COMPOSITE INDEX TO MEASURE THE PERFORMANCE OF TODAY’S CREATIVE CITIES: A HOLISTIC PERSPECTIVE

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Abstract: The urgency to make today’s cities competitive has made political decision-makers focus on strategies oriented towards creativity, intelligence and urban sustainability. This scenario has led to the need to measure, assess and monitor the effects of those strategies on cities’ performance. Therefore, this study aims to present the scientific and robust weighting of the creativity, intelligence and urban sustainability dimensions in cities’ holistic, integrated and overall performance. Implicit in this objective is the previous construction of Composite Indices for each of those dimensions. In this context, the Exploratory Factor Analysis was found to be appropriate to respond to this aim, with empirical evidence being obtained in Portugal. The results show a weighting of 38%, 23.4% and 39.6% for creativity, intelligence and urban sustainability respectively. The contributions and implications for theory and practice, followed by indications for future research and the conclusions are also presented.

Key Words: creativity, intelligence, urban sustainability, composite index, performance, cities.

Introduction

Cities are increasingly seen as the main driver of regional and global economic development, irrespective of their population density or geographical context and cities’ role in economic development has changed considerably, with them ceasing to be simply places of population density, business and employment (Haberstroh and Pinkwart 2018). However, some duality has persisted in the emphasis of local governments and central political decision-makers regarding the strategies adopted and the inherent investment, for example Silicon Valley, Bavaria Valley (Bavaria), Silicon Glen (Scotland), Silicon Saxony (Dresden, Hospers and Pen 2008), Barcelona, San Francisco, Glasgow (Amin and Thrift 2007), Rotterdam and Amsterdam (Romein and Trip 2009), whose strategies differ from each other. Given this scenario, the European Union, aiming for European cities characterised by competitiveness and territorial and social cohesion, defined strategies to be implemented at micro level – cities – by member countries so that inclusive, intelligent and sustainable growth can become a reality (Eurostat 2019).

In this context, interest has been aroused in the academic community regarding cities and the route they have chosen to grow in all their dimensions. Today’s cities are multi-dimensional and pluralist places conciliating the historical past with the future, culture with economic factors, talents, technology and business with sustainability and with creativity (Power and Scott 2011, Ratten 2017), so that wealth creation can be demonstrated and supported by tri-partite pillars – creativity, intelligence and urban sustainability – to allow long-term growth and sustained performance (Rodrigues and Franco 2018). Obviously, this path is an enormous challenge for political decision-makers and local governments, as these objectives imply multiple transformations (Bouton et al. 2013), going beyond the traditional models of economic growth and including both tangible and intangible factors (Romero-Padilla et al. 2016). This means that the strategies implemented and to be implemented in cities should be directed to the strategic governance of spaces and places (Audretsch 2003, Malecki 2007), towards people and not
simply to organisational structures (Audretsch 2003).

For Rodrigues and Franco (2018), a paradigmatic change is found in the vision of the role and future of cities, stimulated by the phenomenon of globalization and it’s meant that cities’ economic and political importance grew quickly and that political decision-makers understood these help to solve their everyday problems of a social, economic and environmental nature. This vision is shared by the Networked Society City Index (Ericsson 2016) where the aim is for cities to become more inclusive, safe, resilient, creative, intelligent and sustainable, supported by the use of ICT and network connectivity, and by adopting a more sustainable consumption model – the circular economy.

However, this paradigmatic change in the role of today’s cities in economic growth has given rise to a vast amount of literature on this topic (Florida 2005, Scott 2006, Mcgranahan and Wojan 2007, Landry 2012, Tranos and Gertner 2012, Cabrita et al. 2013, Ratiu 2013, Letalfa 2015, Girard et al. 2016, FPA 2017, Ortegel 2017, Rahbarianazd and Dorati 2017, Florida 2019), directed towards creative, intelligent and sustainable cities, to the connection between culture, urban regeneration, collaboration processes and partnerships, and the economic and non-economic factors of multi-dimensional performance of cities today. This heterogeneity of theoretical and empirical studies has stimulated the development of indices to measure cities’ performance regarding their creativity (Florida et al. 2007, Giffinger et al. 2007, Kakiuchi 2016, Montalto et al. 2019), intelligence (Picard et al. 2003, Carli et al. 2013, EY 2016, Angelidou 2017) and sustainability (Irungbam 2016, Trivellato 2016, European Commission 2019).

However, these indices have not yet filled the existing gaps in the literature on the measurement of cities’ performance as a whole, noting a shortage of studies including the dimensions of creativity, intelligence and sustainability in a single index with the required scientification. The importance of constructing a composite index was evidenced by Rodrigues and Franco (2018), who claimed that the performance of cities must be measured based on a holistic perspective and objective. In addition, the most studied topics have been global cities, incredible cities, city networks and city paradigms in social, ecological and cultural terms (Nijkamp and Kourtit 2013). In this area, there is a steady production of empirical studies addressing cities’ performance (Malecki 2007) through indices showing a compilation of indicators in the various dimensions characterising cities (Borén and Young 2013, Flores and Teixeira 2017), with a great number of variables and for large samples (Çetindamar and Günsel 2012). Another gap identified concerns the relevance of including performance indicators that ally creativity and culture to sustainability, networks and their synergies for cities’ sustainable and intelligent performance (Carta 2009, Tranos and Gertner 2012, Walker and Hills 2012, Cabrita et al. 2013, Echebarria et al. 2016, Bifulco et al. 2017, Cohen et al. 2017, Della Lucia et al. 2017, Ferraris et al. 2018). It should be noted that it is underlying in these gaps that creativity allows bridges to be created for the smart axis, as an adjective, as well as for sustainability, supported by the formation of networks, which allow synergies to be created between all city amenities (Ratten 2017). Another fundamental gap identified in the extensive literature concerns filling the existing gap between theory and practice (Lee et al. 2014), leading to Mora et al. (2017) calling for more studies designing holistic models of how current cities are built and about the scientific instruments that can help all actors involved in that construction (Piano and Guerra 2014, Huovila et al. 2017).

Aiming to fill these gaps, this study aims to present the scientific and robust weighting of the creativity, intelligence and urban sustainability dimensions in cities’ holistic, integrated and overall performance. More precisely, the following specific objectives are defined: 1) to present an empirical performance measurement study, for sample and large dimension variables; 2) to treat these variables by multivariate statistical techniques, in order to construct a holistic composite index; and 3) with the answer to objectives 1 and 2, it is intended to bridge the gap between theory and practice. In short, this investigation aims to present the scientific and
robust weighting of creativity, intelligence and urban sustainability dimensions in the cities’ holistic, integrated and global performance. This objective implies the previous construction of Composite Indices for each of those dimensions. Thus, among the various contributions of this empirical study, the main one lies in presenting a Composite Index for the holistic performance of today’s creative cities with the respective scientific weightings.

**Literature review**

**Dimensions of today’s creative cities**

The new role attributed to today’s cities concerning economic growth has caused a certain ambiguity around the concept itself and the dimensions included, which means that studies on cities should be holistic and integrated. The literature on this topic highlights creativity (Scott 2000, Florida 2005, Hospers and Pen 2008, Pratt 2008, Grant and Kronstal 2010, Landry 2012, Kong 2014, Kakuichi 2016, Ratten 2017, Florida 2019), intelligence (Dodgson and Gann 2011, Nam and Pardo 2011, Letaifa 2015, Mardikyan et al. 2015, Bouk et al. 2017, Ratten 2017) and urban sustainability (Cavalcanti 1995, Camagni et al. 1998, Elkington 2004, Wheeler and Beatley 2014, Pozdniakova 2017) as inseparable dimensions of cities at the present time. These dimensions point us towards simultaneously creative, intelligent and sustainable cities, and these are defined as possessing a creative, diversified, open and tolerant climate, creative talents and relevant cultural dynamics (Florida 2005, Romein and Trip 2009, Grant and Kronstal 2010), provided by participative governance, the adoption of technology, recognition of the social, human, physical, cultural and natural capital in which social and environmental questions are included (Bibri and Krogstie 2017, Ratten 2017). It should be noted that this line of thinking assumes that urban sustainability in cities integrates social development, economic development, environmental management and urban governance, which refers to the management and investment decisions taken by municipal authorities in coordination with national authorities and institutions (Donegan and Lowe 2008, World Economic and Social Survey 2013). In addition, intelligence here is not only related to ICT and its various vectors, but to how urban creativity can be intelligently developed, and so that to emphasize social and human capital (Partridge 2004, Hoyman and Faricy 2009). In this context, what is understood by the intelligence dimension in the present research is that it can also be encompassed by creative and sustainable cities (Rodrigues and Franco 2019a). In this context, current cities’ overall performance must be addressed in a tri-partite and holistically integrated way.

This holistic approach to today’s cities aims to show that they must be provided with creative/favourable environments to stimulate the attraction and interaction of talented people and the fulfilment of cultural synergies, in articulation with the co-creation of economic value and with a catalysing effect in promoting urban regeneration and thereby achieving urban sustainability (Furtado and Alves 2012). However, the advantages of intelligence must be indexed to those driving forces in order to make cities even more attractive and entrepreneurial (Caragliu et al. 2011). Furthermore, creativity in cities arises from the catalysing benefit of culture through restoration and regeneration of cultural heritage as a driver of the economy by encouraging synergies, networks and partnerships between all stakeholders in order to obtain economic return in the present and future (Girard et al. 2016); intelligence is shown by the support of value exchange cycles, the circular economy process, the participative and creative process and urban sustainability, by recognizing the importance of their tangible and intangible amenities as predictors of their quality of life and performance (Neirotti et al. 2014). In this sense, Fig. 1 shows the conceptual model of a current city, approached holistically and characterised by multiple dimensions and sub-dimensions. This model is complemented in the following section by indicators and proxies to measure the overall, integrated performance of today’s cities.
Cities’ global performance should be measured through a multi-dimensional and holistic approach (Ericsson 2016, Girard et al. 2016), due to cities’ crucial role in the global economic development as places of connectivity (networks), creativity and innovation associated with social and economic progress, culture, diversity and the environment (European Commission 2011). In other words, cities’ performance includes dimensions inherent to their tangible and intangible resources, as argued by Anthopoulos (2017), and it is the reflection of the strategies implemented with a view to giving cities creativity, intelligence and urban sustainability (Davoudi and Sturzaker 2017).

In this context, there is still a dispersion of indices and indicators to measure performance, due to the complexity of managing a city holistically (Albino et al. 2015), despite all of them aiming...
to improve citizens’ quality of life (Shapiro 2006, ISO 2018). In other words, this performance is measured by a battery of indicators, which are understood as a methodological instrument, since the analysis of the used indicators allows political decision-makers to identify cities’ opportunities/threats so that their global performance can improve continuously and sustainably (U4SSC 2017), irrespective of their size. Corroborating this argument, Borsekova et al. (2018) concluded that a city’s size does not determine the implementation of strategies emphasizing creativity, intelligence and sustainability, since people are important in their integrated approach (Giffinger et al. 2007, Hollands 2008, Nam and Pardo 2011).

Recognizing that not all existing indices, indicators and proxies to measure cities’ global performance have been explored, Table 1 compiles the most used of them by the academic community and by other public and private entities.

**Table 1**

| Sub-dimension | General indicator | Source |
|---------------|-------------------|--------|
| **Creativity** |                   |        |
| Culture       | Places of culture and facilities | Giffinger et al. (2007), Durnaz et al. (2010), Hartley et al. (2012), Lombardi et al. (2012), García Suárez and Pulido Fernández (2015), Kakiuchi (2016), Bosch et al. (2017), European Union (2017) |
|               | Cultural participation and attractiveness |        |
| Creative economy | Creativity and employment | Giffinger et al. (2007), Caragliu et al. (2011), Hartley et al. (2012), Landry (2012), Lombardi et al. (2012), Panal and Yáñez (2012), Joss et al. (2013), García Suárez and Pulido Fernández (2015), Kakiuchi (2016), Bosch et al. (2017), European Union (2017), Skavronskaya (2017) |
|               | Intellectual property and innovation |        |
| Favourable environment | Human capital and education | Giffinger et al. (2007), Caragliu et al. (2011), Hartley et al. (2012), Landry (2012), García Suárez and Pulido Fernández (2015), Dingra and Chattopadhyay (2016), EPA (2016), European Union (2017), Skavronskaya (2017) |
|               | Openness, tolerance and trust |        |
|               | Local and international connections |        |
|               | Governance |        |
| Governance | Implementation | Landry (2012), U4SSC (2017) |
|               | Strategy | Landry (2012), Madeira et al. (2018), Angelidou (2017), Bosch |
|               | Best practices | Giffinger et al. (2007), Lombardi et al. (2012), García Suárez and Pulido Fernández (2015), Angelidou (2017), Bloom Consulting (2017), Garau et al. (2017) |
| ICT infrastructure and networks | Telecommunications | EY (2016), Ericsson (2016) |
|               | Transport |        |
|               | Energy |        |
|               | Environment | EY (2016) |
|               | Sensors |        |
The population observed is represented by the 308 towns and cities in Portugal (NUTS II), where those situated on the coast have a greater population density. The metropolitan areas of Lisbon and Porto have the greatest concentration of population. Table 2 presents the population distribution by region (NUTS III) and Fig. 2 represents the geographical spatiality of these 308 cities and towns.

**Data collection, indicators and proxies**

The steps in the construction of composite indicators were: theoretical framework (should be developed to provide a basis for the selection and combination of indicators) and data selection (based on the characteristics of a good indicator) (Nardo et al. 2005, OECD 2008). So, after the compilation of all indicators (variables) for the measurement of the holistic performance of cities/towns and, thus, validating the presented conceptual model, it was necessary to adapt them to the Portuguese context and to construct them from a database directed to cities, which

| ICT accessibility | Tariffs | Ericsson (2016) |
|-------------------|---------|-----------------|
| Mobility          | EY (2016) |
| Use of ICT        | Giffinger et al. (2007), Lombardi et al. (2012), Ericsson (2016) |
| Individual        | Giffinger et al. (2007), Lombardi et al. (2012), Ericsson (2016) |
| Public            | Giffinger et al. (2007), Caragili et al. (2011), Lombardi et al. (2012), EY (2016), Ericsson (2016), Madeira et al. (2016), Bloom Consulting (2017) |
| Vitality          | Individual and public EY (2016) |
| Sustainability    |         |
| Economic          |         |
| Competitiveness   | Giffinger et al. (2007), Lombardi et al. (2012), Devol et al. (2015), Adnan et al. (2016), Arcadis (2016), Bloom Consulting (2017), Bosch et al. (2017), EPA (2016), Ericsson (2016), Trivellato (2016) |
| Economic activity | Giffinger et al. (2007), Lombardi et al. (2012), Ericsson (2016), Trivellato (2016), Angelidou (2017), Bloom Consulting (2017) |
| Population        | Giffinger et al. (2007), Lombardi et al. (2012), EPA (2016), Trivellato (2016), Bloom Consulting (2017), Bosch et al. (2017) |
| Education         | Giffinger et al. (2007), Lombardi et al. (2012), Arcadis (2016), EPA (2016), Ericsson (2016), Trivellato (2016), Bloom Consulting (2017), Bosch et al. (2017) |
| Inclusion and cohesion | Giffinger et al. (2007), Lombardi et al. (2012), Ericsson (2016), Trivellato (2016), Bloom Consulting (2017), Bosch et al. (2017) |
| Social infrastructure | Giffinger et al. (2007), Lombardi et al. (2012), Ericsson (2016), Trivellato (2016), Bloom Consulting (2017), Bosch et al. (2017) |
| Basic infrastructure | Lombardi et al. (2012), Arcadis (2016), Ericsson (2016), Bosch et al. (2017) |
| Emission and production of atmospheric pollution | Giffinger et al. (2007), Lombardi et al. (2012), Joss et al. (2013), Ericsson (2016), Bloom Consulting (2017), Bosch et al. (2017) |
| Circular economy | Ligorio (2017), Smol et al. (2017) |
| Urbanism | Lombardi et al. (2012), Arcadis (2016), Dheingr and Chatto-pedhyay (2016), EPA (2016), Ericsson (2016), Bloom Consulting (2017), Artmann et al. (2019) |
is non-existent in Portugal. The numerical data for each variable was not collected randomly and it met the requirements of a good indicator (Chang et al. 2018).

Table 2

| NUTS II                              | Number of towns/cities | Population (number) |
|--------------------------------------|------------------------|---------------------|
| North                                | 86                     | 3,580,390           |
| Centre                               | 100                    | 2,237,640           |
| Lisbon Metropolitan Area             | 18                     | 2,827,514           |
| Alentejo                             | 58                     | 715,019             |
| Algarve                              | 16                     | 440,543             |
| Autonomous Region of the Azores      | 19                     | 244,573             |
| Autonomous Region of Madeira         | 11                     | 254,622             |
| Total                                | 308                    | 10,300,300          |

Source: Pordata (2019)

Fig. 2 – Population density in Portuguese local authorities

Source: Pordata (2019)
The collection of numerical data to produce the analysis is a crucial phase of this study, since the unavailability of data and resorting to various databases are unavoidable factors in the Portuguese context. Therefore, the database was formed by referring to various secondary sources – the National Statistics Institute (INE), PORDATA, and the official websites of various entities/institutions (e.g., Tripadvisor, Montalto et al. 2019) given the lack of a single database.

In these circumstances, the data-collection process began by obtaining the data available in the above-mentioned sources and by associating them with the dimension, sub-dimensions and indicators. This phase was extremely time-consuming and exhaustive so that the obtained database would be credible, reliable and suitable for the appropriate statistical treatment. Furthermore, the adaptation of the available data to the indicators and proxies most commonly used by academics and other entities implied an exhaustive search of theoretical and empirical work in various geographical contexts, so that this phase would be duly supported by scientific articles, minimizing the subjectivity inherent to the process. Therefore, the collected data present quality, reliability and comparability, as essential characteristics of a good indicator (Chang et al. 2018). Aware of the need to observe the requirements of a good indicator, it was also necessary to transform the absolute data obtained into relative data (proxy/resident population per 1000 city inhabitants), in order to allow the subsequent comparison between cities, irrespective of their size (Rodrigues and Franco 2019b).

The formed database is unique in Portugal, as official databases are not targeted at studies on cities, and so the result of this data-collection is a bonus for decision-makers in Portugal and it can be used for various purposes, besides those defined in this research.

Collecting data about the analysed population (N = 308) was a lengthy process through the need to compile data, due to the non-existence of a single database with numerical information about the dimensions of creativity, intelligence and urban sustainability. Added to the dispersion of data was the insufficiency of data when the unit of analysis is represented by the town/city.

In these circumstances, the selection of indicators and respective proxies was governed above all by data availability, which did not prevent the selection considering the characteristics necessary for a good indicator, i.e., their clarity, simplicity, reproduction, scientificity, salience, credibility, legitimacy and comparability (Mega and Pedersen 1998, Atabek et al. 2005, Nardo et al. 2005). The listed indicators must have these characteristics, as the quality of a composite index depends on this (Saisana and Tarantola 2002, Stanickova and Melecký 2018), as well as the chosen research method. The appropriate definition of the research method, namely the multivariate statistical techniques, aims to overcome the dissimilarity of the units of measure and the periods of reference for the data by employing more than one indicator (Křížik and Haluška 2008, OECD 2008). These authors also explain that the use of multiple indicators endow the obtained results with scientificity, relevance and meaning, as required by this typology of indices.

It was therefore indicated that measuring the global performance of the 308 Portuguese towns and cities should involve the aggregation and weighting methods defined by OECD (2008), i.e., the Exploratory Factor Analysis (EFA). However, a composite indicator is an aggregate of all dimensions, objectives, individual indicators and variables used (OECD 2008). Thus, in this study the composite index is used as an auxiliary means for calculating the weights of each dimension/sub-dimension (Rodrigues and Franco 2019b).

Given the high number of sub-dimensions (8) of used indicators (24 general and 47 specific indicators) and of proxies corresponding to the 154 variables to measure the creative, intelligent and sustainable performance of cities, detailed information on these is found in Appendix 1 (summary of data collection).
Stages of Data Analysis

The statistical treatment of the data to assess the global performance of the 308 Portuguese towns and cities was performed by using the IBM SPSS software (version 25.0) and it covered three distinct stages, as also revealed by various authors (Pestana and Gageiro 2014, Danielis et al. 2018, Marôco 2018), for the studied dimensions: creativity, intelligence and urban sustainability. However, as the intention is to determine the scientific weighting of each of these dimensions in the cities’ total performance, i.e., a Composite Index, the data analysis included two more stages (Kubrusly 2001, OECD 2008). The following paragraphs detail the methodological procedures associated with the set of five analysis stages.

The first step was to determine the validity of the 308 observations, and so the analysed observations represent around five times the studied variables, which ensures that no relevant information is lost. However, the heterogeneity of the units of measurement, the periods of reference and the possible omissions of data required data normalization, as any aggregation of data has to be preceded by this (Hair et al. 1995, Kubrusly 2001, Nardo et al. 2005, OECD 2008, Guimarães and Sarsfield Cabral 2010, Pestana and Gageiro 2014, Pituch and Stevens 2016, El Gibari et al. 2018, Marôco 2018).

In this study, Z-scores were chosen for data normalization. Z-scores converted the variables to a common scale with the mean of zero and the standard deviation of one (OECD 2008, Danielis et al. 2018, El Gibari et al. 2018, Marôco 2018). This means that the degree of dispersion was reduced to around zero for the mean and to one for the standard deviation (Castro-Higueras and de Aguilera-Moyano 2018). This analysis refers to the second stage, of descriptive analysis (mean, standard deviation, variation coefficient and minimum and maximum values), although the transformations arising from the above normalization mean are not presented in this study (OECD 2008, Marôco 2018).

The third stage concerns the calculation of weightings, considering that in building a composite index, the weights to attribute to each indicator have great significance for the total index and the obtained results (El Gibari et al. 2018). Supported by this crucial requirement, all the weightings presented in this study were obtained directly by applying the EFA and the intrinsic Principal Component Analysis (PCA), in order to present a robust Composite Index of quality. This scientific robustness and quality is obtained through the multivariate statistical techniques mentioned above, since they allow towns/cities to be taken as the unit of analysis (Al Sharmin 2011), the grouping of data presenting similar significance in the sample and the restriction of principal components to retain (Stevens 1986, Hair et al. 1995, Guimarães and Sarsfield Cabral 2010, Pestana and Gageiro 2014, Marôco 2018). This technique also allows the obtained weightings to represent the importance of the variables (154) measured by their maximum variance (Kubrusly 2001). The benefits of using EFA and PCA were stated by the OECD (2008), concluding that these can "summarise a set of individual indicators while preserving the maximum possible proportion of the total variation in the original data set", and that the "largest factor loadings are assigned to the individual indicators that have the largest variation across countries, a desirable property for cross-country comparisons, as individual indicators that are similar across countries are of little interest and cannot possibly explain differences in performance" (OECD 2008: 26). It is noted that in this study the unit of analysis is represented by the towns rather than the countries.

Finally, in the third stage, in order to check the acceptability of this technique, we applied the Kaiser–Meyer–Olkin (KMO, Kaiser 1974) sample suitability measure and the Bartlett sphericity test. In order to verify the internal consistency of the eight (sub)dimensions, it is usual to calculate the Cronbach’s alpha, but this was not considered here as the “correlations do not necessarily represent the real influence of the individual indicators on the phenomenon expressed by the composite indicator” (OECD 2008: 27).
The factor extraction requires variables in order to have a normal multivariate distribution, in which various more or less heuristic methods can be used to assess the data quality (Marôco 2018). Thus, the most commonly used method is the Kaiser-Meyer-Olkin sampling adequacy measure, as argued by Maroco (2014) and Pestana and Gageiro (2014). In the same sense, Nardo et al. (2005) and OECD (2008) explained that “multivariate normality of data is required for related significance tests. PCA and PFA have no distributional assumptions. Note, however, that a variant of factor analysis, maximum likelihood factor analysis, does assume multivariate normality. The smaller the sample size, the more important it is to screen data for normality. Moreover, as factor analysis is based on correlation (or sometimes covariance), both correlation and covariance will be attenuated when variables come from different underlying distributions (e.g., a normal vs. a bimodal variable will correlate less than 1.0 even when both series are perfectly co-ordered)” (OECD 2008: 67).

After carrying out the first three stages for each dimension per se (creativity, intelligence and urban sustainability), we were ready for the next stages (4 and 5), since the weightings obtained for the 154 variables distributed over the analysed dimensions represent the starting point for these.

The fourth stage consisted of calculating the observed value for each town and its 8 sub-dimensions (culture, creative economy, favorable environment, governance, information and communication technology, economic, social and environmental sustainability) and then for the three dimensions (creativity, intelligence and urban sustainability), determined by the sum of the product between the value of each normalized variable by the weighting coefficient obtained for each of them in the previous stages (1, 2 and 3). For the values observed by town, by sub-dimension and dimension, the descriptive analysis was performed. The data obtained at this stage were the variables to be analysed in the next stage, the calculation process being according to the one described by the OECD (2008).

Finally, the fifth stage concerned the application of EFA to the dimensions of creativity, intelligence and urban sustainability in order to obtain the total weight of each in the Composite Index of Portuguese towns/cities’ total performance, with the first three stages being repeated.

Results

Following the procedures regarding to the third stage led to obtaining a great volume of statistical information, as all presented in Appendices 2 (creativity dimension), 3 (intelligence dimension) and 4 (urban sustainability dimension). It is important to mention that the values obtained in the KMO test for the sub-dimensions referring to each dimension (Kaiser 1974) show that data quality varies between reasonable, average and good, which means that EFA can be applied to them (Marôco 2018). However, in the creative economy sub-dimension of the creativity dimension, there was found to be a linear dependence between some of the studied variables, of which the Pearson correlation coefficient is 1 (Marôco 2018). Given the values obtained from the analysis of correlation between the variables of this sub-dimension, the variables of ATIC3, ATIC4, ICPIB4, ICPIB5, ICPIB6, TC2 and PP3 were withdrawn, in order to assess data quality through the KMO test.

In addition, the extracted communalities ($h^2$) respect the required minimum of 0.32% (Costello and Osborne 2005, Tabachnick and Fidell 2019) in all the analysed sub-dimensions (8). Similarly, the 154 analysed variables present loadings above the required minimum of 0.40, and so the explained variances have significant values (Marôco 2018).

Finally, EFA and PCA retained a total of 51 factors for the dimensions of creativity (17), intelligence (12) and urban sustainability (22). Based on the values obtained for each factor, the next step (Kubrusly 2001) was to calculate the “weights from the matrix of factor loadings
after rotation, given that the square of factor loadings represents the proportion of the total unit variance of the indicator which is explained by the factor” (OECD 2008: 90).

Based on these results, the conditions were right to calculate the weightings associated with each variable, obtained from the product between the normalized loadings raised to the square and the value of the explained variance for each factor, as shown in Tables 3, 4 and 5.

### Table 3

| Creativity dimension |
|----------------------|
| **Weights – coefficients of variables**<sup>5)</sup> |

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 |
|----------|----------|----------|----------|----------|----------|----------|----------|
| LIC1     | 3.607    |          |          |          |          |          |          |
| MA1      |          | 4.118    |          |          |          |          |          |
| MA2      |          |          | 3.351    |          |          |          |          |
| MA3      |          |          |          | 2.162    |          |          |          |
| CIN1     |          |          |          |          | 4.789    |          |          |
| CIN2     |          |          |          |          |          | 4.908    |          |
| CE1      |          |          |          |          |          |          | 2.785    |
| CE2      |          |          |          |          |          |          | 3.105    |
| TEA1     |          |          |          |          |          |          | 2.112    |
| RAL1     | 2.346    |          |          |          |          |          |          |
| RAL2     | 5.651    |          |          |          |          |          |          |
| RAL3     | 3.149    |          |          |          |          |          |          |
| DORT1    | 5.341    |          |          |          |          |          |          |
| DORT2    | 0.928    |          |          |          |          |          |          |
| DORT3    | 5.420    |          |          |          |          |          |          |
| VISIM1   |          |          |          |          |          |          | 5.251    |
| VISIM2   |          |          |          |          |          |          | 5.095    |
| ATENC1   |          |          |          |          |          |          | 4.432    |
| ATENC2   |          |          |          |          |          |          | 4.577    |
| DCE1     |          |          |          |          |          |          | 2.608    |
| DCE2     |          |          |          |          |          |          | 2.250    |
| OCC1     |          |          |          |          |          |          | 3.701    |
| DM1      |          |          |          |          |          |          | 1.674    |

| Hotels and restaurants | Theatres and similar venues | Cinema | Museums | Cultural supply | Art and museums | Cultural premises |
|------------------------|-----------------------------|--------|---------|-----------------|-----------------|------------------|
| 5) Example of calculation for RAL1: \((0.276*0.085)\times 100 = 2.346\) (values taken from Appendix 2, Table A)
### Creativity dimension

#### Table 3

| Factor | 1 | 2 | 3 | 4 | 5 |
|--------|---|---|---|---|---|
| **Sub-dimension Creative Economy** |   |   |   |   |   |
| EC1 | 4.657 |   |   |   |   |
| ICPiB1 | 6.450 |   |   |   |   |
| ICPiB2 | 6.998 |   |   |   |   |
| ICPiB3 | 5.794 |   |   |   |   |
| ICPiB7 | 5.498 |   |   |   |   |
| ATIC1 | 3.696 |   |   |   |   |
| ATIC2 | 7.055 |   |   |   |   |
| ATIC5 |   | 6.728 |   |   |   |
| ID1 | 4.587 |   |   |   |   |
| ID2 | 6.437 |   |   |   |   |
| ID3 | 4.599 |   |   |   |   |
| TC1 | 5.639 |   |   |   |   |
| TC3 | 3.811 |   |   |   |   |
| TC4 | 6.165 |   |   |   |   |
| PP1 | 5.511 |   |   |   |   |
| PP2 | 5.794 |   |   |   |   |

| Factor | 1 | 2 | 3 | 4 | 5 |
|--------|---|---|---|---|---|
| **R&D in higher education institutions** |   |   |   |   |   |
| Creative industries’ contribution to GDP |   |   |   |   |   |
| R&D in firms |   |   |   |   |   |
| Proportion of creative industries |   |   |   |   |   |
| Weight of creative industries |   |   |   |   |   |
| **Sub-dimension Favourable Environment** |   |   |   |   |   |
| CC1 | 5.721 |   |   |   |   |
| CC2 | 5.645 |   |   |   |   |
| CC3 | 5.937 |   |   |   |   |
| CC4 | 5.508 |   |   |   |   |
| CC5 | 6.422 |   |   |   |   |
| CC6 | 6.503 |   |   |   |   |
| CC7 | 4.209 |   |   |   |   |
| CC8 | 1.946 |   |   |   |   |
| PR1 | 3.427 |   |   |   |   |
| TOL1 | 4.930 |   |   |   |   |
| TOL2 | 5.349 |   |   |   |   |
| TOL3 | 4.006 |   |   |   |   |
| TOL4 | 4.506 |   |   |   |   |
| LI1 | 3.311 |   |   |   |   |
| LI2 |   | 2.220 |   |   |   |
## Creativity dimension

| Variable | Factor | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|----------|--------|---|---|---|---|---|---|---|
| LL1      |        |   |   |   |   |   |   | 5.155 |
| FE1      |        |   |   |   |   |   | 5.155 |   |
| FE2      |        |   |   |   |   |   | 6.276 |   |
| FE3      |        |   |   |   |   |   | 5.759 |   |
| Higher education | Population | Redevelopment of buildings and airports | Foreigners | Transport |

## Intelligence Dimension

| Variable | Factor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|----------|--------|---|---|---|---|---|---|---|---|
| EGOV1    |        |   |   |   | 0.81 |   |   |   |   |
| EGOV2    |        |   |   |   | 5.15 |   |   |   |   |
| EGOV3    |        |   |   |   | 1.54 |   |   |   |   |
| FIN1     |        |   | 6.4 |   |   |   |   |   |   |
| FIN2     |        |   | 3.14 |   |   |   |   |   |   |
| FIN3     |        |   | 6.4 |   |   |   |   |   |   |
| RED1     |        |   |   |   | 3.29 |   |   |   |   |
| RED2     |        |   |   |   | 3.94 |   |   |   |   |
| PEL1     |        |   | 6.08 |   |   |   |   |   |   |
| PEL2     |        |   | 6.31 |   |   |   |   |   |   |
| PEL3     |        |   | 3.66 |   |   |   |   |   |   |
| PEL4     |        |   | 5.91 |   |   |   |   |   |   |
| VIND1    |        |   | 4.58 |   |   |   |   |   |   |
| VIND2    |        |   | 1.42 |   |   |   |   |   |   |
| VIND3    |        |   |   |   | 3.36 |   |   |   |   |
| VIND4    |        |   | 4.93 |   |   |   |   |   |   |
| VIND5    |        |   | 4.37 |   |   |   |   |   |   |
| VPUB1    |        |   |   |   |   |   |   | 5.45 |   |
| VPUB2    |        |   |   |   | 0.81 |   |   | 5.04 |   |

### Table 3

### Table 4
### Table 4

**Intelligence Dimension**

| Sub-dimension ICT | 1     | 2     | 3     | 4     |
|-------------------|-------|-------|-------|-------|
| TEL1              | 10.96 |       |       |       |
| TEL2              | 11.07 |       |       |       |
| AMB1              |       | 10.11 |       |       |
| AMB2              |       | 9.12  |       |       |
| AMB3              |       |       | 8.83  |       |
| AMB4              |       |       |       | 10.77 |
| ACES1             |       |       |       | 5.47  |
| ACES2             |       |       | 8.75  |       |
| PUB1              |       |       | 8.94  |       |
| IND1              |       | 4.24  |       |       |

Communications and internet  Network infrastructure  Energy and mail  Waste

### Table 5

**Urban Sustainability Dimension**

| Variable | Factor | 1     | 2     | 3     | 4     | 5     | 6     |
|----------|--------|-------|-------|-------|-------|-------|-------|
| CREC1    | Factor | 2.75  |       |       |       |       |       |
| CREC2    | Factor | 0.99  |       |       |       |       |       |
| CREC3    | Factor | 4.12  |       |       |       |       |       |
| CREC4    | Factor | 1.05  |       |       |       |       |       |
| CREC5    | Factor | 1.28  |       |       |       |       |       |
| NEG1     | Factor | 4.58  |       |       |       |       |       |
| NEG2     | Factor | 3.75  |       |       |       |       |       |
| NEG3     | Factor | 3.02  |       |       |       |       |       |
| NEG4     | Factor | 3.58  |       |       |       |       |       |
| NEG5     | Factor | 3.46  |       |       |       |       |       |
| NEG6     | Factor | 3.59  |       |       |       |       |       |
| NEG7     | Factor | 4.71  |       |       |       |       |       |
| NEG8     | Factor | 4.35  |       |       |       |       |       |
| NEG9     | Factor | 1.22  |       |       |       |       |       |
| NEG10    | Factor | 3.39  |       |       |       |       |       |
| EMP1     | Factor | 3.79  |       |       |       |       |       |
| EMP2     | Factor | 2.64  |       |       |       |       |       |
| EMP3     | Factor | 3.09  |       |       |       |       |       |
| EMP4     | Factor | 4.37  |       |       |       |       |       |
| EMP5     | Factor | 3.66  |       |       |       |       |       |
| EMP6     | Factor | 4.85  |       |       |       |       |       |

Total 17.76 15.59 12.26 7.31 6.68 3.79 4.85

| Economic activity | Growth and employment | Entrepreneurship | Unemployment | Density of banks and firms | New firms | Public-private partnerships |
|-------------------|-----------------------|-----------------|--------------|-----------------------------|-----------|-----------------------------|
### Table 5

**Urban Sustainability Dimension**

|       | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------|---|---|---|---|---|---|---|---|
| **Sub-dimension Social sustainability** |   |   |   |   |   |   |   |   |
| AD1   | 4.77 |   |   |   |   |   |   |   |
| AD2   | 4.52 |   |   |   |   |   |   |   |
| AD3   | 2.16 |   |   |   |   |   |   |   |
| AD4   | 4.67 |   |   |   |   |   |   |   |
| AD5   | 3.00 |   |   |   |   |   |   |   |
| AD6   | 2.41 |   |   |   |   |   |   |   |
| AD7   | 1.97 |   |   |   |   |   |   |   |
| ICH1  | 4.27 | 0.00 |   |   |   |   |   |   |
| ICH2  |   | 3.32 |   |   |   |   |   |   |
| ICH3  |   | 4.12 |   |   |   |   |   |   |
| ICOM1 | 4.55 | 0.00 |   |   |   |   |   |   |
| ICOM2 | 3.16 |   |   |   |   |   |   |   |
| ICOM3 | 3.08 |   |   |   |   |   |   |   |
| ICOM4 | 3.16 |   |   |   |   |   |   |   |
| ICOM5 | 3.75 |   |   |   |   |   |   |   |
| PD1   | 3.37 |   |   |   |   |   |   |   |
| PD2   |   | 1.74 |   |   |   |   |   |   |
| PD3   |   | 4.61 |   |   |   |   |   |   |
| DSA1  | 3.83 |   |   |   |   |   |   |   |
| DSA2  | 1.34 |   |   |   |   |   |   |   |
| DSA3  |   | 1.59 |   |   |   |   |   |   |
| DSA4  | 3.92 |   |   |   |   |   |   |   |
| DSA5  |   | 4.10 |   |   |   |   |   |   |
| DSE1  |   | 3.76 |   |   |   |   |   |   |
| DSE2  |   | 4.11 |   |   |   |   |   |   |
| **Total** | 35.58 | 7.75 | 8.66 | 8.71 | 8.39 | 5.50 | 4.96 | 5.73 |

**Demo- graphy and education** | Health | Other | Social projects | Poverty and criminality | Urban renewal (a) | Other benefits (a)
The respective weightings allowed the calculation of the value observed for each town, which was obtained by summing the product of each normalized variable (Z scores), as obtained with the IBM SPSS software by the weighting (the fourth stage). These calculations were made for all the analysed dimensions (3) and sub-dimensions (8). For example, the numerical value of the creativity dimension for a town was obtained as follows:

\[ \sum (Z_{score \text{ variable } i} \times \text{weighting } i) = \text{value observed for a town in the creativity sub-dimension} \]

\( i = \text{LIC1 to DM1, where } i = 23 \text{ variables; Z scores obtained through SPSS} \)

However, in order to calculate the final weighting of each of the 3 analysed dimensions, it was necessary to determine the weight of each sub-dimension analysed in the respective dimension, and so the EFA was applied.

It was then necessary to calculate the numerical value per town for each dimension, resulting from the sum of the product between the value observed per town for each sub-dimension in the dimension. As an example for the creativity dimension, we have the following formula:

\[ \text{Creativity} = \text{Culture} \times 0.232 + \text{Creative Economy} \times 0.387 + \text{Favourable Environment} \times 0.396 \]

\[ = \text{Creativity} \times 0.3158 \]

1) Values obtained from formula 1
2) Appendix 5
3) Values obtained from formula 1
4) Values obtained from formula 1
Finally, following the descriptive analysis (Table 6), the values obtained from formula 2 for the 308 Portuguese towns and cities represented the numerical data to enter in SPSS for the creativity (variable 1), intelligence (variable 2) and urban sustainability (variable 3) dimensions in order to apply the EFA (Table 7), aiming to obtain the composite weighting of each dimension in the total performance of Portuguese towns (the fifth stage).

Table 6

| Dimensions          | N   | Mean  | Standard Deviation | Minimum | Maximum |
|---------------------|-----|-------|--------------------|---------|---------|
| Creativity          | 308 | 0.000 | 0.383              | -0.3077 | 3.5158  |
| Intelligence        | 308 | 0.000 | 0.261              | -0.6105 | 0.9299  |
| Urban Sustainability | 308 | 0.000 | 0.230              | -0.4519 | 1.5015  |

Table 7

| Dimensions           | $h^2$ | Factor Total Performance | Weights $^6$ |
|----------------------|-------|--------------------------|--------------|
| Creativity           | 0.692 | 0.832                    | 0.380        |
| Intelligence         | 0.426 | 0.652                    | 0.234        |
| Urban Sustainability  | 0.702 | 0.838                    | 0.396        |
| Eigenvalue           |       | 1.82                     |              |
| % explained variance | 60.65 |                         |              |
| Total explained variance | 60.65 |                   |

Discussing*

The analysis results led to obtaining the scientific weighting of each dimension forming the Composite Index for the towns’ total performance. So, in the Portuguese context, the intelligence dimension has the least significant weighting (0.234), followed by the creativity dimension (0.380) and the urban sustainability dimension (0.396).

The global reading of these results indicates that political decision-makers and local governments have made relevant efforts to reflect the importance of these three dimensions in their strategies and guidelines, particularly at town level. These efforts represent a constant challenge given the transformations this implies in the various urban spaces, infrastructure, institutions and the implementation and monitoring processes. It is noted that this transformative scenario was mentioned by Bouton et al. (2013), due to economic growth also being stimulated by intangible and tangible amenities (Romero-Padilla et al. 2016). Furthermore, this paradigmatic alteration in the model of economic growth in urban areas led to people and spaces involved in the urban environment being revealed as crucial for cities’ urban growth, with positive effects on their total performance (Audretsch 2003, Malecki 2007). In addition, for the Portuguese towns, it was confirmed that there has been a concentration on the endogenous cultural factors associated with the revitalization of places, aiming to develop the

6) Example of calculation for creativity: $0.832^2/1.821628 = 0.380$
cultural activities and to also provide the premises for new businesses linked to culture and creativity. This involvement has been mentioned by several authors (Florida 2005, Cabrita et al. 2013, Ortegel 2017, Florida 2019).

The following paragraphs analyse the dimensions of creativity, intelligence and urban sustainability individually, as the weightings obtained for each require this.

The creativity dimension has a weighting of 0.380 in the total performance of Portuguese towns, in which culture has an impact of 0.22, the creative economy 0.38 and the favourable environment 0.40. This means that local governments in the 308 analysed towns and cities have directed their policies towards providing regenerated or even new cultural spaces, pluralist, tolerant and open urban environments, which in turn are attractive amenities for the so-called creative class (Florida 2005, Florida et al. 2007, McGranahan and Wojan 2007, Hoyman and Faricy 2009, Lawton et al. 2010, Florida 2019) and the implicit cultural and creative industries (Pratt 2008). This type of city provision was mentioned by Florida (2005), Grant and Kronstal (2010) and Romein and Trip (2009), who highlighted the importance of cities generating a favourable environment and a creative economy associated with the dynamics produced by culture and people’s creativity as a lever to direct cities to creativity, intelligence and urban sustainability. Moreover, the factors obtained through EFA and the respective weightings of the variables included in them clearly show the positive impacts of creativity on performance in the 308 Portuguese towns and cities, for example, in the significance of the weightings of creative and cultural industries in the sub-dimension of the creative economy (Table 3), which means this is already happening in Portugal and it is generating economic value. The wealth produced by these industries was shown by Furtado and Alves (2012). These authors also argued that the economic results of cultural and creative industries allow them to contribute to cities’ urban sustainability.

Although the intelligence dimension of Portuguese towns still requires action to improve infrastructure and accessibility, urban networks (belonging to inter and intra networks) in those towns are a positive aspect, as a reflection of adopting open, participative governance aiming to improve urban performance. Urban networks as predictors of improved city performance were emphasized by Cohen et al. (2016), Echebarria et al. (2016), Ferraris et al. (2018), in which creativity stimulates the creation of urban networks as a consequence of the adopted governance typology, as well as those networks increasing synergies between all urban agents, with an economic return in the present and future (Girard et al. 2016). Nevertheless, the implementation of ICT in Portuguese towns may fall short of expectations, despite the significant progress being made in terms of e-government. ICT’s articulation with cities’ governance is fundamental for their improved intelligent performance and for the benefits to be duly enjoyed (Neirotti et al. 2014). In this dimension, it is essential to mention that the obtained statistical results were influenced by the lack of data at the Portuguese town level, and so these could be overestimated.

The urban sustainability dimension is visible in the 308 Portuguese towns in a tri-partite way. Economic sustainability (weighting of 0.386) has been strengthened, for example, by entrepreneurship, which has created new business supported by public-private partnerships, such as living labs, which has contributed to less urban unemployment. Living labs, understood as open networks and collaborative partnerships, have been indicated as a means to extend connectivity inside and outside towns (Girard et al. 2016, Ericsson 2016), allowing the development and implementation of intangible projects with social, environmental and cultural effects, besides the projects with sustainable economic synergies (European Comission 2011, Anthopoulos 2017). Standing out in social sustainability (weighting of 0.245) represents the development of projects promoting cohesion and social inclusion and actions to improve the social infrastructure in Portuguese towns, for example, projects promoted by the healthy town...
network and others. This type of social projects and policies aiming for improved infrastructure is necessary to achieve urban sustainability (Giffinger et al. 2007, Arcadis 2016, Trivellato 2016, Bosch et al. 2017). Finally, environmental sustainability (weighting of 0.369), locally in Portugal, has emphasized waste management and actions to preserve and protect natural resources and the environment in general. However, the circular economy model proposed by the European Union is a scenario in need of additional strategies and policies, since it is at an embryonic stage in Portuguese towns. It is clearly necessary for towns to go down this route and thereby to improve their environmental performance even more. The importance of this model for the cities’ improved sustainable performance was explained by Ligorio (2017) and by Smol et al. (2017), despite the suggestion that the circular economy should be interlinked with ICT and open governance (intelligence, Neirotti et al. 2014, Girard et al. 2016). Neirotti et al. (2014) also argue that cities with urban sustainability predict their performance positively and raise their residents’ quality of life, and, in the case of Portugal, this dimension’s weighting is very close to 0.40.

Summarizing, the results obtained show that cities’ performance can be measured in a multidimensional and holistic way, without losing relevant information and with scientific quality and robustness. Fig. 3 shows the results obtained for the 308 towns and cities in Portugal.

![Composite Index for the Total Performance of Cities](image)

**Fig. 3 – Composite index for the total performance of cities**
Portuguese towns and cities are moving according to the European Union directives towards achieving intelligent, inclusive and sustainable growth (Eurostat 2019), associated with creativity, culture and urban networks, with the last-named being understood as a new intangible factor of the current model of cities’ economic growth and a predictor of improved total performance.

The contributions arising from the results obtained in this empirical study have relevant implications for theory and practice, allowing the existing gap between both to be filled (Lee et al. 2014), and this represents the study’s general contribution.

The presentation of a theoretical and holistic framework, importance of which was already defended by Mora et al. (2017), is the first contribution of this study with implications for theory. The framework shows that today’s towns aim to be simultaneously creative, intelligence and sustainable, and to grow economically in the short and long term in order to provide their residents with quality of life, well-being and happiness, besides improving their total performance predicted by inter and intra networks formed in urban spaces where the intangible effects give a financial return today and in the future.

The second contribution, also with implications for theory, lies in the compilation of indicators from various indices in a single index. This index includes indicators for the dimensions of creativity, intelligence and sustainability, divided in 8 sub-dimensions. Concerning the theoretical implications, a Composite Indicator with 24 general indicators and 47 specific indicators was developed, filling the gap regarding a single index to measure the total performance in all its inseparable dimensions (Malecki 2007, Borén and Young 2013), added to which is the volume of the used variables (Çetindamar and Günsel 2012).

Filling the theoretical gaps was followed by the empirical operationalization of the Composite Index. Consequently, the third contribution lies in the application of that index in the Portuguese context, with robustness and scientific quality being confirmed through the application of EFA (OECD 2008), in order for this to be a methodological instrument to be adopted by cities and/or countries to assess and monitor their total performance. It is highlighted that Composite Indices are an instrument increasingly valued by the political decision-makers and important in discussing economic growth, this being an implication for practice.

Overall, the main contribution of this study lies in the Composite Index for cities’ total performance, with the statistical treatment allowing the scientific calculation of the weightings of each studied dimension for the cities’ holistic performance.

Like any study, this one is not without limitations. One is the subjectivity presented in selecting the used indices/indicators, which were affected by the limited availability of data about towns and the fact of the choice also having to consider the characteristics of a good indicator. Also, the unavailability of data when the unit of analysis is the town, whatever its population density, is another limitation.

Given the multiplicity of theoretical concepts and implications for theory and practice, measuring cities’ total performance does not end with this study, but it continues to be a fertile area for future research. The extensive data treatment carried out allows the elaboration of a ranking of Portuguese towns and cities by size and their total performance, directing future research to the analysis of clusters of Portuguese towns. Another future topic would be the application of other multivariate statistical techniques, for example, the Data Envelopment Analysis (DEA), which allows multiple entries and exits and it could establish a model of multifactor measurement of performance and frontiers in order to measure efficiency. A final
suggestion is to apply the Composite Index in other geographical contexts, leading to comparative studies to determine the factors of cities’ success and failure. Another study could take countries as the unit of analysis.

Conclusions

Creative cities in this century included in the so-called European Cities must ally the creativity dimension to those of intelligence and urban sustainability, as their growth is supported by the holistic, determinant pillars of their total performance. In this context, it was demonstrated that this can be scientifically measured through a Composite Index with the respective weightings, which allows its generalized application in any geographical context and unit of analysis. This generalization transforms this index into a scientific instrument for political decision-makers and town planners. It was also proven that when understood and managed as strategic places, cities are able to respond to the major challenge of being the drivers of a country’s economic growth. This means that cities that increase their growth according to the premises inherent to creativity, intelligence and urban sustainability, as a whole and without neglecting the importance of urban networks, will show an improved total performance.

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| Specific indicator | Variable | N | Proxies                                                                 | Databases | Period of reference | Unit of measure |
|--------------------|----------|---|-------------------------------------------------------------------------|-----------|---------------------|-----------------|
| **GENERAL indicator: 1.1** Places of culture and facilities |          |   |                                                                         |           |                     |                 |
| A) Places of historical interest | LIC1     | 308 | 1) Places of historical, cultural and artistic interest, such as buildings, religious structures, monuments and statues, churches and cathedrals, bridges, towers and others | Tripadvisor | 2018                | Number          |
|                      | MA1      | 308 | 1) Art galleries: buildings                                             | Pordata   | 2016                | Number          |
|                      | MA2      | 287 | 2) Art galleries: exhibitions                                           |           |                     |                 |
|                      | MA3      | 308 | 3) Number of museums open to the public                                 |           |                     |                 |
| C) Cinema            | CIN1     | 308 | 1) Capacity                                                             |           |                     |                 |
|                      | CIN2     | 308 | 2) Places                                                               |           |                     |                 |
| D) Concerts and Shows| CE1      | 304 | 1) Number of cultural locations                                        | Pordata   | 2015                | Number          |
|                      | CE2      | 179 | 2) Capacity of cultural locations                                       |           |                     |                 |
| E) Theatres          | TEA1     | 308 | 1) Theatres                                                             | Meloteca.com | 2018            | Number          |
| F) Restaurants and accommodation | RAL1   | 308 | 1) Number of hotel establishments                                       | Pordata   | 2016                | Number          |
|                      | RAL2     | 266 | 2) Number of rooms in hotel establishments                              |           |                     |                 |
|                      | RAL3     | 308 | 3) Restaurants                                                           | Tripadvisor | 2018            | Number          |
| **GENERAL indicator: 1.2** Cultural participation and attractiveness |          |   |                                                                         |           |                     |                 |
| A) Tourist bednights | DORT1    | 247 | 1) Total bednights in hotel establishments                              | Pordata   | 2015                | Number          |
|                      | DORT2    | 244 | 2) Proportion of foreign guests                                         |           |                     | %               |
|                      | DORT3    | 286 | 3) Total income from hotel establishments                               |           |                     | M.€             |
| B) Museum visitors   | VISM1    | 264 | 1) Total visitors                                                        | Pordata   | 2016                | Number          |
|                      | VISM2    | 264 | 2) Total foreign visitors                                                |           |                     |                 |
| C) Cinema attendance | ATENC1   | 308 | 1) N° of spectators                                                      | Pordata   | 2016                | Number          |
|                      | ATENC2   | 308 | 2) Ticket sales                                                          |           |                     | M.€             |
| D) Concerts and shows| DCE1     | 147 | 1) N° of spectators                                                      | Pordata   | 2016                | Number          |
|                      | DCE2     | 147 | 2) Ticket sales                                                          |           |                     | M.€             |
| E) Cultural supply   | OCC1     | 308 | 1) Total cultural premises (local authority)                            | Annals by region - INE | 2016        | Number          |
| F) Local authority/ public expenditure | DM1     | 308 | 1) Expenditure on cultural activities and similar                        |           |                     |                 |

**II) Creative Economy**
| General indicator: 2.1) Creative Industries |  |
|------------------------------------------|---|
| **A) Creative jobs**                    |  |
| EC1                                      | 308 |
| 1) Jobs in creative and cultural activities | INE | 2016 |
| **B) Impact of creative industries on GDP** |  |
| ICPB1                                    | 308 |
| 1) Turnover of cultural and creative industries | INE | 2016 |
| ICPB2                                    | 308 |
| 2) % of creative industries in total economic activity |  | € |
| ICPB3                                    | 308 |
| 3) Expenses with staff in cultural and creative industries |  | % |
| ICPB4                                    | 308 |
| 4) Production of cultural and creative industries |  | € |
| ICPB5                                    | 308 |
| 5) Intermediate consumption of cultural and creative industries |  | € |
| ICPB6                                    | 308 |
| 6) Gross added value, at market prices, of cultural and creative industries |  | € |
| ICPB7                                    | 308 |
| 7) Gross fixed capital formation of cultural and creative industries |  | € |
| **C) Territorial analysis of creative industries** |  |
| ATIC1                                    | 308 |
| 1) Total number of cultural and creative industries | INE | Number |
| ATIC2                                    | 308 |
| 2) Number of people employed in creative and cultural companies, divided by the total of people employed in all economic activities and multiplied by 100 | Own calculation | 2016 |
| ATIC3                                    | 308 |
| 3) Total number of industries by city over the total of all cities (concentration) multiplied by 100 |  | % |
| ATIC4                                    | 308 |
| 4) Density per capita of cultural and creative industries (N° of industries/resident population multiplied by 100) |  | % |
| ATIC5                                    | 308 |
| 5) Weight of cultural and creative industries in the total industries in the city (relevance) multiplied by 100 |  | % |

| General indicator: 2.2) Research & Development |  |
|-----------------------------------------------|---|
| **A) Firms**                                  |  |
| ID1                                          | 308 |
| 1) Firms with most expenditure on R&D activities | Dgeec.mec | Number |
| ID2                                          | 308 |
| 2) R&D expenditure of those firms            | Dgeec.mec | M € |
| ID3                                          | 308 |
| 3) Total resources allocated by firms to R&D areas | Dgeec.mec | Number |
| **B) Knowledge transfer**                    |  |
| TC1                                          | 308 |
| 1) R&D units in higher education institutions | Dgeec.mec | Number |
| TC2                                          | 308 |
| 2) Total researchers in those units financed by FCT | Dgeec.mec | Number |
| TC3                                          | 308 |
| 3) Higher education establishments           | Pordata | 2017 |
| TC4                                          | 308 |
| 4) Lecturers in higher education             | Pordata | 2015 |

| General indicator: 2.3) Intellectual property and innovation |  |
|---------------------------------------------------------------|---|
| **A) Patent applications**                                   |  |
| PP1                                          | 308 |
| 1) Applications for patents and similar | INPI | 2017 |
| PP2                                          | 308 |
| 2) Applications for patents from higher education institutions | INPI | Number |
| PP3                                          | 308 |
| 3) Applications for patents from other entities              | INPI | Number |

**III) Favourable Environment**
### General Indicator: 3.1) Human capital and education

| Creative class (talent) | CC1  | 308 | 1) Number of higher education students enrolled in arts and humanities courses | Pordata | 2016 | Number |
|-------------------------|------|-----|---------------------------------------------------------------------------------|---------|------|--------|
| CC2                     | 308  |     | 2) Higher education graduates in arts and humanities                               |         |      |        |
| CC3                     | 308  |     | 3) Number of higher education students enrolled in ICT courses                    |         |      |        |
| CC4                     | 308  |     | 4) Higher education graduates in ICT                                              | Annals by region - INE | 2016 | Number |
| CC5                     | 308  |     | 5) Higher education graduates                                                      |         |      |        |
| CC6                     | 308  |     | 6) Number of students in higher education                                          | Pordata | 2016 | Number |
| CC7                     | 308  |     | 7) Number of higher education institutions                                          |         |      |        |
| CC8                     | 308  |     | 8) Employed population with average/high qualifications (secondary, post-secondary and higher) |         | 2013 |        |

| B) HEIs presence in rankings | PR1  | 308 | 1) HEIs in rankings | Webometrics | 2018 | Number |

### General Indicator: 3.2) Openness and diversity

| Tolerance, social classes and young people | TOL1  | 308 | 1) Legally resident foreign population: total | Pordata | 2016 | Number |
|--------------------------------------------|-------|-----|---------------------------------------------|---------|------|--------|
| TOL2                                       | 308  |     | 2) Socio-cultural heterogeneity (social classes) – employees’ basic average monthly salary |         | 2013 |        |
| TOL3                                       | 308  |     | 3) Young population (resident population, estimated at 31 December: 0-25 years) |         | 2016 | %      |
| TOL4                                       | 308  |     | 4) Marriages solemnized between nationals and foreigners |         | 2017 | Number |

### General Indicator: 3.3) Local and international connections

| International connections | LI1  | 308 | 1) Airports | INE | 2017 | Number |
|----------------------------|------|-----|-------------|-----|------|--------|
| LI2                        | 308  |     | 2) Passenger arrivals by airport |         |      |        |

| Local connections | LL1  | 308 | 1) Transport and storage companies | INE | 2017 | Number |

### General Indicator: 3.4) Governance

| Endogenous factors | FE1  | 308 | 1) Concluded building redevelopment (urban regeneration) | Annals by region - INE | 2016 | Number |
|--------------------|------|-----|----------------------------------------------------------|------------------------|------|--------|
| FE2                | 308  |     | 2) Licensed building redevelopment (urban regeneration) |                        |      |        |
| FE3                | 308  |     | 3) Annual population variation (global attractiveness for new residents) |                    |      | %      |

### Intelligence

#### I) Governance

| E-government | EGOV1 | 308 | 1) Use of electronic commerce | Annals by region - INE | 2016 | Number |
|--------------|-------|-----|-------------------------------|------------------------|------|--------|
| EGOV2        | 308   |     | 2) Online consultation processes available on the website |                        |      |        |
| EGOV3        | 308   |     | 3) Online completion and submission of forms |                        |      |        |
| **General indicator: 1.2) Strategy** |
|-------------------------------------|
| **A) Finance**                      |
| FIN1 306  | 1) Total debt  | Annals by region - INE  | 2016  | M.€  |
| FIN2 308  | 2) Municipal income per inhabitant |
| FIN3 308  | 3) Municipal expenditure per inhabitant |
| **B) Network**                      |
| RED1 308  | 1) Members of national networks  | http://redemunicipios.sapo.pt/ | 2018  | Number |
| RED2 308  | 2) Members of international networks | Webpages municipals, http://www.mii.pt/visa, http://www.intel.pt, www.openlivinglabs.eu; | |

| **General indicator: 1.3) Citizen participation** |
|-----------------------------------------------|
| **A) Elections**                              |
| PEL1 308  | 1) Presidential - Voter turnout  | Annals by region - INE  | 2016  | Number |
| PEL2 308  | 2) Central Government - Voter turnout |
| PEL3 308  | 3) Local Authority - Voter turnout |
| PEL4 307  | 4) European Parliament - Voter turnout |

| **General indicator: 1.4) City vitality** |
|------------------------------------------|
| **A) Individual**                        |
| VIND1 308  | 1) Renewal index of the population of working age  | INE  | 2013  | % |
| VIND2 308  | 2) Population density per residence  |
| VIND3 308  | 3) Newspapers and other regular publications: circulation |
| VIND4 308  | 4) Resident population <15 years |
| VIND5 308  | 6) Inactive population: total |
| **B) Public**                              |
| VPUB1 272  | 1) Area of urban parks and facilities  | INE  | 2013  | Ha |
| VPUB2 272  | 2) Land use for tourism |

| **II) Information and communication technology (ICT)** |
|------------------------------------------------------|
| **A) Telecommunications**                            |
| TEL1 308  | 1) Main public telephones  | Pordata  | 2016  | Number |
| TEL2 308  | 2) Residential telephones per thousand inhabitants |
| **B) Environment**                                   |
| AMB1 308  | 1) Quality of the water network for human consumption: safe water  | Pordata  | 2016  | % |
| AMB2 308  | 2) Population served by waste water treatment networks (ETAR)  |
| AMB3 308  | 3) Electricity consumption for road lighting |
| AMB4 308  | 4) Hierarchy index of urban waste management |

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### General Indicator: 2.2) Accessibility

| A) Mail and internet  | ACEB1 | 306 | 1) Post offices per local authority | Annual reports 2016 by region - INE | Number |
|-----------------------|-------|-----|-----------------------------------|-------------------------------------|--------|
|                       | ACEB2 | 306 | 2) Access to broadband internet service at a fixed point |                                     |        |

### General Indicator: 2.3) Use of ICT

| A) Public  | PUB1 | 306 | 1) Average number of pupils per computer with internet connection in primary and secondary schools: total | Pordata 2016 | % |
|------------|------|-----|--------------------------------------------------------------------------------------------------|--------------|---|
| B) Private | IND1 | 306 | 1) Companies providing ICT services | INE 2016 | Number |

### URBAN SUSTAINABILITY

#### 1) Economic Sustainability

### General Indicator: 1.1) Competitiveness and economic activity

| A) Economic growth | CREC1 | 306 | 1) Purchasing power per capita | Pordata 2015 | % |
|-------------------|-------|-----|--------------------------------|--------------|---|
|                   | CREC2 | 306 | 2) Exports                      |               |    |
|                   | CREC3 | 306 | 3) Imports                      |               |    |
|                   | CREC4 | 306 | 4) Town's employment rate      |               |    |
|                   | CREC5 | 306 | 5) Total unemployment rate      |               |    |
| B) Business       | NEG1  | 306 | 1) Firms formed in the period of reference | Pordata 2017 |    |
|                   | NEG2  | 306 | 2) Firms dissolved              |               |    |
|                   | NEG3  | 306 | 3) Banks and Savings Institutions |               |    |
|                   | NEG4  | 306 | 4) Non-financial firms          |               |    |
|                   | NEG5  | 306 | 5) Firms                        |               |    |
|                   | NEG6  | 306 | 6) Employees in non-financial firms: total and by economic activity | Pordata 2016 | Euros |
|                   | NEG7  | 306 | 7) Turnover of non-financial firms: total and by economic activity |               |    |
|                   | NEG8  | 306 | 8) Gross added value of non-financial firms: total and by sector of economic activity |               | M€ |
|                   | NEG9  | 306 | 9) Non-financial firms with under 50 employees as a % of all non-financial firms: by sector of economic activity |               |    |
|                   | NEG10 | 306 | 10) Youth unemployment rate (unemployed registered with job centres and in vocational training (annual average): total and by age-group) | Pordata 2017 | % |

| C) Entrepreneurship | EMP1 | 306 | 1) % of new firms in activity after 2 years | INE 2015 |    |
|                    | EMP2 | 306 | 2) % of employment with higher competencies (employees: total and by level of education) | Pordata 2013 | % |
|                    | EMP3 | 306 | 3) % of self-employment (self-employed, but employers) | Pordata 2011 |    |
|                    | EMP4 | 306 | 4) % of self-employment (self-employed, not employers) |               |    |
|                    | EMP5 | 306 | 5) Density of established firms | INE 2016 | Km² |
|                    | EMP6 | 306 | 6) FABlabs, living labs | www.fablabsportugal.pt | Number: 1=Yes, 0=No |
## II) Social sustainability

### General indicator: 2.1) Population and citizenship

| Code | Year | Description |
|------|------|-------------|
| AD1  | 2011 | Percentage of population over 65 |
| AD2  | 2013 | Percentage of population under 15 |
| AD3  | 2016 | Migratory growth — contribution of migratory balance to the population variance |
| AD4  |       | Index of dependent elderly |
| AD5  |       | Index of dependent young people |
| AD6  | 2017 | Child mortality rate (<1 ano) |
| AD7  | 2016 | Gross birth rate |

### General indicator: 2.2) Education

| Code | Year | Description |
|------|------|-------------|
| ICOM1| 2016 | Establishments of pre-school, primary and secondary education |
| ICOM2|       | Pupils enrolled in pre-school, primary and secondary education |
| ICOM3| 2011 | Total literacy rate — Resident population of 15 years and over according to the Census: total |
| ICOM4| 2016 | Pupils enrolled in pre-school, primary and secondary education as a % of the resident population |
| ICOM5|       | Rate of completion of levels of education — Pupils in regular basic education completing the year: total |

### General indicator: 2.3) Inclusion and cohesion

| Code | Year | Description |
|------|------|-------------|
| PD1  | 2017 | Recipients of social benefits — Recipients of Guaranteed Minimum Income and Social Inclusion Income from Social Security in total active beneficiaries (%) |
| PD2  |       | Residents at risk of poverty — Beneficiaries of unemployment subsidy from Social Security: total |
| PD3  | 2018 | Equity and citizenship projects |

### General indicator: 2.4) Social infrastructure

| Code | Year | Description |
|------|------|-------------|
| DSA1 | 2016 | Number of hospital beds — Hospital accommodation |
| DSA2 | 2012 | Health centres: appointments per inhabitant |
| DSA3 | 2011 | Inhabitants per health centre |
| DSA4 | 2016 | General and specialized hospitals |
| DSA5 | 2018 | Promotion of physical and mental well-being |
### General Indicator: 3.1) Basic infrastructure

#### A) Energy, Water and Gas

| Indicator | Code | Description | Unit |
|-----------|------|-------------|------|
| EGA1      | 308  | 1) Annual energy consumption per capita - Electricity consumption per inhabitant | KWH/inhabitant |
| EGA2      | 308  | 2) Natural gas consumption per capita - Natural gas consumption per inhabitant | M3/inhabitant |
| EGA3      | 308  | 3) Annual water consumption per capita - Water distributed/consumed per inhabitant | m³/inhabitant |

#### B) Emission and production of pollutants

| Indicator | Code | Description |
|-----------|------|-------------|
| EPAT1     | 308  | 1) Undifferentiated urban waste collected (Urban waste: total and by type of collection) |
| EPAT2     | 308  | 2) Differentiated urban waste collected (Urban waste: total and by type of collection) |

### General Indicator: 3.2) Circular economy

#### A) Recycling and reuse

| Indicator | Code | Description                   |
|-----------|------|-------------------------------|
| RR1       | 308  | 1) Income from waste management |
| RR2       | 308  | 2) Expenditure on waste management |
| RR3       | 308  | 3) Urban waste sent to energy recovery |
| RR4       | 308  | 4) Urban waste sent to organic recovery |
| RR5       | 308  | 5) Urban waste sent to recycling |
| RR6       | 308  | 6) Urban waste sent to landfill |

### General Indicator: 3.3) Environmental protection in urban areas

#### A) Territory

| Indicator | Code | Description |
|-----------|------|-------------|
| TER1      | 308  | 1) Income from biodiversity and landscape protection |
| TER2      | 308  | 2) Expenditure on biodiversity and landscape protection |
| TER3      | 308  | 3) Actions of environmental improvement and territorial development |
| TER4      | 308  | 4) Expenditure on air and climate protection, Protection and recuperation of soil, underground and surface water, protection against noise and vibrations, protection against radiation, R&D and other activities of environmental protection |
| TER5      | 308  | 5) Income from air and climate protection, protection and recuperation of soil, underground and surface water, protection against noise and vibrations, protection against radiation, R&D and other activities to protect the environment |
### Table A - Sub-dimension Culture

| Variable | $n^2$ | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 |
|----------|-------|----------|----------|----------|----------|----------|----------|----------|
| LIC1     | 0.795 | 0.775    |          |          |          |          |          |          |
| MA1      | 0.722 |          | 0.828    |          |          |          |          |          |
| MA2      | 0.587 |          | 0.747    |          |          |          |          |          |
| MA3      | 0.579 |          | 0.600    |          |          |          |          |          |
| CIN1     | 0.908 | 0.893    |          | 0.290    |          |          |          |          |
| CIN2     | 0.849 | 0.904    |          | 0.297    |          |          |          |          |
| CE1      | 0.584 |          | 0.681    |          |          |          |          | 0.407    |
| CE2      | 0.713 |          | 0.719    |          |          |          |          | 0.386    |
| TEA1     | 0.402 | 0.593    |          |          | 0.104    |          |          |          |
| RAL1     | 0.652 | 0.625    |          |          | 0.086    |          |          |          |
| RAL2     | 0.945 | 0.970    |          |          | 0.206    |          |          |          |
| RAL3     | 0.741 | 0.723    |          |          | 0.114    |          |          |          |
| DORT1    | 0.913 | 0.943    |          |          | 0.194    |          |          |          |
| DORT2    | 0.485 | 0.383    |          |          | 0.034    |          |          |          |
| DORT3    | 0.920 | 0.960    |          |          | 0.197    |          |          |          |
| VISM1    | 0.899 | 0.935    |          |          |          |          |          | 0.382    |

1 Example of calculation for RAL1: 0.652^2 / 0.625 / 0.59 = 0.085
Example of calculation for: $4.59/\sum 4.59+3.38+2.75+2.29+1.34+1.16+1.14 = 0.276$

| Variable | VISM 2 | ATENC 1 | ATENC 2 | DCE1 | DCE2 | OCC1 | DM1 | Eigenvalue | % Explained variance | Total explained variance |
|----------|--------|---------|---------|------|------|------|-----|------------|----------------------|-------------------------|
|          | 0.882  | 0.659   | 0.873   | 0.553| 0.567| 0.664| 0.606| 4.59       | 17.21                | 72.35                   |
|          |        |         |         |      |      |      |     | 3.38       | 11.53                |                         |
|          |        |         |         |      |      |      |     | 2.75       | 9.87                 |                         |
|          |        |         |         |      |      |      |     | 2.29       | 9.32                 |                         |
|          |        |         |         |      |      |      |     | 1.34       | 9.01                 |                         |
|          |        |         |         |      |      |      |     | 1.16       | 6.03                 |                         |
|          |        |         |         |      |      |      |     | 1.14       |                      |                         |
|          |        |         |         |      |      |      |     | 0.276      |                      |                         |
|          |        |         |         |      |      |      |     | 0.203      |                      |                         |
|          |        |         |         |      |      |      |     | 0.165      |                      |                         |
|          |        |         |         |      |      |      |     | 0.138      |                      |                         |
|          |        |         |         |      |      |      |     | 0.080      |                      |                         |
|          |        |         |         |      |      |      |     | 0.070      |                      |                         |
|          |        |         |         |      |      |      |     | 0.068      |                      |                         |

Varimax rotation; N = 308; KMO = 0.711; Bartlett Sphericity Test = 2335.137; gl = 255; p < 0.000
Table B – Sub-dimension Creative economy

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 |
|----------|----------|----------|----------|----------|----------|
| EC1 | 0.984 | 0.797 | 0.244 | 0.333 | 0.697 |
| IC1B1 | 0.960 | 0.938 | 0.977 | 0.289 | 0.289 |
| IC1B2 | 0.671 | 0.671 | 0.898 | 0.184 | 0.184 |
| IC1B3 | 0.850 | 0.850 | 0.970 | 0.981 | 0.981 |
| AT1C1 | 0.705 | 0.705 | 0.705 | 0.979 | 0.979 |
| AT1C2 | 0.966 | 0.966 | 0.966 | 0.979 | 0.979 |
| AT1C3 | 0.877 | 0.877 | 0.877 | 0.979 | 0.979 |
| ID1 | 0.639 | 0.639 | 0.639 | 0.979 | 0.979 |
| ID2 | 0.905 | 0.905 | 0.905 | 0.979 | 0.979 |
| ID3 | 0.774 | 0.774 | 0.774 | 0.979 | 0.979 |
| TC1 | 0.774 | 0.774 | 0.774 | 0.979 | 0.979 |
| TC2 | 0.616 | 0.616 | 0.616 | 0.979 | 0.979 |
| TC3 | 0.791 | 0.791 | 0.791 | 0.979 | 0.979 |
| TC4 | 0.616 | 0.616 | 0.616 | 0.979 | 0.979 |
| TP1 | 0.850 | 0.850 | 0.850 | 0.979 | 0.979 |
| TP2 | 0.889 | 0.889 | 0.889 | 0.979 | 0.979 |
| PPI | 0.791 | 0.791 | 0.791 | 0.979 | 0.979 |
| Total | 59.2% | 26.1% | 14.4% | 13.6% | 6.5% |

Variance inflation factor: N = 306, VIF = 0.22, Bartlett’s Sphericity test: 0.024 at 195 degrees of freedom, p < 0.000
| Variable | h² | Factor | | Factor | | Factor | | Factor | | Factor | | Factor |
|----------|----|--------|---|--------|---|--------|---|--------|---|--------|---|--------|
| CC1      | 0.832 | 0.907 | | 0.115 | | 0.115 | | 0.115 | | 0.115 | | 0.115 |
| CC2      | 0.821 | 0.901 | | 0.113 | | 0.113 | | 0.113 | | 0.113 | | 0.113 |
| CC3      | 0.866 | 0.924 | | 0.119 | | 0.119 | | 0.119 | | 0.119 | | 0.119 |
| CC4      | 0.802 | 0.890 | | 0.110 | | 0.110 | | 0.110 | | 0.110 | | 0.110 |
| CC5      | 0.934 | 0.961 | | 0.129 | | 0.129 | | 0.129 | | 0.129 | | 0.129 |
| CC6      | 0.947 | 0.987 | | 0.130 | | 0.130 | | 0.130 | | 0.130 | | 0.130 |
| CC7      | 0.638 | 0.778 | | 0.054 | | 0.054 | | 0.054 | | 0.054 | | 0.054 |

Table C – Sub-dimension Favourable Environment

Results of Exploratory Factor Analysis

| Variable | h² | Factor | | Factor | | Factor | | Factor | | Factor | | Factor |
|----------|----|--------|---|--------|---|--------|---|--------|---|--------|---|--------|
| CC8      | 0.562 | 0.529 | | 0.039 | | 0.039 | | 0.039 | | 0.039 | | 0.039 |
| PR1      | 0.546 | 0.702 | | 0.069 | | 0.069 | | 0.069 | | 0.069 | | 0.069 |
| TCL1     | 0.714 | 0.842 | | 0.496 | | 0.496 | | 0.496 | | 0.496 | | 0.496 |
| TCL2     | 0.802 | 0.877 | | 0.306 | | 0.306 | | 0.306 | | 0.306 | | 0.306 |
| TCL3     | 0.619 | 0.759 | | 0.230 | | 0.230 | | 0.230 | | 0.230 | | 0.230 |
| TCL4     | 0.695 | 0.805 | | 0.463 | | 0.463 | | 0.463 | | 0.463 | | 0.463 |
| L11      | 0.580 | 0.690 | | 0.222 | | 0.222 | | 0.222 | | 0.222 | | 0.222 |
| L12      | 0.618 | 0.565 | | 0.285 | | 0.285 | | 0.285 | | 0.285 | | 0.285 |
| LL1      | 0.794 | 0.861 | | 0.662 | | 0.662 | | 0.662 | | 0.662 | | 0.662 |
| FE1      | 0.794 | 0.950 | | 0.422 | | 0.422 | | 0.422 | | 0.422 | | 0.422 |
| FE2      | 0.925 | 0.910 | | 0.387 | | 0.387 | | 0.387 | | 0.387 | | 0.387 |
| FE3      | 0.859 | 0.896 | | 0.320 | | 0.320 | | 0.320 | | 0.320 | | 0.320 |

Eigenvalue | 7.18 | 2.81 | 2.14 | 1.43 | 1.12 |
% Explained variance | 35.93 | 12.37 | 12.01 | 9.08 | 6.25 |
Total explained variance | 75.64 | 0.499 | 0.175 | 0.149 | 0.099 |

Varimax rotation. N = 308, KMO = 0.785. Bartlett's Sphericity Test = 6677.490, df = 171, p = 0.000.
### Exploratory Factor Analysis of Intelligence Dimension

| Factor | n^2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|--------|-----|---|---|---|---|---|---|---|---|
|        |     | 0.543 | 0.485 | 0.993 | 0.989 | 0.989 | 0.709 | 0.993 | 0.696 |
| 1      |     | 0.993 | 0.999 | 0.520 | 0.520 | 0.520 | 0.776 | 0.993 | 0.736 |
| 2      |     | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| 3      |     | 0.993 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| 4      |     | 0.989 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| 5      |     | 0.485 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 |
| 6      |     | 0.543 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 |
| 7      |     | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 |
| 8      |     | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |

**Note:** The table above represents the results of exploratory factor analysis for intelligence dimensions with squared factor loadings (scaled to unit sum). The values indicate the strength of the relationship between the factors and the observed variables.
|       | PEL4 | 0.955 | 0.951 | 0.202 |
|-------|------|-------|-------|-------|
| VIND1 | 0.785 | 0.837 |       | 0.223 |
| VIND2 | 0.694 | 0.466 |       | 0.150 |
| VIND3 | 0.581 |       | 0.736 | 0.462 |
| VIND4 | 0.880 | 0.868 |       | 0.240 |
| VIND5 | 0.897 | 0.817 |       | 0.213 |
| VPUB1 | 0.852 |       | 0.913 | 0.754 |
| VPUB2 | 0.793 |       |       | 0.779 |
| Eigenvalue | 4.47 | 3.14 | 1.88 | 1.45 |
| % Explained | 23.53 | 16.51 | 9.02 | 7.36 |
| Variances | 23.53 | 16.51 | 9.02 | 7.36 |

Varmax Rotation; N = 305; KMO = 0.697; Bartlett Sphericity Test; = 6471.567, gl = 171, p < 0.000
### Table B – Sub-dimension ICT

| Variable | Results of Exploratory Factor Analysis | Squared factor loading (scaled to unit sum) |
|----------|----------------------------------------|---------------------------------------------|
|          | $h^2$ 1 2 3 4                          | Factor                                      |
| TEL1     | 0.945 0.961 0.225                      |                                             |
| TEL2     | 0.940 0.966 0.228                      |                                             |
| AMB1     | 0.935 0.923 0.361                      |                                             |
| AMB2     | 0.806 0.877 0.326                      |                                             |
| AMB3     | 0.798 0.863 0.683                      |                                             |
| AMB4     | 0.970 0.953 1.032                      |                                             |
| ACES1    | 0.727 0.679 0.423                      |                                             |
| ACES2    | 0.890 0.859 0.180                      |                                             |
| PUB1     | 0.781 0.868 0.319                      |                                             |
| IND1     | 0.648 0.598 0.087                      |                                             |
| Eigenvalue | 4.10 2.36 1.09 0.88            |                                            |
| % Explained Variance | 40.98 23.65 10.94 8.850 |                                            |
| Total explained variance | 84.41 | 0.486 | 0.280 | 0.129 | 0.104 |

Varimax Rotation; N = 308; KMO = 0.741; Bartlett Sphericity Test: 2378.938; gl = 45; p < 0.000

1 Example of calculation for TEL1: $4.10 / \sum (4.10 + 2.36 + 1.09 + 0.88) = 0.486$
### Exploratory Factor Analysis of urban sustainability dimension

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 |
|----------|----------|----------|----------|----------|----------|----------|----------|
| CREC1    | 0.911    | 0.068    | 0.191    |          |          |          |          |
| CREC2    | 0.541    | 0.389    | 0.025    | 0.104    | 0.005    | 0.135    |          |
| CREC3    | 0.392    | 0.167    | 0.022    | 0.232    | 0.026    | 0.206    | 0.395    |
| CREC4    | 0.702    | 0.700    | 0.100    | 0.110    | 0.101    | 0.308    | 0.996    |
| CREC5    | 0.903    | 0.994    | 0.119    |          |          |          |          |
| CREC6    | 0.792    | 0.789    | 0.708    | 0.740    | 0.090    | 0.090    | 0.360    |
| CREC7    | 0.976    | 0.976    | 0.976    | 0.976    | 0.976    | 0.976    | 0.976    |
| CREC8    | 0.791    | 0.791    | 0.791    | 0.791    | 0.791    | 0.791    | 0.791    |
| CREC9    | 0.916    | 0.916    | 0.916    | 0.916    | 0.916    | 0.916    | 0.916    |
| CREC10   | 0.679    | 0.679    | 0.679    | 0.679    | 0.679    | 0.679    | 0.679    |
| CREC11   | 0.761    | 0.761    | 0.761    | 0.761    | 0.761    | 0.761    | 0.761    |
| CREC12   | 0.812    | 0.812    | 0.812    | 0.812    | 0.812    | 0.812    | 0.812    |
| CREC13   | 0.896    | 0.896    | 0.896    | 0.896    | 0.896    | 0.896    | 0.896    |
| CREC14   | 0.893    | 0.893    | 0.893    | 0.893    | 0.893    | 0.893    | 0.893    |
| CREC15   | 0.578    | 2.852    | 1.94     | 1.63     | 1.07     | 1.07     | 1.23     |
| CREC16   | 30.95    | 13.68    | 9.26     | 7.34     | 5.64     | 4.08     | 4.75     |
| CREC17   | 0.397    | 0.112    | 0.124    | 0.007    | 0.005    | 0.002    | 0.002    |
| CREC18   | 0.397    | 0.112    | 0.124    | 0.007    | 0.005    | 0.002    | 0.002    |
| CREC19   | 0.397    | 0.112    | 0.124    | 0.007    | 0.005    | 0.002    | 0.002    |
| CREC20   | 0.397    | 0.112    | 0.124    | 0.007    | 0.005    | 0.002    | 0.002    |

**Note:** The table above shows the squared factor loadings (scaled to unit sum) for the variable CREC1 to CREC20. The factor loadings indicate the strength of the relationship between each variable and its assigned factor. The squared factor loadings are used to understand the variance explained by each factor. The factor loadings range from 0 to 1, with higher values indicating a stronger relationship.
## Results of Exploratory Factor Analysis

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 | 1   | 2   | 3   | 4   |
|----------|----------|----------|----------|----------|-----|-----|-----|-----|
|          |          |          |          |          | 0.14| 0.05| 0.02| 0.01|
|          |          |          |          |          | 0.18| 0.07| 0.03| 0.01|
|          |          |          |          |          | 0.12| 0.07| 0.04| 0.01|
|          |          |          |          |          | 0.11| 0.07| 0.04| 0.01|
|          |          |          |          |          | 0.03| 0.02| 0.01| 0.01|
|          |          |          |          |          | 0.04| 0.02| 0.01| 0.01|
|          |          |          |          |          | 0.03| 0.02| 0.01| 0.01|
|          |          |          |          |          | 0.04| 0.02| 0.01| 0.01|

### Squared factor loading (related to unit sum)

| Variable | Squared factor loading |
|----------|------------------------|
|          | 0.03                   |
|          | 0.04                   |
|          | 0.03                   |
|          | 0.03                   |
|          | 0.02                   |
|          | 0.02                   |
|          | 0.02                   |
|          | 0.02                   |

### Model fit

- **Explained Variance**
  - Factor 1: 31.92%
  - Factor 2: 21.70%
  - Factor 3: 14.40%
  - Factor 4: 10.11%

- **Total Explained Variance**: 88.13%

- **Box Plot of Standardized Residuals**: All residuals fall within the range of -3 to 3.

- **KMO Measure of Sampling Adequacy**: 0.95

- **Bartlett's Test of Sphericity**: χ²(36) = 123.14, p < 0.001

### Composite Index to Measure the Performance of Today’s Creative Cities: A Holistic Perspective

This index allows for a comprehensive assessment of creative city performance, integrating various dimensions such as culture, innovation, and sustainability.
Table C - Sub-dimension Environmental sustainability

| Variable | $h^2$ | Factor |          | $\varepsilon^2$ |          |
|----------|-------|--------|----------|-----------------|----------|
|          |       | 1 2 3 4 | 5 6 7    | 1 2 3 4 5 6 7  | 1 2 3 4 5 6 7 |
| EGA1     | 0.888 | 0.925  |          | 0.488          |          |
| EGA2     | 0.898 | 0.945  |          | 0.488          | 0.160    |
| EGA3     | 0.783 | 0.792  |          | 0.165          |          |
| EPAT1    | 0.740 | 0.802  |          | 0.165          | 0.183    |
| EPAT2    | 0.778 | 0.845  |          | 0.183          | 0.113    |
| RR1      | 0.819 | 0.885  |          | 0.113          |          |
| RR2      | 0.696 | 0.852  |          | 0.109          |          |
| RR3      | 0.838 | 0.877  | 0.965    | 0.486          | 0.870    |
| RR4      | 0.956 | 0.965  |          |                |          |
| RR5      | 0.813 | 0.882  |          | 0.119          |          |
| RR6      | 0.913 | 0.838  |          | 0.104          | 0.521    |
| TER1     | 0.716 | 0.842  | 0.803    | 0.474          |          |
| TER2     | 0.875 |        | 0.803    | 0.474          |          |
| TER3     | 0.581 | 0.73   |          | 0.555          |          |
| TER4     | 0.588 | 0.776  |          | 0.478          | 0.089    |
| TER5     | 0.700 | 0.809  |          | 0.519          |          |

|                |       |
|----------------|-------|
| Eigenvalue     | 3.61  |
| % Explained    | 24.46 |
| Varimax Rotation, N = 300, KMO = 0.558, Bartlett Sphericity Test = 1792.370, gl = 120, p < 0.000 | 75.27  |
### Appendix 5

#### Calculation of the weightings of each sub-dimension in the dimension

**Table D – Exploratory Factor Analysis of the Creativity Dimension and Weights**

| Subdimensions          | \( h^2 \) | Factor – Creativity | Weights |
|------------------------|-----------|---------------------|---------|
| Culture                | 0.446     | 0.668               | 0.22    |
| Creative Economy       | 0.772     | 0.878               | 0.38    |
| Favourable Environment | 0.810     | 0.900               | 0.40    |

| Eigenvalue             |           |                     |         |
| % Explained variance   |           |                     | 67.59   |
| Total explained variance|         |                     | 67.59   |

Varimax rotation; \( N = 308; \) KMO = 0.607; Bartlett Sphericity Test: \( 299.642; gl = 3; p < 0.000; h^2 > 67\%; loadings > 40\% |

**Table E – Exploratory Factor Analysis of the Intelligence Dimension and Weights**

| Subdimensions | \( h^2 \) | Factor – Intelligence | Weights |
|---------------|-----------|-----------------------|---------|
| Governance    | 0.566     | 0.752                 | 0.50    |
| ICT           | 0.566     | 0.752                 | 0.50    |

| Eigenvalue     |           |                     | 1.13    |
| % Explained variance |         |                     | 56.55   |
| Total explained variance|         |                     | 56.55   |

Varimax Rotation; \( N = 308; \) KMO = 0.500; Bartlett Sphericity Test: \( 5.290; gl = 1; p < 0.000; h^2 > 0.5 \) loadings > 0.40

**Table F – Exploratory Factor Analysis of the Urban Sustainability Dimension and Weights**

| Subdimensions          | \( h^2 \) | Factor – Urban Sustainability | Weights 1) |
|------------------------|-----------|-------------------------------|------------|
| Economic sustainability| 0.621     | 0.788                         | 0.386      |
| Social sustainability  | 0.393     | 0.627                         | 0.245      |
| Environmental sustainability| 0.593     | 0.770                         | 0.369      |

| Eigenvalue             |           |                               | 1.61       |
| % Explained variance   |           |                               | 53.60      |
| Total explained variance|         |                               | 53.60      |

Varimax Rotation; \( N = 308; \) KMO = 0.598; Bartlett Sphericity Test: \( 83.775; gl = 3; p < 0.000; h^2 > or near 0.4 \) loadings > 0.40

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1 Example of calculation for Economic sustainability: \( 0.788^2/1.61 = 0.386 \)
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