger flights per day, accessible within 90 minutes of travel by road, divided by the total population and then multiplied by 100,000.	City	2013	2013	86%	DG REGIO
27. Potential road accessibility	Computed indicator based on road network data.	City	2012	2012	86%	DG REGIO
28. Direct trains to other cities	Average hourly number of departures between 6:00 and 20:00 of direct trains to other cities or greater cities divided by the total population and then multiplied by 1 million.	City	2014	2014	86%	DG REGIO
Dimension 3.4	**Quality of Governance**					
29. Quality of governance	Computed indicator measuring the quality of government in three areas of public services: education, healthcare and law enforcement.	NUTS 2, NUTS 1 and NUTS 0	2013	2013	96%	DG REGIO

Table A2.
Data coverage

City	C3 Index	DATA COVERAGE		
		1. Cultural Vibrancy	2. Creative Economy	3. Enabling Environment
Vienna	76%	56%	63%	100%
Graz	76%	56%	63%	100%
Linz	62%	44%	63%	75%
Brussels	90%	100%	63%	100%
Antwerp	76%	89%	63%	75%
Ghent	72%	78%	63%	75%
Leuven	76%	89%	63%	75%
Bruges	62%	89%	50%	50%
Ostend	62%	89%	50%	50%
Mons	79%	100%	63%	75%
Liège	66%	89%	63%	50%
Namur	69%	78%	88%	50%
Veliko Turnovo	83%	89%	88%	75%
Varna	100%	100%	100%	100%
Sofia	86%	89%	100%	75%
Plovdiv	76%	100%	63%	67%
Geneva	62%	89%	63%	42%
Bern	62%	89%	63%	42%
Basel	76%	100%	63%	67%
Zurich	55%	33%	25%	92%
Nicosia	48%	44%	25%	67%
Limassol	90%	100%	63%	100%
Prague	72%	89%	50%	75%
Pilsen	72%	89%	50%	75%
Karlovy Vary	76%	89%	63%	75%
Brno	90%	100%	63%	100%
Ostrava	76%	89%	63%	75%
Stuttgart	76%	89%	63%	75%
Karlsruhe	72%	78%	63%	75%
Heidelberg	72%	78%	63%	75%
Mannheim	90%	100%	63%	75%
Munich	76%	89%	63%	100%
Nuremberg	90%	100%	63%	100%
Berlin	76%	100%	63%	75%
Hamburg	90%	89%	63%	100%
Frankfurt	76%	89%	63%	75%
Hannover	76%	89%	63%	75%
Essen	90%	100%	63%	100%
Cologne	76%	89%	63%	100%
Bochum	76%	89%	63%	100%
Dresden	76%	89%	63%	75%
Weimar	69%	78%	50%	100%
Copenhagen	86%	100%	100%	100%
Aarhus	79%	89%	63%	75%
Tallinn	100%	78%	63%	75%
Tartu	83%	89%	88%	75%
Thessaloniki	69%	44%	50%	75%
Patras	69%	44%	50%	75%
Kalamata	62%	33%	75%	75%
Athens	72%	56%	88%	50%
Santiago	83%	78%	100%	50%
San Sebastián-Donostia	72%	78%	88%	75%
Bilbao	62%	78%	100%	25%
Zaragoza	83%	78%	100%	75%
Madrid	100%	100%	100%	100%
Burgos	79%	78%	88%	75%
Salamanca	79%	78%	88%	75%
Barcelona	90%	100%	100%	75%
Lleida	72%	56%	88%	75%
Valencia	86%	89%	100%	75%
Cordova	79%	78%	88%	100%
Granada	79%	78%	88%	75%
Seville	83%	78%	100%	75%
Las Palmas	76%	78%	75%	75%
Tampere	76%	89%	63%	75%
Helsinki	79%	100%	63%	75%
Turku	76%	89%	63%	75%
Paris	83%	78%	100%	75%
Lille	93%	78%	100%	100%
Nantes	79%	67%	100%	75%
Bordeaux	93%	78%	100%	100%
Toulouse	79%	67%	100%	75%
Saint-Etienne	79%	67%	100%	100%
Lyon	79%	67%	100%	75%
Montpellier	79%	67%	100%	75%
Marseilles	93%	78%	100%	100%
Avignon	79%	89%	63%	75%
Rijeka	79%	89%	63%	75%
Split	79%	89%	63%	75%
Zagreb	93%	100%	50%	100%
Osijek	69%	78%	75%	67%
Budapest	93%	78%	100%	100%
Győr	72%	56%	88%	75%
Pécs	72%	56%	88%	75%
Szeged	79%	67%	100%	75%
Galway	69%	67%	88%	75%
Dublin	76%	89%	63%	75%
Limerick	69%	67%	88%	75%
Waterford	69%	67%	100%	75%
Cork	69%	78%	50%	75%
Turin	76%	56%	75%	92%
Genoa	62%	44%	75%	67%
Brescia	62%	44%	75%	67%
Milan	52%	44%	75%	42%
Naples	66%	56%	75%	75%
Lecce	59%	44%	63%	67%
Matera	62%	44%	75%	67%
Cagliari	59%	44%	63%	67%
Trento	62%	44%	75%	67%
Venice	59%	33%	75%	67%
Trieste	62%	44%	75%	67%
Parma	62%	44%	75%	67%
Bologna	76%	56%	75%	92%
Ravenna	52%	44%	75%	42%
Florence	66%	44%	88%	67%
Perugia	59%	33%	75%	75%
Rome	76%	56%	75%	100%
Kaunas	79%	67%	100%	75%
Klaipeda	79%	67%	100%	100%
Vilnius	97%	100%	88%	75%
Luxembourg	59%	44%	25%	92%
Liepāja	72%	89%	50%	75%
Riga	79%	100%	25%	100%
Valletta	45%	44%	13%	67%
Groningen	79%	44%	100%	75%
Leeuwarden	62%	22%	100%	67%
Utrecht	69%	44%	100%	67%
Amsterdam	72%	56%	100%	67%
The Hague	69%	44%	100%	67%
Leiden	66%	33%	100%	67%
Rotterdam	72%	56%	100%	67%
s-Hertogenbosch	55%	33%	100%	42%
Eindhoven	66%	33%	100%	67%
Maastricht	69%	44%	100%	67%
Oslo	62%	56%	25%	92%
Stavanger	48%	44%	25%	67%
Bergen	45%	44%	13%	67%
Łódź	86%	89%	100%	75%
Warsaw	100%	100%	100%	100%
Krakow	100%	100%	100%	100%
Katowice	76%	89%	100%	50%
Lublin	83%	89%	88%	75%
Poznan	86%	89%	100%	75%
Wroclaw	86%	89%	100%	75%
Torun	83%	89%	88%	75%
Gdansk	97%	100%	88%	100%
Guimarães	59%	89%	38%	50%
Porto	62%	89%	50%	50%
Coimbra	69%	89%	50%	67%
Lisbon	76%	100%	50%	75%
Cluj-Napoca	69%	78%	63%	67%
Baia Mare	41%	44%	38%	42%
Sibiu	48%	67%	38%	42%
Iasi	52%	67%	50%	42%
Bucharest	69%	78%	63%	67%
Timisoara	48%	67%	38%	42%
Stockholm	90%	100%	100%	75%
Malmö	97%	89%	88%	100%
Lund	55%	33%	63%	67%
Gothenburg	83%	78%	100%	75%
Umeå	79%	89%	75%	75%
Maribor	72%	89%	88%	50%
Ljubljana	86%	100%	88%	75%
Bratislava	90%	100%	75%	92%
Nitra	79%	89%	88%	67%
Prešov	79%	78%	78%	67%
Košice	86%	100%	100%	67%
Manchester	72%	78%	63%	67%
Liverpool	48%	33%	63%	67%
York	66%	56%	63%	42%
Bradford	59%	33%	63%	67%
Nottingham	62%	78%	63%	67%
Birmingham	59%	67%	63%	92%
Norwich	69%	78%	50%	67%
London	66%	44%	50%	67%
Dundee City	55%	33%	50%	75%
Edinburgh	59%	33%	63%	100%
Glasgow	72%	44%	63%	100%

Note: cities in red and italic font have not been ranked due to poor data coverage (<33% on "Cultural Vibrancy" or "Creative Economy"); cities in aqua and italic font have not been ranked because outside EU countries.

Table A3.
Number of winsorised values and skewness and kurtosis after winsorisation

Sub-indices	Dimensions	Indicators	Winsorised values	Skewness < 2	Kurtosis < 3.5
1. Cultural Vibrancy	D1.1 Cultural Venues & Facilities	1. Sights & landmarks	0	1.5	2.2
		2. Museums	0	1.6	2.2
		3. Cinema seats	0	1.3	2.5
		4. Concerts & shows	2	1.9	3.4
		5. Theatres	1	1.4	1.2
	D1.2 Cultural Participation & Attractiveness	6. Tourist overnight stays	2	2.0	4.7
		7. Museum visitors	1	1.9	4.2
		8. Cinema attendance	0	1.8	3.8
		9. Satisfaction with cultural facilities	0	0.2	-0.6
2. Creative Economy	D2.1 Creative & Knowledge-based Jobs	10. Jobs in arts, culture & entertainment	1	1.0	1.6
		11. Jobs in media & communication	0	1.4	2.5
		12. Jobs in other creative sectors	0	1.0	1.0
	D2.2 Intellectual Property & Innovation	13. ICT patent applications	3	*2.1*	*3.7*
		14. Community design applications	3	1.7	3.6
	D2.3 New Jobs in Creative Sectors	15. Jobs in new arts, culture & entertainment enterprises	2	1.1	1.6
		16. Jobs in new media & communication enterprises	2	2.0	3.4
		17. Jobs in new enterprises in other creative sectors	3	*2.1*	*4.1*
3. Enabling Environment	D3.1 Human Capital & Education	18. Graduates in arts and humanities	1	1.6	3.1
		19. Graduates in ICT	0	1.4	1.5
		20. Average appearances in university rankings	2	1.4	2.1
	D3.2 Openness, Tolerance & Trust	21. Foreign graduates	3	1.7	2.5
		22. Foreign-born population	0	0.9	1.6
		23. Tolerance of foreigners	0	0.4	-0.4
		24. Integration of foreigners	0	1.3	1.0
		25. People trust	0	0.7	-0.7
	D3.3 Local & International Connections	26. Passenger flights	0	1.9	3.7
		27. Potential road accessibility	0	-1.8	3.8
		28. Direct trains to other cities	1	1.9	3.7
	D3.4 Quality of Governance	29. Quality of governance	0	-0.5	-0.4

Endnotes

1   https://composite-indicators.jrc.ec.europa.eu/cultural-creative-cities-monitor

2   The analysis was based on the recommendations of the OECD & EC JRC *Handbook on Constructing Composite Indicators* (2008) and on more recent research from the JRC. JRC audits of composite indicators and scoreboards, conducted by the JRC upon request of indices' developers, are available at: http://composite-indicators.jrc.ec.europa.eu/.

3   An exception has been made for Baia Mare (41%) as the data coverage for 'Cultural Vibrancy' is well above 33% (44%) and the data coverage for 'Creative Economy' is also relatively good (38%) compared to the other cities included in the C3 Monitor but excluded from the final rankings, namely Nicosia (25%), Limassol (25%), Luxembourg (25%), Riga (25%) and Valletta (13%).

4   The Expectation-Maximization (EM) algorithm (Little and Rubin, 2002) is an iterative procedure that finds the maximum likelihood estimates of the parameter vector by repeating two steps: (1) The expectation E-step: Given a set of parameter estimates, such as a mean vector and covariance matrix for a multivariate normal distribution, the E-step calculates the conditional expectation of the complete-data log likelihood given the observed data and the parameter estimates. (2) The maximization M-step: Given complete-data log likelihood, the M-step finds the parameter estimates to maximize the complete-data log likelihood from the E-step. The two steps are iterated until the iterations converge.

5   Groeneveld & Meeden (1984) set the criteria for absolute skewness at above 1 and for kurtosis above 3.5. The skewness criterion was relaxed to account for the small sample (155 cities).

6   The association between Foreign graduates and Foreign-born population to D3.2, Openness, Tolerance and Trust, is 0.44-0.46, while the other three indicators under D3.2 correlate at 0.57-0.72.

7   In the budget allocation method experts are given a budget of N points, to be distributed over a number of indicators (or dimensions), allocating more to those indicators whose importance they want to stress. The budget allocation method can be divided into four different phases: (a) selection of experts for the valuation; (b) allocation of budget to the indicators; (c) calculation of the weights; (d) iteration of the budget allocation until convergence is reached (optional). See more at: https://composite-indicators.jrc.ec.europa.eu/?q=10-step-guide/step-6-weighting

8   The four city groups based on population are as follows: 'XXL': more than 1 million; 'XL': between 500,000 and 1 million; 'L': between 250,000 and 500,000; 'S-M': between 50,000 and 250,000.

9   Regarding the aggregation formula, decision theory practitioners have challenged the use of simple arithmetic averages on conceptual grounds because of their fully compensatory nature, in which a comparatively high advantage on a few dimensions can compensate for a comparative disadvantage on many dimensions. Despite justification for the arithmetic averaging formula in the development of the C3 Index, as discussed in the previous section, the geometric average was initially considered as a possible alternative. This is a partially compensatory approach that rewards cities with similar performance in all dimensions; it motivates those cities with uneven performance to improve in those dimensions in which they perform poorly, and not just in any dimension. However, as the geometric average runs counter to the idea of a 'specialisation' strategy, which encourages a city to improve in those dimensions where it already has a comparative advantage, it was finally not included in the simulations. A geometric average would contradict a principle adopted in the development of the C3 Index, whereby weak performance in some of the C3 dimensions should not be penalised.

10 Note that the 2017 Cultural and Creative Cities Monitor includes 168 cities, roughly 90% of the European cities which have been designated, under different approaches, Cultural and Creative Cities. Thirteen cities have been included in the Monitor but not in the final rankings because they did not meet the data coverage criterion, meaning at least 45% data coverage at the index level and at least 33% for the 'Cultural Vibrancy' and 'Creative Economy' sub-indices, or because they were located in countries outside the EU (namely: Switzerland and Norway). The rankings and the analysis presented henceforth are therefore always based on a total of 155 cities, but qualitative information is provided for the full sample of 168 cities.

11 A Community design is a unitary industrial design right that covers the European Union. A design is defined as the appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colours, shape, texture and/or materials of the product itself and/or its ornamentation.

12 ISCED 5: Short cycle tertiary education. ISCED 6: Bachelor's or equivalent programmes. ISCED 7: Master's or equivalent programmes.

13 Ibid.

14 Ibid.