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Rodrigues, Margarida; Franco, Mário

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

Margarida **RODRIGUES**, *Mário* **FRANCO**
University of Beira Interior, Covilhã, Portugal

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, Letaifa 2015, Girard et al. 2016, FPA 2017, Ortegel 2017, Rahbarianyazd and Doratli 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 scientificity. 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 (Priano 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, Kakiuchi 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.

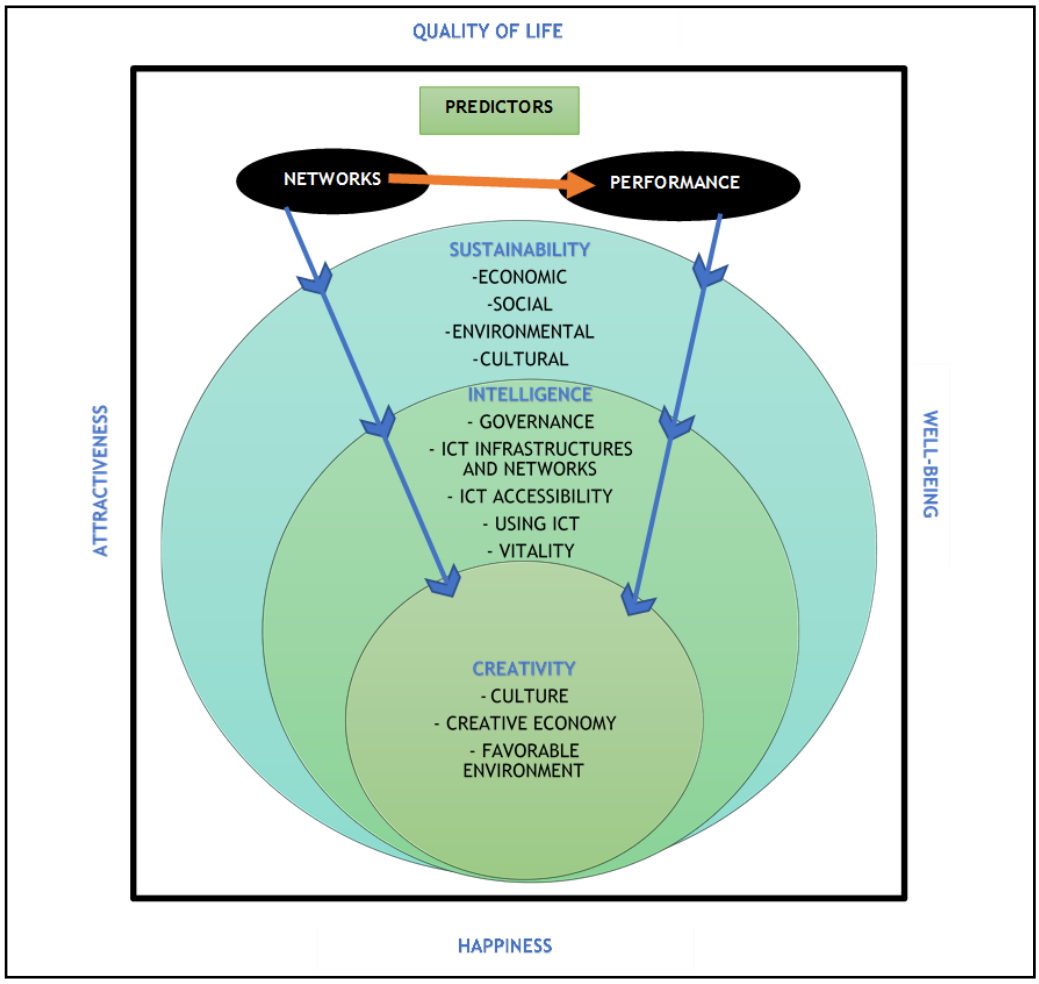

Fig. 1 **– Multi-dimensional design model for currents cities**
Source: *Rodrigues and Franco (2018)*

Creative, intelligent and sustainable performance of creative 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

Index of creativity, intelligence and urban sustainability

Sub-dimension	General indicator	Source
Creativity		
Culture	Places of culture and facilities	Giffinger et al. (2007), Durmaz 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), Skavronska (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), Dhingra and Chattopadhyay (2016), EPA (2016), European Union (2017), Skavronska (2017)
	Openness, tolerance and trust	
	Local and international connections	
	Governance	
Intelligence		
Governance	Implementation	Landry (2012), U4SSC (2017)
	Strategy	Landry (2012), Madeira et al. (2016), 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	EY (2016)
	Energy	
	Environment	
	Sensors	

ICT accessibility	Tariffs	Ericsson (2016)
	Mobility	EY (2016)
Use of ICT	of technology	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), Caragliu 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), Caragliu et al. (2011), 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)
Social	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), Trivellato (2016), 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)
Environmental	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), Dhingra and Chattopadhyay (2016), EPA (2016), Ericsson (2016), Bloom Consulting (2017), Artmann et al. (2019)

Methodology

Population

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

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

Population distribution in Portugal for 2017

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)*

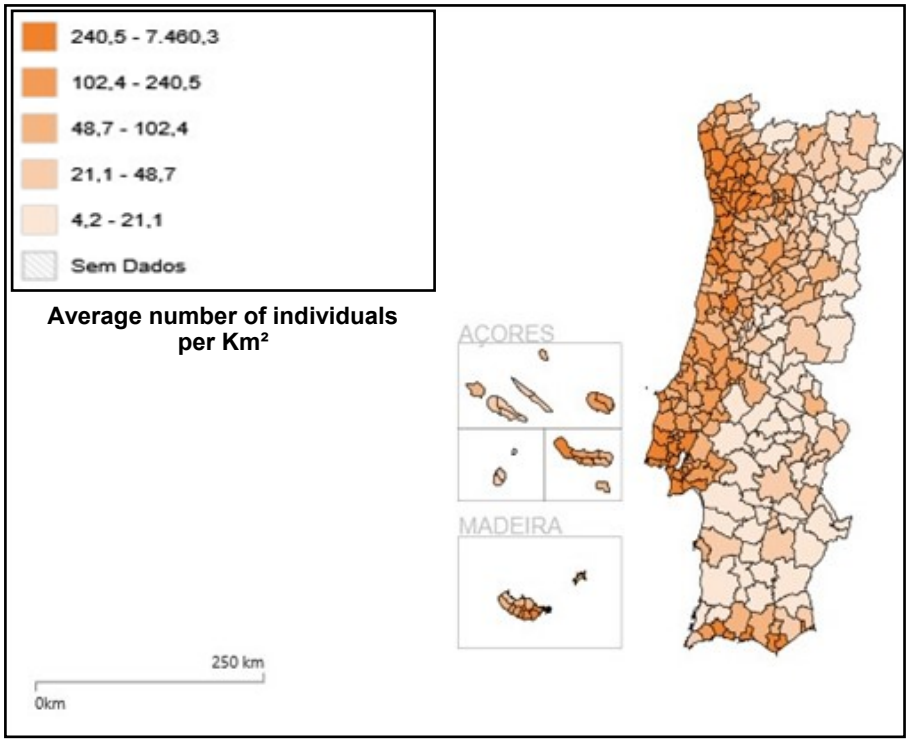

Fig. 2 **– Population density in Portuguese local authorities**
Source: *Pordata (2019)*

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 (Kľúčik 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 (eg., 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[5)]							
Variable	**Factor**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Sub-dimension culture							
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						
VISM1				5.251			
VISM 2				5.095			
ATENC 1		4.432					
ATENC2		4.577					
DCE1							2.608
DCE2		2.250					
OCC1					3.701		
DM1						1.674	
	Hotels and restaurants	**Theatres and similar**	**Cinema**	**Museum visitors**	**Cultural supply**	**Art and museums**	**Cultural premises**

5) Example of calculation for RAL1: (0.276*0.085)*100 = 2.346 (values taken from Appendix 2, Table A)

Table 3

Creativity dimension

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				
	R&D in higher education institu-tions	**Creative industries' contribution to GDP**	**R&D in firms**	**Proportion of creative industries**	**Weight of creative industries**
	1	**2**	**3**	**4**	**5**
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

Table 3

Creativity dimension

Weights – coefficients of variables[5)]							
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**

Table 4

Intelligence Dimension

Weights – coefficients of variables								
Variable	**Factor**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Sub-dimension governance								
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
	Election turnout	**Population vitality**	**Local public debt**	**E-government vs. Density and Income**	**Access**	**Municipal provision**	**Urban networks**	**Tourism**

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

Weights – coefficients of variables							
Variable	Factor						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Sub-dimension Economic sustainability							
CREC1		2.75					
CREC2	0.99						
CREC3	4.12						
CREC4		1.05					
CREC5				1.28			
NEG1		4.58					
NEG2		3.75					
NEG3					3.02		
NEG4			3.58				
NEG5		3.46					
NEG6	3.59						
NEG7	4.71						
NEG8	4.35						
NEG9			1.22				
NEG10				3.39			
EMP1						3.79	
EMP2				2.64			
EMP3			3.09				
EMP4			4.37				
EMP5					3.66		
EMP6							4.85
Total	17.76	15.59	12.26	7.31	6.68	3.79	4.85
	Eco-nomic activity	**Growth and employ-ment**	**Entrepre-neurship**	**Unem-ployment**	**Density of banks and firms**	**New firms**	**Public-private partner-ships**

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 edu-cation	**Health**	**Other**	**Social projects**	**Poverty and criminality**	**Urban renewal (a)**	**Other bene-fits**	**(a)**

Table 5

Sustainability Dimension

Weights – coefficients of variables							
Variables	**Factor**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Sub-dimension Environmental sustainability							
EGA1		7.11					
EGA2		7.42					
EGA3	5.21						
EPAT1	5.34						
EPAT2	5.93						
RR1	3.67						
RR2	3.53						
RR3			6.39				
RR4						7.73	
RR5	3.86						
RR6	3.38						
TER1				5.89			
TER2				5.36			
TER3							4.43
TER4					5.00		
TER5					5.44		
	Management of waste and basic consumption (a)			**Preservation and protection of the environment (b)**		**(a)**	**(b)**

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:

$$\sum(Zscore\ \ i * weighting\ i) + \cdots (Zscore\ i * weighting\ i)$$
$$= value\ observed\ for\ a\ town\ in\ the\ culture\ sub-dimension\ (1.61926)\ \ Formula\ 1$$

(i = LIC1 to DM1, where i = 23 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:

$$Culture\ (1.6191^{1} * 0.222^{2}) + Creative\ Economy\ (4.9873^{3} * 0.38) + Favourable\ Environment\ (3.1714^{4} * 0.396)$$
$$= Creativity\ (3.5158)\ Formula\ 2$$

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

Descriptive statistics of the population

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

Exploratory Factor Analysis for the dimensions of creativity, intelligence and urban sustainability

Dimensions	h^2	Factor Total Performance	Weights[6)]
		1	
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	

Varimax Rotation; N = 308; KMO = 0.613; Bartlett Sphericity Test:=162.366; gl = 3; $p < 0.000$;

Discussion

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 multi-dimensional 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.

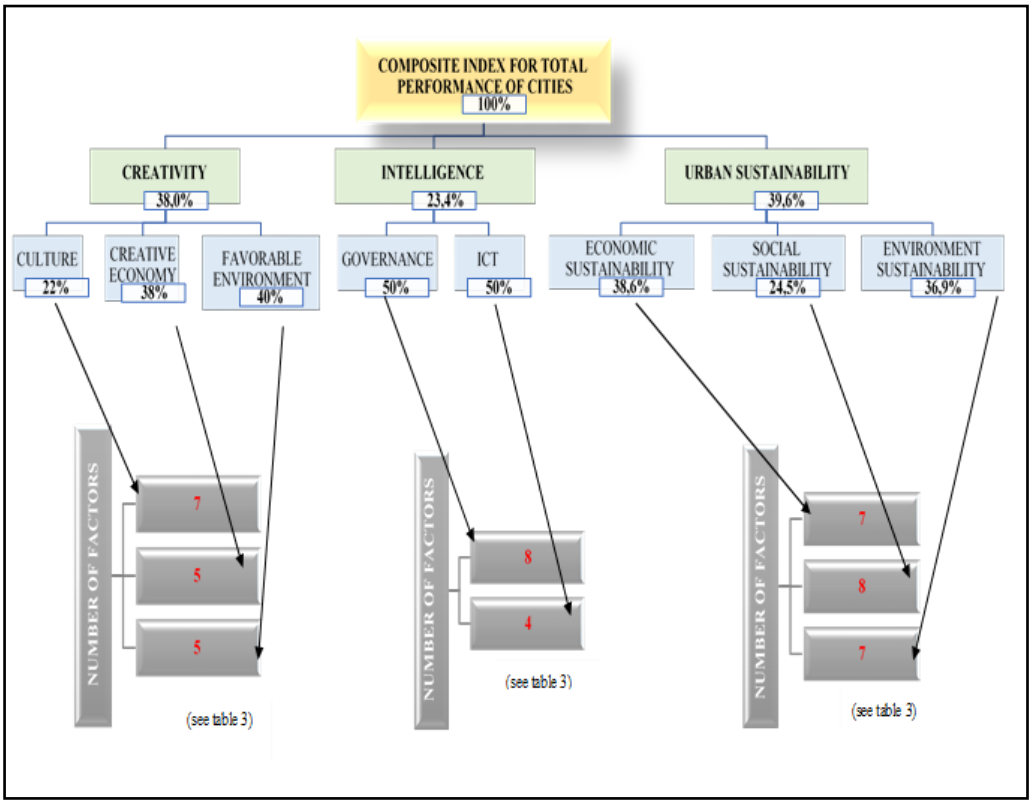

Fig. 3 **– Composite index for the total performance of cities**

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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Appendix 1

Index of creativity, intelligence and urban sustainability for cities in Portugal

Specific indicator	Variable	N	Proxies	Databases	Period of reference	Unit of measure
CREATIVITY						
I) Culture						
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
B) Museums and similar	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	268	3) Total income from hotel establishments		2016	M.€
B) Museum visitors	VISM1	264	1) Total visitors	Pordata	2016	Number
	VISM2	264	2) Total foreign visitors			
C) Cinema attendance	ATENC1	308	1) Nº of spectators	Pordata	2016	Number
	ATENC2	308	2) Ticket sales			M.€
D) Concerts and shows	DCE1	147	1) Nº 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	Number
B) Impact of creative industries on GDP	ICPIB1	308	1) Turnover of cultural and creative industries	INE	2016	€
	ICPIB2	308	2) % of creative industries in total economic activity			%
	ICPIB3	308	3) Expenses with staff in cultural and creative industries			€
	ICPIB4	308	4) Production of cultural and creative industries			
	ICPIB5	308	5) Intermediate consumption of cultural and creative industries			
	ICPIB6	308	6) Gross added value, at market prices, of cultural and creative industries			
	ICPIB7	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	2016	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		%
	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 (Nº 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	2016	Number
	ID2	308	2) R&D expenditure of those firms			M.€
	ID3	308	3) Total resources allocated by firms to R&D areas			Number
B) Knowledge transfer	TC1	308	1) R&D units in higher education institutions	Dgeec.mec	2016	Number
	TC2	308	2) Total researchers in those units financed by FCT			
	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	Number
	PP2	308	2) Applications for patents from higher education institutions			
	PP3	308	3) Applications for patents from other entities			
III) Favourable Environment						

General indicator: 3.1) Human capital and education						
A) 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			2016
	CC4	308	4) Higher education graduates in ICT	Annals by region - INE	2016	Number
	CC5	308	5) Higher education graduates	Pordata	2016	Number
	CC6	308	6) Number of students in higher education			
	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						
A) 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						
A) International connections	LI1	308	1) Airports	INE	2017	Number
	LI2	308	2) Passenger arrivals by airport			
B) Local connections	LL1	308	1) Transport and storage companies	INE	2012	Number
General indicator: 3.4) Governance						
A) 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						
General indicator: 1.1.) Implementation						
A) E-government	EGOV1	308	1) Use of electronic commerce	Annals by region - INE	2016	Number : 1-Yes; 0-No
	EGOV2	308	2) Public consultation processes available on the website			
	EGOV3	308	3) Online completion and submission of forms			

General indicator: 1.2) Strategy						
A) Finance	FIN1	308	1) Total debt	Annals by region - INE	2016	M.€
	FIN2	308	2) Municipal income per inhabitant			Euros
	FIN3	308	3) Municipal expenditure per inhabitant			
B) Network	RED1	308	1) Members of national networks	http:// redemunicipios saudaveis; *Webpages* municipais; http:// www.rni.pt/visa; http:// www.inteli.pt www.openliving labs.eu;	2018	Number
	RED2	308	2) Members of international networks			
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		2015	
	PEL3	308	3) Local Authority - Voter turnout		2013	
	PEL4	307	4) European Parliament - Voter turnout		2014	
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		2014	Km²
	VIND3	308	3) Newspapers and other regular publications: circulation	Pordata	2016	Number
	VIND4	308	4) Resident population <15 years		2011	
	VIND5	308	5) Inactive population: total		2011	
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)						
General indicator: 2.1) Network infrastructure						
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)		2009	
	AMB3	308	3) Electricity consumption for road lighting	Pordata	2016	Kwh
	AMB4	308	4) Hierarchy index of urban waste management			%

General indicator: 2.2) Accessibility						
A) Mail and internet	ACES1	308	1) Post offices per local authority	Annual reports by region - INE	2016	Number
	ACES2	308	2) Access to broadband internet service at a fixed point			
General indicator: 2.3) Use of ICT						
A) Public	PUB1	308	1) Average number of pupils per computer with internet connection in primary and secondary schools: total	Pordata	2016	%
B) Private	IND1	308	1) Companies providing ICT services	INE	2016	Number
URBAN SUSTAINABILITY						
I) Economic Sustainability						
General indicator: 1.1) Competitiveness and economic activity						
A) Economic growth	CREC1	308	1) Purchasing power per capita	Pordata	2015	%
	CREC2	308	2) Exports		2016	Euros
	CREC3	308	3) Imports			
	CREC4	308	4) Town's employment rate		2011	%
	CREC5	308	5) Total unemployment rate			
B) Business	NEG1	308	1) Firms formed in the period of reference	Pordata	2017	Number
	NEG2	308	2) Firms dissolved			
	NEG3	308	3) Banks and Savings Institutions			
	NEG4	308	4) Non-financial firms		2016	
	NEG5	308	5) Firms			
	NEG6	308	6) Employees in non-financial firms: total and by economic activity			
	NEG7	308	7) Turnover of non-financial firms: total and by economic activity			M.€
	NEG8	308	8) Gross added value of non-financial firms: total and by sector of economic activity			
	NEG9	308	9) Non-financial firms with under 10 employees as a % of all non-financial firms: by sector of economic activity			%
	NEG10	308	10) Youth unemployment rate - Unemployed registered with job centres and in vocational training (annual average): total and by age-group		2017	
C) Entrepreneurship	EMP1	308	1) % of new firms in activity after 2 years	INE	2015	%
	EMP2	308	2) % of employment with higher competences _ Employees: total and by level of education	Pordata	2013	
	EMP3	308	3) % of self-employment (self-employed, but employers)		2011	
	EMP4	308	4) % of self-employment (self-employed, not employers)			
	EMP5	308	5) Density of established firms	INE	2016	Km²
	EMP6	308	6) FABlabs, living labs	www.fablabsportugal.pt/;	2018	Number : 1-Yes; 0-No

II) Social sustainability						
General indicator: 2.1) Population and citizenship						
A) Demographic changes cultural/ historic identity	AD1	308	1) Percentage of population over 65	Pordata	2011	Number
	AD2	308	2) Percentage of population under 15			
	AD3	308	3) Migratory growth – contribution of migratory balance to the population variance		2013	%
	AD4	308	4) Index of dependent elderly		2016	
	AD5	308	5) Index of dependent young people			
	AD6	308	6) Child mortality rate (<1 ano)		2017	
	AD7	308	7) Gross birth rate		2016	
General indicator: 2.2) Education						
A) Infrastructure and competences	ICOM1	308	1) Establishments of pre-school, primary and secondary education	Pordata	2016	Number
	ICOM2	308	2) Pupils enrolled in pre-school, primary and secondary education			
	ICOM3	308	3) Total literacy rate – Resident population of 15 years and over according to the Census: total		2011	
	ICOM4	308	4) Pupils enrolled in pre-school, primary and secondary education as a % of the resident population		2016	%
	ICOM5	308	5) Rate of completion of levels of education – Pupils in regular basic education completing the year: total			Number
General indicator: 2.3) Inclusion and cohesion						
A) Poverty and inequality	PD1	308	1) Recipients of social benefits – Recipients of Guaranteed Minimum Income and Social Insertion Income from Social Security in total active beneficiaries (%)	Pordata	2017	%
	PD2	308	2) Residents at risk of poverty – Beneficiaries of unemployment subsidy from Social Security: total			Number
	PD3	308	3) Equity and citizenship projects	redemunicipiossaudaveis.com	2018	Number
General indicator: 2.4) Social infrastructure						
A) Health	DSA1	308	1) Number of hospital beds – Hospital accommodation	Pordata	2016	Number
	DSA2	308	2) Health centres: appointments per inhabitant		2012	%
	DSA3	308	3) Inhabitants per health centre		2011	
	DSA4	308	4) General and specialized hospitals		2016	Number
	DSA5	308	5) Promotion of physical and mental well-being	redemunicipiossaudaveis.com	2018	

B) Security	DSE1	308	1) Number of crimes: total	Pordata	2016	Number
	DSE2	308	2) PSP and GNR (police) stations	www.psp.pt.http://www.gnr.pt	2018	
III). Environmental sustainability						
General indicator: **3.1)** Basic infrastructure						
A) Energy, Water and Gas	EGA1	308	1) Annual energy consumption per capita – Electricity consumption per inhabitant: total	Pordata	2016	KWH /Inhabitant
	EGA2	308	2) Natural gas consumption per capita - Natural gas consumption per inhabitant			Nm3/ Inhabitant
	EGA3	308	3) Annual water consumption per capita – Water distributed/consumed per inhabitant		2015	m^3/ Inhabitant
B) Emission and production of pollutants	EPAT1	308	1) Undifferentiated urban waste collected (Urban waste: total and by type of collection)		2016	Tons
	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	RR1	308	1) Income from waste management	INE	2016	M.€
	RR2	308	2) Expenditure on waste management			
	RR3	308	3) Urban waste sent to energy recovery	Pordata		Tons
	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	TER1	308	1) Income from biodiversity and landscape protection	INE	2016	M.€
	TER2	308	2) Expenditure on biodiversity and landscape protection			
	TER3	308	3) actions of environmental improvement and territorial development	redemunicipiossaudaveis.com	2018	Number
	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	INE	2016	M.€
	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			

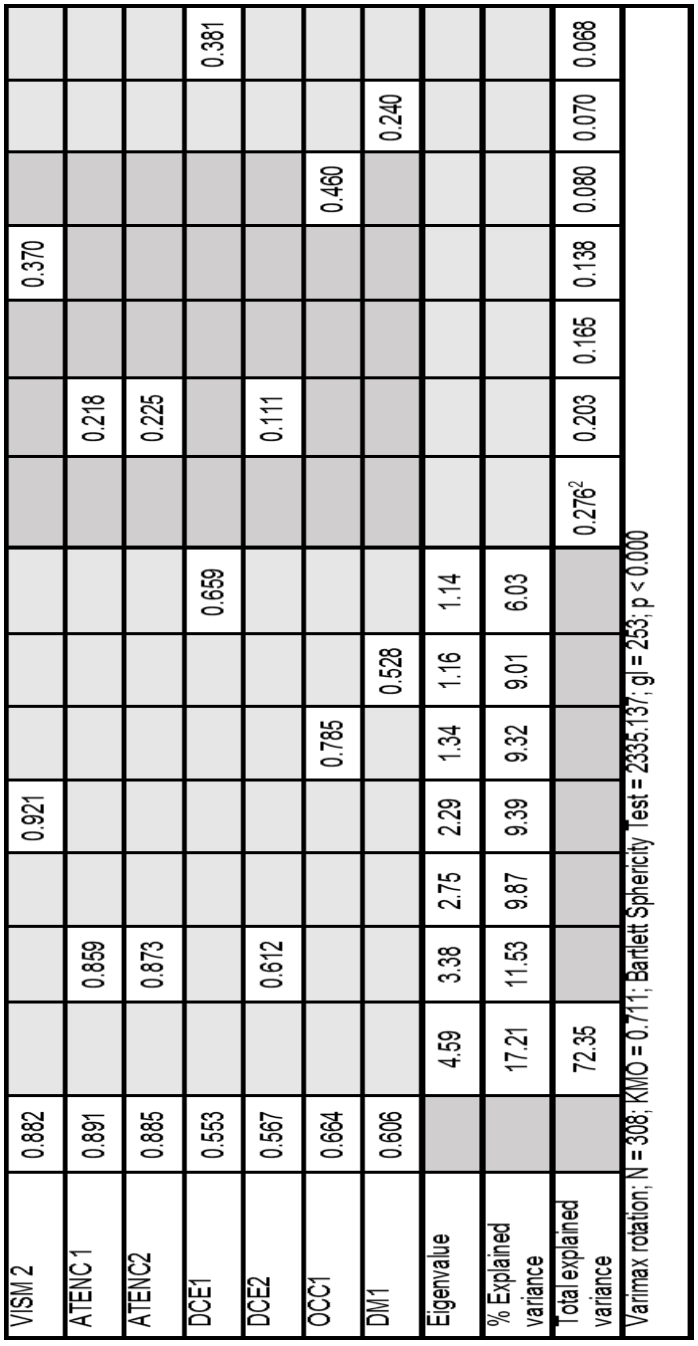
Appendix 2

Exploratory Factor Analysis of creativity dimension

Table A – Sub-dimension Culture

Variable	h^2	Results of Exploratory Factor Analysis – Factor 1	2	3	4	5	6	7	Squared factor loading (scaled to unit sum[1]) – Factor 1	2	3	4	5	6	7
LIC1	0.795					0.775							0.448		
MA1	0.722						0.828							0.591	
MA2	0.587						0.747							0.481	
MA3	0.579						0.600							0.310	
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	0.552	0.625							0.085						
RAL2	0.945	0.970							0.205						
RAL3	0.741	0.723							0.114						
DORT1	0.913	0.943							0.194						
DORT2	0.485	0.393							0.034						
DORT3	0.920	0.950							0.197						
VISM1	0.899				0.935							0.382			

1 Example of calculation for RAL1: 0.625^2/4.59 = 0.085



VISM 2	0.882			0.921								0.370							
ATENC 1	0.891		0.859								0.218								
ATENC2	0.885		0.873								0.225								
DCE1	0.553								0.659										0.381
DCE2	0.567		0.612								0.111								
OCC1	0.664					0.785								0.460					
DM1	0.606						0.528									0.240			
Eigenvalue		4.59	3.38	2.75	2.29	1.34	1.16	1.14											
% Explained variance		17.21	11.53	9.87	9.39	9.32	9.01	6.03											
Total explained variance		72.35									0.276[2]	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 = 253; p < 0.000																			

2 Example of calculation for: 4.59/∑ 4.59+3.38+2.75+2.29+1.34+1.16+1.14 = 0.276

Table B – Sub-dimension Creative economy

Results of Exploratory Factor Analysis							Squared factor loading (scaled to unit sum)				
Variable	h^2	**Factor**					**Factor**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
EC1	0.964		0.797					0.241			
ICPIB1	0.960		0.938					0.333			
ICPIB2	0.971				0.977					0.697	
ICPIB3	0.930		0.889					0.299			
ICPIB7	0.806		0.866					0.284			
ATIC1	0.705		0.710					0.191			
ATIC2	0.979				0.981					0.702	
ATIC5	0.956					0.958					0.987
ID1	0.639			0.791					0.297		
ID2	0.905			0.937					0.416		
ID3	0.774			0.792					0.297		
TC1	0.877	0.887					0.117				
TC3	0.615	0.721					0.079				
TC4	0.945	0.917					0.128				
PP1	0.809	0.867					0.114				
PP2	0.795	0.889					0.120				
Eigenvalue		6.59	2.64	2.11	1.37	0.93					
% Explained variance		25.42	25.12	14.49	13.69	6.52					
Total explained variance		85.25					0.483	0.194	0.155	0.100	0.068
Varimax rotation; N = 308; KMO = 0.723; Bartlett Sphericity Test:= 6244.488; gl = 120; $p < 0.000$											

Table C – Sub-dimension Favourable Environment

Results of Exploratory Factor Analysis							Squared factor loading (scaled to unit sum)				
Variable	h^2	**Factor**					**Factor**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
CC1	0.832	0.907					0.115				
CC2	0.821	0.901					0.113				
CC3	0.866	0.924					0.119				
CC4	0.802	0.890					0.110				
CC5	0.934	0.961					0.129				
CC6	0.947	0.967					0.130				
CC7	0.638	0.778					0.084				

Table C – Sub-dimension Favourable Environment

Results of Exploratory Factor Analysis							Squared factor loading (scaled to unit sum)				
Variable	h^2	**Factor**					**Factor**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
CC8	0.562	0.529					0.039				
PR1	0.546	0.702					0.069				
TOL1	0.714				0.842					0.496	
TOL2	0.802		0.877					0.306			
TOL3	0.619		0.759					0.230			
TOL4	0.695				0.805					0.453	
LI1	0.560			0.690					0.222		
LI2	0.618					0.565					0.285
LL1	0.794					0.861					0.662
FE1	0.794			0.950					0.422		
FE2	0.925			0.910					0.387		
FE3	0.859		0.896					0.320			
Eigenvalue		7.18	2.51	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	0.078

Varimax rotation; N = 308; KMO = 0.750; Bartlett Sphericity Test:= 6577.490; gl = 171; $p < 0.000$

Appendix 3

Exploratory Factor Analysis of Intelligence dimension

Table A – Sub-dimension Governance

h^2	Results of Exploratory Factor Analysis – Factor 1	2	3	4	5	6	7	8	*Squared factor loading (scaled to unit sum)* – Factor 1	2	3	4	5	6	7	8
0.540				0.352								0.085				
0.805				0.887								0.543				
0.486							0.485								0.224	
0.993			0.989								0.520					
0.846				0.693								0.331				
0.993			0.989								0.520					
0.666						0.709								0.445		

Table A – Sub-dimension Governance

h^2	Results of Exploratory Factor Analysis – Factor 1	2	3	4	5	6	7	8	*Squared factor loading (scaled to unit sum)* – Factor 1	2	3	4	5	6	7	8
0.736						0.776								0.533		
0.971	0.964								0.208							
0.988	0.982								0.216							
0.818	0.748								0.125							

PEL4	0.955	0.951								0.202							
VIND1	0.785		0.837								0.223						
VIND2	0.694				0.466								0.150				
VIND3	0.581					0.738								0.462			
VIND4	0.880		0.868								0.240						
VIND5	0.897		0.817								0.213						
VPUB1	0.852							0.913								0.794	
VPUB2	0.793								0.878								0.779
Eigenvalue		4.47	3.14	1.88	1.45	1.18	1.13	1.05	0.99								
% Explained Variance		23.53	16.51	9.92	7.64	6.18	5.94	5.52	5.19								
Total explained variance		80.42								0.292	0.205	0.123	0.095	0.077	0.074	0.069	0.065
Varimax Rotation; N = 308; KMO = 0.697; Bartlett Sphericity Test:= 6471.587; 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	**Factor**				**Factor**			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
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[1]	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/∑ 4.10+2.36+1.09+0.88 = 0.486

Appendix 4

Exploratory Factor Analysis of urban sustainability dimension

Table A – Sub-dimension Economic sustainability

Results of Exploratory Factor Analysis									Squared factor loading (scaled to unit sum)						
Variable	h^2	Factor							Factor						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7
CREC1	0.811		0.665							0.151					
CREC2	0.541	0.399							0.025						
CREC3	0.728	0.813							0.104						
CREC4	0.740		0.411							0.058					
CREC5	0.702				0.454							0.135			
NEG1	0.803		0.858							0.252					
NEG2	0.664		0.776							0.206					
NEG3	0.716					0.697							0.395		
NEG4	0.788			0.758							0.296				
NEG5	0.791		0.745							0.190					
NEG6	0.916	0.759							0.090						
NEG7	0.841	0.870							0.119						
NEG8	0.829	0.836							0.110						
NEG9	0.815			0.443							0.101				
NEG10	0.679				0.738							0.356			
EMP1	0.781						0.780							0.569	
EMP2	0.751				0.651							0.277			
EMP3	0.812			0.704							0.255				
EMP4	0.866			0.838							0.362				
EMP5	0.680					0.767							0.478		
EMP6	0.803							0.883							0.780
Eigenvalue		6.37	2.92	1.94	1.53	1.23	1.07	1.00							
% Explained Variance		30.35	13.88	9.26	7.31	5.84	5.08	4.75							
Total explained variance		76.46							0.397	0.182	0.121	0.095	0.077	0.067	0.062
Varimax Rotation; N = 308; KMO = 0.779; Bartlett Sphericity Test:= 4305.614; gl = 210; p < 0.000															

Table B – Sub-dimension Social sustainability

Results of Exploratory Factor Analysis										*Squared factor loading (scaled to unit sum)*							
Variable	h^2	Factor								Factor							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
AD1	0.934	0.954								0.114							
AD2	0.891	0.929								0.109							
AD3	0.540	0.642								0.052							
AD4	0.902	0.944								0.112							
AD5	0.744	0.757								0.072							
AD6	0.500								0.678								0.430
AD7	0.763	0.613								0.047							
ICH1	0.828					0.903								0.582			
ICH2	0.656								0.796								0.592
ICH3	0.834					0.887								0.562			
ICOM1	0.893			0.932								0.400					
ICOM2	0.860	0.777								0.076							
ICOM3	0.800	0.767								0.074							
ICOM4	0.860	0.777								0.076							
ICOM5	0.799	0.846								0.090							
PD1	0.703							0.802								0.579	
PD2	0.564						0.576								0.263		
PD3	0.888				0.938								0.483				
DSA1	0.777		0.855								0.318						
DSA2	0.492	0.506								0.032							
DSA3	0.518							0.550								0.273	
DSA4	0.762		0.865								0.325						
DSA5	0.899				0.885								0.430				
DSE1	0.784						0.847								0.569		
DSE2	0.883			0.886								0.362					
Eigenvalue		7.95	2.30	2.17	1.82	1.40	1.26	1.11	1.07								
% Explained Variance		31.82	9.21	8.67	7.30	5.58	5.03	4.42	4.26								
Total explained variance		76.29								0.417	0.121	0.114	0.095	0.073	0.066	0.058	0.056

Varimax Rotation; N = 308; KMO = 0.802; Bartlett Sphericity Test:= 9623.441; gl = 300; p < 0.000

Table C – Sub-dimension Environmental sustainability

Results of Exploratory Factor Analysis									Squared factor loading (scaled to unit sum)						
Variable	h^2	Factor							Factor						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7
EGA1	0.888		0.925							0.468					
EGA2	0.898		0.945							0.488					
EGA3	0.763	0.792							0.160						
EPAT1	0.740	0.802							0.165						
EPAT2	0.778	0.845							0.183						
RR1	0.619	0.665							0.113						
RR2	0.696	0.652							0.109						
RR3	0.838			0.877							0.466				
RR4	0.956						0.965							0.870	
RR5	0.613	0.682							0.119						
RR6	0.913	0.638							0.104						
TER1	0.716				0.842							0.521			
TER2	0.675				0.803							0.474			
TER3	0.581							0.730							0.555
TER4	0.668					0.776							0.478		
TER5	0.700					0.809							0.519		
Eigenvalue		3.91	1.83	1.65	1.36	1.26	1.07	0.96							
% Explained Variance		24.46	11.42	10.30	8.51	7.87	6.68	6.03							
Total explained variance		75.27							0.325[1]	0.152	0.137	0.113	0.105	0.089	0.080
Varimax Rotation; N = 308; KMO = 0.558; Bartlett Sphericity Test:= 1792.370; gl = 120; p < 0.000															

1 Example of calculation: 3.91/∑ 3.91+1.83+1.65+1.36+1.26+1.07+0.96 = 0.325

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**
		1	
Culture	0.446	0.668	0.22
Creative Economy	0.772	0.878	0.38
Favourable Environment	0.810	0.900	0.40
Eigenvalue		2.03	
% 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**
		1	
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)]
		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

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

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Correspondence: Management and Economics Department, University of Beira Interior, CEGAGE-UBI Research Center, Estrada do Sineiro, 6200-209 Covilhã, Portugal.

Email: mfranco@ubi.pt