Evaluation of performance of European cities with the aim of increasing quality of life

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ABSTRACT

This thesis proposes a new model of evaluation and improvement of urban quality of life. Using the Data Envelopment Analysis technique, European cities are assessed in order to study the factors that induce quality of life. We propose different composite indicators of urban quality of life, an evaluation of the performance of local management given national wealth, and a model to explain citizens' perception on local management.

By varying the weights of the DEA model, to a certain extent, we provided different pictures of urban quality of life: each city shown at its best light, a consensual perspective to reflect the common features of European cities, and from the perspective of the well-educated work force. Each city is assessed, in the first place, highlighting its own strengths and weaknesses. For the cities considered to have less quality of life, this approach allows to identify what components of quality of life can be improved. In a second moment, this assessment is enhanced, allowing the construction of a ranking of European cities based on a common standard of evaluation. A third evaluation of urban quality of life is processed in order to incorporate in the analysis the perspective of different stakeholders, namely the qualified human resources, that have been proven to be important assets in cities competitiveness mainly by attracting investment and economic development.

European cities are also assessed in terms of their ability to promote quality of life, given the wealth of the country. Also using DEA technique, this efficiency assessment is contextualized by national Gross Domestic Product. Benchmarking strategies are explored, offering less efficient European cities tools to improve urban quality of life by adopting the best practice of peer cities in the different dimensions identified by the model.

Finally, we present an explanatory model of why citizens judge good or bad the allocation of resources of a city in order to promote quality of life, identifying the factors underlying this subjective assessment.

We conclude with some remarks on the implication of these assessments in terms of public policy, supporting urban planners and policy-makers aiming at increase quality of life.

RESUMO

Esta tese propõe um novo modelo de avaliação e melhoria da qualidade de vida urbana. Usando a técnica Data Envelopment Analysis (DEA), as cidades europeias são avaliadas em termos dos factores que induzem qualidade de vida. São propostos diferentes indicadores compostos de qualidade de vida urbana, uma avaliação de desempenho da gestão local tendo em conta a riqueza nacional e um modelo explicativo da forma como a gestão local é percepcionada pelos cidadãos.

Com variações do modelo DEA, até certo ponto, são providenciadas diferentes imagens de qualidade de vida urbana: cada cidade é apresentada do ponto de vista que lhe é mais favorável, as cidades são comparadas entre si, bem como apresentamos as cidades a partir da perspectiva dos recursos humanos qualificados. Cada cidade é avaliada, em primeiro lugar, em termos de suas próprias forças e fraquezas. Esta abordagem permite identificar que componentes podem ser melhoradas nas cidades com menor qualidade de vida. Num segundo momento, essa avaliação é feita de forma a permitir comparações entre diferentes cidades, dando origem a um *ranking* de cidades. Numa outra pesrpectiva, a avaliação de qualidade de vida urbana incorpora na análise a perspectiva de diferentes intervenientes. Desenvolvendo uma metodologia que pode ser replicada, considerando a perspectiva adoptada, exemplificamos com o caso dos recursos humanos qualificados, pelo facto de serem activos importantes para a competitividade das cidades.

As cidades europeias são também avaliadas em termos de sua capacidade de promover a qualidade de vida, dada a riqueza de cada país, expressa através do seu produto interno bruto. Também utilizando a técnica DEA, proporcionam-se às cidades menos eficientes instrumentos para melhorar a qualidade de vida urbana, através da adopção das melhores práticas de cidades consideradas suas pares. Por fim, apresentamos um modelo explicativo das causas que levam os cidadãos a julgar como boa ou má a alocação de recursos da sua cidade na perspectiva da promoção da qualidade de vida.

Concluímos com considerações sobre as implicações das diversas avaliações em termos de políticas públicas, apoiando os técnicos de planeamento urbano e os decisores políticos.

RÉSUMÉ

Cette thèse propose un nouveau modèle d'évaluation et l'amélioration de la qualité de vie urbaine. En utilisant la téchnique Data Envelopment Analysis (DEA), les villes européennes sont évaluées en fonction des facteurs qui induisent la qualité de vie. Nous proposons différents indicateurs composés de qualité de vie urbaine, une évaluation de performance de la gestion locale en function de la richesse de chaque pays et un modèle pour expliquer la perception des citoyens sur la gestion locale.

En faisant varier le poids du modèle DEA, dans une certaine mesure, nous avons fourni des images différentes de la qualité de vie urbaine: chaque ville est présentée de la façon qui lui est plus favorable, les villes sont comparées entre elles et les villes sont étudiées du point de vue des ressources humaines qualifiées. Chaque ville est évaluée, premièremment, en fonction de ses propres forces et faiblesses. Cette approche permet d'identifier les composantes qui peuvent être améliorées dans les villes qui présentent moins de qualité de vie. Dans une seconde phase, cette évaluation est présentée avec des critères qui permettent la construction d'un *ranking* de villes. Une troisième évaluation de la qualité de vie urbaine permet d' intégrer dans l'analyse le point de vue des différentes parties prenantes. Nous developpons une méthodologie qui peut être reproduite compte tenue la perspective adoptée; nous presentons le cas des ressources humaines qualifiées, qui ont été révélés être des atouts importants dans la compétitivité des villes.

Les villes européennes sont également évaluées en fonction de leur capacité à promouvoir la qualité de vie, étant donné la richesse du pays, representée par le Produit National Brut. On offre des instruments aux villes les moins efficaces qui leur permettent d' améliorer la qualité de vie urbaine en adoptant les meilleures pratiques des villes qui sont leurs pairs.

Finalement, nous présentons un modèle explicatif des raisons pour lesquelles les citoyens jugent comme bonne ou mauvaise l' allocation des ressources d'une ville, afin de promouvoir la qualité de vie.

Nous concluons par quelques remarques sur l'implication de ces évaluations en termes de politiques publiques, en soutenant les urbanistes et les décideurs politiques visant à améliorer la qualité de vie urbaine.

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A last word to my children, who I expect will benefit in the future from a better quality of life, and to my wife for the support she has always given me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

The evaluation of urban quality of life (QoL) is an issue with growing importance in the scientific literature. Several authors, from different academic backgrounds, have approached this theme. Contributions from diverse disciplines illustrate the complexity of this phenomenon: sociology, geography, economy, public health, transport or environment engineering are only some of the possible references that show the interest this issue raises in different areas of knowledge. The multidisciplinary views show, on one hand, the scientific wealth of this issue, but it raises, on the other hand, research constrains as it is difficult to reach a worldwide accepted concept of QoL, as well as an agreement on the underlying dimensions that should be used for its assessment. In the scientific literature that addresses this theme, the lack of agreement is well shown.

However, the discussion on QoL shows that the issue is inseparable from the analysis of the conditions of modern life (Pacione, 2003a). In varying degrees, the authorities responsible for public administration have shown a growing concern over this issue, trying to intervene and organize their operations in order to enhance QoL. Several examples of indexes of QoL with policy purposes are available in Hagerty et al. (2001). Citizens, on the other side, are becoming more demanding, seeking answers and solutions to fit their perception of well-being and satisfaction (Dijk and Wulp, 2010). The main purpose of the investigation reported in this thesis is to develop new instruments to assess and intervene in urban QoL, providing objective evaluations of QoL to decision-makers and public administrations and insights on what explains citizen’s perception of QoL, such that successful QoL improvements strategies can be successfully implemented.

1.1. Motivation

Modern society faces several obstacles when it comes to ensuring QoL for citizens: poverty, insecurity and unregulated urban development are just some of the problems that pose serious difficulties for government action and policies designed to promote QoL. In this analysis, the urban scale is essential in the assessment of the focus and effectiveness of public policies. “Much of the debate over urban liveability and QoL takes place within the framework of the urban political system” (Pacione, 2009: 416).

The role of cities and public policy framework, at the core of action and thought on the QoL, is being valued by legislative and administrative tools, but mostly by the importance it has been awarded by bodies such as the European Union, World Health Organization and even the Organization for Economic Cooperation and Development (OECD), or human resources consulting firms like Mercer. “Politicians, policy makers and planners are constantly faced with decisions on environmental, social and economic issues, directly linked with QoL, at a national, regional, urban and neighborhood level” (Lambiri et al., 2007: 2). This is why urban QoL is a reality that has also been demanding increased attention from the authorities of European institutions, namely through programs to characterize urban QoL such as the Urban Audit project from the European Commission.

This characterization is even more useful when we consider the great asymmetries that can be found in cities. A resolution of the European Parliament from 2005, considering the urban dimension within the process of the enlargement, explains that “towns and cities and urban agglomerations or areas, where 78% of the European Union population is concentrated, are the place where both the most complex and the most common problems are concentrated (social exclusion, spatial and ethnic segregation, housing shortages, insecurity, drugs, pollution, contaminated former industrial sites, traffic, unemployment, lack of competitiveness, poverty, demographic changes, and so on)”, but it is also “the place where the future is built: universities, research centers, and so on” (Beaupuy, 2005).

This presentation of cities as central points to future development is also essential in terms of urban economics. This may be why the economic literature focusing on urban aspects has been attributing a growing importance to issues related to QoL (Lambiri et al., 2007). Though a multidimensional and multidisciplinary concept, QoL has been increasingly discussed from the perspective of competitiveness of cities, in an international environment characterized by creativeness as the drive of development. In this perspective, qualified human resources are of outmost importance to the equation of competitiveness.

A recent report sponsored by European Commission (2007) stated that "in virtually all European countries, urban areas are the foremost producers of knowledge and innovation - the hubs of a globalizing world economy", and pointed out that "urban economies are rapidly becoming service economies. The service sector is by far the most important source of employment in European cities". In service economies, human resources are the fundamental capital to activity. One of the main references in this matter is Florida (2002), who has been arguing that in urban economic contexts workers are more important than firms, and that urban policies should focus on creative people (the drivers of this new economy). In this perspective, QoL is increasingly considered as an essential element for the development of cities. As Trip (2007: 502) sums it, "crucial for this is quality of place: an attractive, diverse and tolerant urban environment is being increasingly recognized as a key factor in urban competitiveness".

This recent line of discussion on the urban dimension of QoL, focusing on key concepts of modern economics – including competition, productivity and innovation – have increasingly linked wealth creation to the cities (Rogerson, 1999). Investment attraction is then essential in any strategy for urban planning. Florida (2002) discusses the importance of quality of urban life in this area, arguing that this factor is responsible for attracting skilled and creative human resources, thus being the key factor of motivation that explains the location of investments and businesses.

Florida's theory is not free from criticism and some empirical studies have not proved his assumption. Darchen and Tremblay (2010: 232), for instance, have not proved that QoL is a sufficient criterion to explain the mobility of students from Ottawa and Montreal, although their research has shown that "Ottawa achieves better results in retaining students with the criterion of QoL". Also Martin-Brelot et al. (2010: 854), in a study involving 11 European cities, showed that the creative class in Europe is not very mobile and that soft factors such as QoL "play only a marginal role in attracting members of the creative class to a city", although "they do indeed play an important role in retaining them once they have relocated". Works of Cheshire and Magrini (2006, 2009) have presented interesting insights in this issue, showing that mobility do exists, but only at a national level: "Labour in Europe is geographically immobile and, in as far as there is mobility in search of QoL, it is a within-country phenomenon" (Cheshire and Magrini, 2006: 24).

Although it is certainly not the unique issue to consider in terms of the competitiveness of an urban center, local QoL has become an increasingly important factor for cities from an economic point of view. Several studies producing evidence of the importance of QoL for urban competitiveness are available. The study by Salvesen and Renski (2003) states that "an increasing number of firms are seeking locations that will attract and retain a well-educated work force" and that areas with cultural and recreational amenities could have a competitive advantage.

QoL is becoming increasingly important in modern business location decisions, particularly in the high-technology sector. Studies like Blair and Premus (1987) and Stafford (1983) have highlighted the importance attributed by firms to QoL factors. Ritter (1990) also found that R&D firms are very sensitive to factors of QoL, as they need to recruit and maintain employees with high qualifications. Blomquist et al. (1988:105) have also found that "QoL is clearly one factor considered in location decisions along with other facts such as job availability". Wong (2001: 31) has shown that traditional factors to local economic development are still important, but that "QoL provides the cutting-edge in the competitive process when a number of potential investment locations are on a “level playing field” in terms of traditional factors”.

Myers (1987: 268), in a founding work in the field of urban QoL, argues that “it is necessary to measure local trends in QoL components to guard against deterioration of competitive advantages in the future”, considering that it is useful to perspective QoL as a "strategic resource" that can be improved or degraded, but which, when properly managed, can help local economic development.

The perception of QoL is essential even in the equation of population movements. A study of the Federal Reserve Bank of Kansas City (Rappaport, 2007) points out, for example, that U.S. residents have moved to areas where they perceive greater QoL, particularly in terms of climate, geographical location and services in the leisure area, as amenities and entertainment venues.

On the other hand, evaluation of public government has become a central issue in the past decades and “there is now an interest in measuring the success of public interventions in terms of the QoL changes which they bring about for those affected by them” (Bovaird and Löffler, 2009: 317). This means, namely, the perception and experiences of citizens in those matters, notwithstanding the importance of still evaluating the quality of the public interventions.

However, in the literature related to public management, the evaluation of local policies only by listening to the citizens present problems as a direct link between satisfaction and quality of public performance cannot be established (Bouckaert and Walle, 2003). Holzer et al. (2009) and Swindell and Kelly (2000) report the existence of several external variables (to public performance) that impact on citizen satisfaction: public or private nature of the service, previous expectations of citizens, size municipality and race, among others. Although being a valuable tool, surveys to citizens do not reflect totally the quality of the public management performance.

This discussion does not hide the fact that performance evaluation of public administration is indispensible. Measuring the outcomes of public policies in the management of urban QoL is essential as disparities in urban QoL are explained by “material conditions offered by each city to its inhabitants”, that depend also on the “management of the city” (Tobelem-Zanin, 1995: 108). Assessing outcomes of policies is essential as it “provides the key to improved effectiveness at both organizational and policy levels as defined in terms of capacity to satisfy needs and improve the QoL of citizens”, but a sound methodology and theory must guide this evaluation (Sanderson, 1996).

This assessment in a generalized way is, however, very difficult. In the American context, there is not an effort to collect information on municipalities action in a standardized way and when the data actually exists, access is not easy (Holzer et al., 2009) or, at the European level, presented in readable format (Bovaird and Löffler, 2003). Although existing, data does not necessarily transform into evaluation.

To our knowledge, few models of evaluation of local management in the promotion of urban QoL are available in literature. One example is presented by Green et al. (2005) that developed a performance index to assess funded service activities in the promotion of QoL for youth, combining evaluation data from grantees and track community-wide indicators. Many local authorities do present documents with evaluation items on policies for QoL improvements, but without clear assessment of policies outcomes – see, for instance, the scotish “Quality of Life Fund” or the Quality of life Reporting System of the Federation of Canadian Municipalities.

There is still little academic body on the evaluation of policies for urban QoL improvement, in spite of many local government or other institutions providing periodical reports – such as in the BigCities project or the Quality of Life Monitoring Programme of MeglioMilano. The problem may lie in the fact that “little evidence so far that elected politicians make much use of QoL indicators” (Bovaird and Löffler, 2003: 321). So systematic evaluations of local management in the promotion of QoL, acknowledged in the literature as essential to evaluate performance of public policies, are not available.

1.2. Framework for the analysis

An evaluation of urban QoL is essential to define public policies aiming at improving the well-being of citizens. Any local decisors and planners wishing to intervene in the QoL of their city need objective information and measurement tools that can provide guides for action. This assessment is also important in case national or international institutions, such as the European Union, set up programs to support cities in their fight for better urban QoL, by allowing the definition of strategic and objective criteria to distribute economic funds – moreover if the goal is to promote cohesion within the European space.

Brown (2003: 92) noted the existence of a division between academic research and policy-makers or decision-makers, and suggested that a more assertive connection should be established: "As well as research that will focus inwardly on clarifying the nature and measurement of environmental quality, research also needs to focus outwardly, and downstream, on the relationship between environmental quality concepts and indicators, and the potential users".

However, when it comes to defining public policies and urban interventions, measuring QoL in cities, as well as identifying key areas for action, has not always been an easy task and several methods were adopted by local authorities as well as by researchers in the area. Objective data and quantitative methods are most valued in this field, but research has also been considering the perception of citizens, that can make important contributions to identify the dimensions most valued and where public intervention may be more fruitful. In order to help local management, it would also be important to identify which components of quality of urban life are associated by citizens to good public policies.

So, despite the growing interest and work in the field of QoL, consistent tools for measuring and planning the improvement of citizens' wellbeing are not available. This research project intends to present a contribution that can overcome some of the gaps in the measurement and promotion of QoL by exploring new methodologies.

The methodology we intend to apply to the field of QoL is Data Envelopment Analysis (DEA). The DEA technique was initially used in nonprofit organizations (e.g. schools and hospitals) given the fact that it can deal with various inputs and outputs expressed in different units without requiring a normalization process, namely the homogenization through prices. Private sector companies have also began to adopt this methodology and the DEA technique has quickly been adopted in many fields, showing its versatility.

For instance, Gorman and Ruggiero (2008) applied this methodology to evaluate state police performance. Bougnol et al (2010) also demonstrated the advantage of using DEA models for ranking the world's nations using the HDI indicators. Zhu (1998) illustrated the potential of this method in an urban context, presenting a study on the economic performance of Chinese cities. Its ability to handle multiple inputs and outputs can give fundamental contributions to help local policy-makers to achieve better performance. The application of DEA to social indicators can be tracked back to, at least, 1993, with the work of Hashimoto and Hishakawa (1993) on the measurement of Japanese society through negative and positive indicators. They analyzed the desirability of living in 47 prefectures of Japan, showing the potential of DEA in multidimensional evaluation analysis other than the standard DEA efficiency analysis. It was argued that DEA avoid uniform evaluation by an *a priori* weighting system, and therefore is a comprehensive evaluation tool different from traditional ones.

There are few experiences of measuring QoL with DEA, but the methodology has proved to provide interesting results, such as in work of Zhu (2001) and Hashimoto et al. (2009). The work by Hashimoto et al. (2009) presented a Data Envelopment Analysis/Malmquist index (DEA/MI) approach to analyze the change in quality-of-life in Japan's 47 prefectures for the period 1975–2002, having identified significant movement in the country's overall QoL using a “cumulative” frontier shift index. Zhu (2001) also applied DEA to the 20 winning cities of the magazine *Fortune*’s ranking.

1.3. Purposes of the research

The first aim of this work is to develop models to evaluate urban QoL. These models should provide an evaluation that is synthetic, easily transposable to different cities and replicable over time. These models should also allow to find good practices in the promotion of urban QoL.

The second objective is to provide an evaluation of local management in the promotion of QoL. By incorporating information on the resources that each city has, the model should assess the efficiency of local management in supporting QoL, as well as detect good practices.

The final objective is the evaluation of local management in the perspective of citizens, by identifying what factors citizens perceive as drivers of QoL.

Given these objectives, the expected results are as follows:

1. The development of a composite indicator for the evaluation of urban QoL, using quantitative data collected systematically by national statistics institutes;
2. A benchmarking tool to find good practices in urban QoL, enabling the identification of the best and worst QoL dimensions for each city, and the identification of benchmark cities that can be considered as examples to follow in terms of QoL;
3. The construction of a ranking of urban QoL for European cities, using a consensual system of weights, common to all cities compared;
4. The construction of a composite indicator of QoL in the perspective of qualified human resources. This QoL assessment should use the same framework as points 1 and 2 previously described, except that the weights assigned to each QoL dimension must take into account the perspective of these stakeholders, which are essential for cities competitiveness;
5. An assessment of local managers performance in the promotion of QoL, given the economic wealth of the country.

6. The identification of factors that citizens associate with good local management for the promotion of QoL.

1.4. Summary of the thesis

This thesis is structured as follows: chapter 2 will discuss the concept of urban QoL, its dimensions and measurement experiences, following a review of the state-of-art. This chapter also includes an overview of the Urban Audit, a project of the European Commission that provides extensive data on urban QoL for 284 cities.

Chapter 3 presents the methodology used to assess urban QoL, which is based on the Data Envelopment Analysis technique. A review of the literature concerning DEA performance assessment models will be presented. This chapter also explores the literature on the construction of composite indicators, focusing on the contributions of the DEA technique to this topic.

Chapter 4 presents the composite indicator constructed with DEA, and discusses the data used and the results achieved. Firstly, an assessment of QoL in European cities is presented, identifying the strengths and weaknesses of each city. For this purpose, the cities are first assessed using a system of weights that allows for specialization policies, such that each city can select its own weights for the QoL evaluation. This is followed by the identification of a consensual system of weights, such that QoL can be evaluated using comparable standards, which allows presenting a ranking of European cities QoL.

In chapter 5 we propose the analysis of urban QoL in the perspective of qualified human resources by presenting another composite indicator whose weighting assumptions follow the framework provided by the consulting firm Mercer. The cities considered benchmarks from the perspective of qualified human resources are identified, providing examples of good practices that non-benchmarks cities should reproduce in order to improve QoL and competitiveness.

Chapter 6 analyses the efficiency of cities management in the promotion of QoL, given the wealth of the country (proxied by GDP *per capita*). This evaluation looks at the achievements of cities in terms of urban QoL, as in the previous chapters, but also incorporates in the assessment the economic context of the country.

In chapter 7, we use perceptions surveys conducted in European cities to identify which policies of urban local management citizens associate with good practices in the promotion of QoL. The purpose is to identify which are the factors of urban QoL that explain residents' perception on the responsible expenditure of cities. By judging if the expenditure of their city is responsible or not, residents are judging local management in what concerns the improvement of their QoL. We develop an explanatory model, based on logistic regression, of the perception of citizens on cities' expenditure by identifying the factors (such as culture, availability of sports equipments, functioning of public services, among others) citizens value when establishing that judgment.

Conclusions and suggestions for future research are presented in chapter 8.

2. Understanding Quality of Life

This chapter discusses the academic and empirical approaches to QoL, showing the ongoing debates on the theme and exploring some of the empirical and theoretical experiences. Research and theoretical considerations on urban QoL are presented, as well as the discussion over the concept and its dimensions. We then explore some empirical approaches to QoL measurement, highlighting some of the most debated issues. Studies previously undertaken are presented in order to provide a comprehensive insight to this field of research and to identify gaps that might be addressed. The Urban Audit project is presented in more detail, as it will provide the data and empirical foundations for our analysis.

2.1. The concept of Quality of life

It is obvious from a first analysis of the scientific discussion in this field that it is difficult to define the concept of QoL, since it has not yet stabilized in the literature. There is no agreement on the terminology, underlying methods of evaluation or criteria that comprise QoL (Mitchell, 2001). “Literature has presented more than 100 definitions of life quality” (Yuan et al., 1999: 3). Efforts to reach a consensual definition did not fully succeed and therefore “the absence of a generally accepted framework for QoL research is acknowledged as an obstacle to progress” (Pacione, 2003a: 2). Although a total agreement on what constitutes QoL has not been reached so far, some consensus has been established on the fact that “QoL usually refers to the degree to which a person's life is desirable versus undesirable, often with an emphasis on external components, such as environmental factors and income" (Diener, 2006: 401).

This discussion mirrors the fact that QoL is a multifaceted concept, embracing “not only the material aspects of life such as level of living, availability of physical and social infrastructural facilities but also the less tangible aspects of life such as good health and opportunities for recreation and play”, with some researchers even “including basic elements of life like rights, privileges and decision-making role of people in a society” (Yuan et al., 1999: 3).

While QoL is, in some approaches such as the one proposed by Mitchell (2001), a set of factors such as health, physical environment, natural resources, personal development and safety, for other researchers economics is seen “as one of the three major pillars of quality” (Kamp et al., 2003: 9), along with health and physical environment.

The fact that QoL is a multidimensional concept is also visible in the historical construction of the concept. Philosophy and health related fields have been addressing the concept of QoL (as a synonymous to happiness or wellbeing) for a long time back to ancient Greece, but other disciplinary fields, like psychology or economics, have more recently focused their research in measuring and assessing QoL (Sirgy et al, 2006). From a sociological perspective, the first studies on QoL can be traced back to the early 40’s in an article by Cottam and Mangus (1942) and measures of QoL began to be introduced into surveys in the 1970 and 1980, but the issue of QoL is not a mainstream theory yet in the discipline (Sirgy et al., 2006). None of these disciplines, of course, can by itself tell the whole story of QoL research, because the concept is not fully embraced by a unique academic field given its multidisciplinary nature.

Although these previous references allow us to reach a concept of quantitative nature, some authors defend QoL as a mainly subjective concept. This is the case of the definition proposed by the WHO-QOL group in 1993, which argues that QoL is “an individual’s perception of his/her position in life in the context of the culture and value systems in which he/she lives in relation to his/her goals, expectations, standards and concerns” (WHO, 1997: 1). Some authors, such as Diener and Suh (1997) and Raphael et al. (1996), have presented QoL as life satisfaction and others as the degree to which a person enjoys the possibilities of his/her life (Kamp et al., 2003).

Also the report on the Measurement of Economic Performance and Social Progress, prepared by the Stiglitz Commission in response to the French president Nicholas Sarkozy's unsatisfaction with the use of GDP as a single measure for the well-being in societies, asserted the importance of both objective and subjective components of well-being, recommending that "steps should be taken to improve measures of people's health, education, personal activities and environmental conditions. In particular, substantial effort should be devoted to developing and implementing robust, reliable measures of social connections, political voice, and insecurity that can be shown to predict life satisfaction" and that "statistical offices should incorporate questions to capture people's life evaluations, hedonic experiences and priorities in their own survey" (Stiglitz et al., 2009: 15). In other words, a "thorough understanding of subjective well-being requires knowledge of how objective conditions influence people's evaluations of their lives" and that "similarly, a complete understanding of objective indicators and how to select them requires that we understand people's values, and have knowledge about how objective indicators influence people's experience of well-being" (Diener and Suh, 1997: 214).

There have been many attempts to measure QoL and a list of 22 indexes is explored by Hagerty et al. (2001) discussing their advantages and limitations. This article concludes for the great variety in coverage and definitions of QoL and for the absence of full convergent validity between indexes. Even if it is not possible to reach a general agreement on a definition and measurement of QoL, this issue should not be overshadowed by a never ending controversy. Growth of scientific research in the field is expected as well as of political pressure to force public officials to address QoL issues (Sirgy et al., 2006). So, although the variety of understanding and experiences can be great, measurements exercises are possible, since "within a context, that is, a given time, place and society, some agreements can usually be reached on what would constitute QoL" (Yuan et al., 1999: 3).

2.2. The dimensions of Quality of Life

When going from the concept to a real-world analysis, we realize that the complexity of QoL is expressed in the diverse dimensions that are chosen by researchers. When exploring QoL as an empirical concept that can be operationalized in the urban context, studies have presented different dimensions and indicators, a diversity explained by different understandings on what constitutes QoL but also by the diverse focus of the research developed.

This is not only an academic problem, but also a political one. Policy-makers are also interested in defining the factors of satisfaction that their policies may alter, driving researchers to study in what way satisfaction is influenced by various objective conditions. The Stiglitz Commission, for instance, identified the following key-dimensions to QoL: material living standards (income, consumption and wealth); health; education; personal activities including work; political voice and governance; social connections and relationships; environment (present and future conditions); insecurity, from economic or physical nature. "All these dimensions shape people's well-being, and yet many of them are missed by conventional income measures" (Stiglitz, 2009: 14-15).

The growing interest of urban planners and decisors in this matter can be explained by the fact that "QoL is increasingly considered a crucial element of urban competitiveness and growth" (Lambiri et al., 2007: 4). Thus, research on QoL has also increasingly focused in its urban aspects, and the dimensions chosen for the studies reflect this focus.

Direct approaches to QoL assessment differed from place to place. Some proposals from New Zealand (Bigcities, 2003) have specified several dimensions, including demography, knowledge and skills, health, safety, housing, social connectedness, civil and political rights, economic standard of living, economic development, the natural environment and the built environment. In Canada, in the city of Winnipeg, five dimensions were chosen to express the factors that influence QoL: individual well-being, urban economy, urban environment, community assets, community leadership and pride (IISD, 1997). In the Urban Audit program (www.urbanaudit.org) – the study of QoL promoted by the European Union – the definition of the relevant dimensions to evaluate QoL has been subject to an intensive research effort, resulting in the specification of nine dimensions: demography, social aspects, economic aspects, civic involvement, training and education, environment, transport and travel, culture and leisure, innovation and technology.

The variety of understanding and experiences is vast, but measurement exercises have become possible since "within a context, that is, a given time, place and society, some agreements can usually be reached on what would constitute QoL" (Yuan et al., 1999: 3). From the analysis of these references it is possible to realize that a sort of central core for research has been constructed: the studies undertaken have been focused in a similar set of equivalent dimensions, such as health and economics, that may then be enlarged to a wider conception that reveals a different understanding of QoL. For example, it can be more focused on individual or collective life of the population (such as the New Zealand study and the Urban Audit, in a certain way) or more directed to urban aspects of space enjoyment.

2.3. Measuring Quality of Life – Identifying opportunities for research

Several experiences of QoL measurement have been constructed in the last decades. In this section, we will look at some of the empirical approaches to QoL, exploring the aims, scope and models used in the studies, as well as the nature of the data they relied on. The analysis of existing research in the field provides useful insights on key issues, as well as gaps in the research that could be addressed, namely in what concerns the adoption of weighting system for the dimensions of QoL, the scope of analysis and temporal framework.

2.3.1. Urban Quality of Life in perspective

Cities are the place where most citizens now live. The increased interest in the study of QoL in the cities as explained by Seik (2001:1) is that "it is inevitable that as cities move forward into the 21st century, urban QoL studies will increasingly become important tools for planning and managing liveable, viable and sustainable cities". Projects now actively pursued by researchers reflect "the response of urban professionals and institutions of urban residents to achieve a better QoL" (Seik, 2001: 2).

However, the literature has presented different meanings for QoL. In the urban context, agreement in terminology has not been reached: "Concepts as livability, living quality, living environment, quality of place, residential-perception and satisfaction, the evaluation of the residential and living environment, QoL and sustainability do overlap, and are often used as synonyms – but every so often are contrasted" (Kamp et al., 2003: 6). However, research has grown, also because "whatever is the definition of QoL, the contribution to people's life is important", since "from the planners point of view, cities are the center of economic, politics, commerce and other activities" (Türksever and Atalik, 2001: 165).

Different levels of analysis of QoL can be presented, from the neighborhood (for instance, Bonaiuto et al., 2003) to supra-city or regional level (such as González et al., 2010; Hashimoto and Ishikawa, 1993). González et al. (2010) applied DEA to evaluate to what extent QoL conditions in a given Spanish municipality is explained by the province and region in which the municipality is located. This research used 19 variables that were weighted using a refinement of DEA: the Value Efficiency Analysis, where an expert is asked to select, from the unit located in the frontier, his most preferred unit (municipality), which is incorporated in the model as a reference to underly the QoL evaluation. In a work aiming to analyze the desirability of living in the 47 prefectures of Japan, Hashimoto and Ishikawa (1993) used as input and outputs of the DEA models negative and positive social indicators and identified 26 desirable prefectures. The authors concluded that DEA, which can avoid uniform evaluation by an *a priori* weighting system, proved to give comprehensive evaluations. Hashimoto et al. (2009) also applied DEA, combined with the Malmquist Index, to analyze the change in Japanese prefectures' QoL from 1975 to 2002, identifying significant movements. It was concluded that the use of both upper- and lower-bound DEAs has enabled an evaluation of both "good" and "bad" movements in QoL.

Most studies have, however, focused on the city level. The lack of consensus has not stopped the research and multiple experiences of measuring QoL have taken place under the umbrella of urban context (whether the terminology used is city or community). Sirgy and al. (2004) and Sirgy et al. (2009) have presented a collection of studies on urban QoL, showing that the assessment is widespread. Measurement experiences have taken place all over the world, from American cities like Jacksonville, Boston and Seattle, to Asian contexts like Hong Kong, passing through cities in European region, like Amsterdam (Netherlands), Zurich (Switzerland), Florence (Italy) and others. These studies have relied on different methodological approaches, with a focus on subjective assessment, based on surveys to residents and the use of objective data. Many of these studies resulted from the collaboration between local universities and city councils.

Several experiences reported also the involvement of local stakeholders and experts. According to Sirgy (2010), most of these studies, however, suffer from a constrain in terms of their theoretical relevance, as they are built in a bottom-top approach, meaning that they rely in a methodology simply based on listening community residents and community stakeholders to identify which indicators to measure. The lack of a theoretical framework does not allow to give meaning to this system. This is why projects for assessing QoL in a given community should be grounded in theoretical concepts. Sirgy (2010) identify six fields (socio-economic development, personal utility, just society, human development, sustainability and functioning) in which indicators can be framed in order to allow researchers to develop and recommend meaningful public policies.

This means, for instance, that if a project is framed within the socio-economic development theory, on the assumption that economic development will bring social development, the choice of indicators will be guided by economic data (Sirgy, 2010). So, since recent theories on urban economics have focused on QoL as a key-factor to attract highly skilled workers, projects following this theoretical line should focus on indicators important to this human capital.

Another important aspect to deepen when studying urban QoL is the fact that research has increasingly adopted a double perspective, by focusing on the perception of residents as well as on objective data. Both approaches, quantitative and qualitative, have been fruitful to research and presented as essential to understand QoL by researchers in USA and Europe (Türksever and Atalik, 2001: 165-166).

2.3.2. Objective and perceived data in Quality of Life

Research on urban QoL has, in many cases, been based on objective data, such as the one collected in census, crime statistics, economic measures and health indicators. These studies (see, for example, Marans, 2003; Santos and Martins, 2007; or Big Cities, 2003) have allowed to characterize urban QoL in cities using a quantitative approach. But studies have also increasingly focused the efforts on listening to citizens in order to assess their perception of QoL. This approach that does not ignore the fact that objective data is also important for a more comprehensive understanding of the concept, but seeks to interact with the subjective nature of the concept (that is, the perception of citizens).

Marans (2003: 73) argues in favor of the importance of a “systematic study of the interrelationships between objective measures of environmental phenomena and people’s responses to them”. A consensus is growing on the fact that “it is axiomatic that in order to obtain a proper understanding of urban environmental quality it is necessary to employ both objective and subjective evaluations”, meaning that “we must consider both the city on the ground and the city in the mind” (Pacione, 2003b: 20). Typically, studies of perception – that is of the appraisal concerning QoL factors provided by a sample of citizens in a given city – have evaluated three kinds of opinions: satisfaction (with a given domain expressed in sentences), agreement (to sentences expressing feelings over the city conditions) and intensity (of feelings regarding the various domains of the city conditions).

Marans (2003) proposed a working model for establishing and studying the relationship between objective data on the variables selected to measure QoL and the subjective assessments, considering that there are opportunities to explore the relationships suggested by the models using bivariate and multivariate analysis. Relationships to be studied could be determined by local decision makers, such that this kind of research would be able to satisfy "the informational needs of the policy makers and planners" (Marans, 2003: 81).

Using the example of the Detroit Area Study (DAS) in 2001, conducted by the University of Michigan, Marans (2003) advocates the opportunity that scientific research has in documenting QoL, by measuring objectively the environment and how it is experienced by residents. With the aim of providing correct and credible information to public authorities on the quality of community life, as well as of determining the degree of correspondence between public perceptions and the environmental and community conditions, the DAS consisted of an annual questionnaire and secondary information sources such as census, crime statistics and health data.

Sirgy et al. (2010) presented a new measure of community well-being, framed within a theoretical approach in life satisfaction named bottom-up spillover. This approach states that life satisfaction is functionally related to satisfaction with all of life’s domains, meaning that life satisfaction is on the top of a hierarchical function being influenced by satisfaction in lower stages. The measure is presented in 14 domains through which community conditions and services impact resident’s overall life satisfaction. A survey conducted in the Flint area (Michigan, USA) showed that the perception over these life domains influences residents’ overall perception of community well-being, their commitment to the community and their overall life satisfaction.

The also mentioned Project Big Cities (Big Cities, 2003), from New Zealand, uses secondary sources of objective data and conducts a survey among the population of the cities studied, attempting to assess the perceptions of residents on eight factors: QoL; health and wellbeing; crime and safety; community, culture and social networks; council processes; built and natural environment; public transport; lifestyle – work and study.

Using surveys of local citizens to assess subjective aspects of QoL is an established practice of studies in the area, although the purposes of the survey may vary. In some studies, such as the Urban Audit surveys, the objective may be to gather citizens opinions. Other studies have used the perception of QoL indicators to compare to objective data, as the work of McCrea (2007) and also Santos and Martins (2007). In Porto (Portugal), Santos and Martins (2007) pointed out that listening to citizens could provide ground to assign different levels of importance to different domains of QoL. The study conducted in Porto defends the relevance of subjective assessments by the fact that they allow a more integrated view of what constitutes QoL, given the difficulties to obtain an index from objective data. Finally, the justification for considering the perceptions of citizens lies also on a deeper understanding of local conditions. Santos and Martins (2007) found a significant association between the objective conditions of QoL and the perceptions of citizens, except for the areas of crime and urban security, as well as sports facilities and health care.

Senlier et al. (2009) have used Urban Audit data to compare perceived QoL in Kocaeli (an important industrial Turkish city) with satisfaction in European cities, using data provided by the Urban Audit. They stated that the Turkish city is “the city that inhabitants are least satisfied to live in” (2009: 225) and consider that internationally accepted subjective indicators should guide policies as well as spatial development strategies.

Other studies such as Myers (1987) and Ulengin et al. (2001) used population surveys to assign different weights to the objective components of QoL, which opens a vast field of discussion, as explored in the following section.

2.3.3. Weighting the dimensions

Being a multidimensional concept, QoL offers a fertile ground to discuss the different importance attributed to the factors of QoL, expressed by the differential weighting of dimensions in the final assessment of QoL.

Weights are then a central issue when evaluating QoL. In research that has been carried out in the field, factor analysis has been explored, such as in Senlier et al. (2009) and in Tesfazghi et al. (2010), but weights have been mainly defined by experts, politicians or citizens. This is the case of Ulengin et al. (2001), that developed a study aimed at determining the weight of the different attributes of QoL given by the inhabitants of Istanbul. Since the work of these researchers answered to the purpose to make policy recommendations to local decision makers, the attributes chosen to be valued by the people were the ones that could be manipulated by the authorities. The survey showed preference for opportunities to find satisfactory employment, municipal services and adequate infrastructure, low fluid level of traffic and living accommodation.

Myers (1987; 1988), who assessed the QoL in Austin (Texas), conducted a survey to citizens with the aim to confirm the assessment of objective trends. On one hand, the results of this consultation led to validate the estimates made in the objective analysis and, on the other hand, allowed the assignment of weights to the different components of a comprehensive assessment of QoL. The results have demonstrated that perceptions of citizens have a strong parallel with the trends measured in objective data. According to citizens, urban concerns like crime, cost of living, schools, jobs and transit issues are more valued than leisure, shopping and entertainment opportunities.

Weighting is also an essential issue when QoL is expressed in a final unique score, as in the form of a composite index. Sirgy et al. (2010), for instance, have proposed the construction of a measure of community well-being in the form of a composite index by averaging the composite scores of 14 individual life domains. Equal weighting of all dimensions is also the option in the Human Development Index (HDI), the most consolidated composite indicator for QoL. Developed by United Nations, the HDI provides a score for countries through the arithmetic sum of three dimensions: education, longevity and standard of living.

Zhu (2001) proposes the development of a multidimensional measure to characterize QoL, applied to the 20 best cities chosen by the Fortune magazine, using DEA. This study showed that DEA can be used when information on how to weight multiple factors is not clear or it is even unknown, by allowing flexible weighting systems that may also reflect expert opinion or value judgment. Another contribution of the study is that it “also offers a way to identify critical QoL factors for a given city” (2001: 282), thus providing relevant information for maintaining a best QoL status.

Some publications have provided rankings of QoL, mostly related to countries. One of them is the International Living, but the most well-known is probably the ranking constructed by The Economist, that has published an index for “Quality of life”, covering 111 countries in 2005, combining data from life satisfaction surveys with objective data. This index relies in nine dimensions (material wellbeing, health, political stability, job security, family relations, community life, climate and geography, political freedom and gender equality) and their weights were derived from the regression coefficients. The dimensions considered the most important were health, material wellbeing, and political stability and security. These were followed by family relations and community life.

Hagerty et al. (2001) reviewed 22 indexes of QoL, considered to be the most used, and studied their validity and usefulness. It was concluded that “many of these indexes are potentially very useful for public policy and planning” and it was also argued that “the component measures are largely reliable and show some convergent validity with other reasonable measures” (Hagerty et al, 2001: 86). However, the assignment of weights to the different components of QoL needs to be addressed more profoundly, because even in indexes that supposedly do not use weights, an equal weighting system is, in fact, implicitly assumed. Hagerty et al. (2001:84) propose “using two advanced statistical methods to improve weighting – two-stage factor analysis and conjoint analysis" to provide insights into the relative importance of dimensions.

There is not a single approach to this question, as there is not a single understanding of QoL. In fact, what constitutes QoL is, ultimately, an individual conception, but different perspectives, understood as the perspectives of different social groups, can be assessed incorporating in the analysis the importance they attribute to the different dimensions of QoL. This is the case for the composite indicator provided by Mercer, that assesses QoL according to the importance qualified human resources attribute to the different dimensions comprised in the concept. The annual report presented by this firm (that will be explored in more detail in chapter 5) is used by companies all over the world to compensate expatriate workers.

2.3.4. Urban QoL evaluation studies – addressing the gaps in research

In the literature, we can find several examples of QoL evaluation in urban settings. A summary of some studies, identifying their aims, methods and results, is presented in Table 2.1. The purposes of these studies vary, although most of them focus mainly on selecting indicators for measuring QoL (such as in IISD, 1997), monitoring urban conditions in terms of QoL (as in Santos e Martins, 2007; Senlier et al., 2009; Tesfazghi, 2010), and identifying citizen's preference or priorities in QoL factors (such as in McCrea et al., 2005). When looking for factors influencing QoL and their importance in the balance of dimensions, the majority of studies (such as in Ulengin et al., 2001; IISD, 1997) has chosen to listen to citizens or experts.

Endogenous weighting of the different dimensions, without relying on "external" assignments (such as the ones provided by citizens, experts or local decisors), is not a common practice. In line with Hagerty et al. (2001) recommendation on the use of statistical methodologies, more recent studies, such as Senlier et al. (2009) and Tesfazghi (2010), used factor analysis.

However, there is still much space for a more comprehensive approach to this issue, exploring new methodologies.

Most studies have also concluded that the use of both objective and subjective approach is needed, namely bringing together quantitative data and perception studies. The techniques used are mostly statistical, applied to objective data and surveys. The methodologies used are diverse: from administration of surveys (Myers, 1987; Marans, 2003; Santos e Martins, 2007) to regression (McCrea et al., 2005; Senlier et al., 2009) and multivariate analysis techniques (Ulengin et al., 2001; Senlier et al, 2009; Tesfazghi, 2010). In what concerns temporal approach, some studies considered a single measurement moment (e.g. Santos and Martins, 2007), but others have been repeated over time, assessing changes and trends of evolution (like in Winnipeg or in the Big Cities project). The latter were mainly conducted by city councils or national entities.

On the other hand, only the cities – for instance, Detroit (USA), Brisbane (Australia), Istanbul (Turkey), Porto (Portugal) or Kirkos (Ethiopia) – that are studied can benefit from the study as these are locally focused. The opportunity of cities learning from each other, in their experiences to improve QoL, is not yet discussed in a generalised way. Best practices are, in the context of these studies, not easily transposable and copied, because the framework in which cities' conditions are assessed is different among studies.

Another limitation of these studies is that they are centred in only one city, except for the Urban Audit program, the Big Cities project, the Mercer report, Sufian (1993) and Zhu (2001) research. The scope of the analysis is then reduced and a vast intervention in the field, focusing on large regional areas, is in need.

Table 2.1.- Some experiences on measuring urban QoL

Studies	Place	Aims	Methods	Period studied	Results
IISD (1997)	Winnipeg	Development of community indicators for QoL	Experts reasoning with the participation of local stakeholders	1997	List of QoL indicators, classified in five dimensions
Marans (2003)	Detroit – Detroit Area Study 2001	Examine a range of issues(such as transport, neighborhood, parks, housing and open space) associated with the lives of people in Detroit	Multivariate analysis to survey and objective data from secondary sources of information (geographical information system and census)	DAS range from 1951 to 2004, but only the 2001 specifically reflect on QoL	(Results not ready at paper time)
McCrea et al. (2005)	Brisbane - South East Queensland (Australia)	Test links between urban residents' assessment of various urban attributes and their level of satisfaction in three urban domains-housing, neighborhood or local area	Path analysis (correlation matrix) and regression applied to data collected in surveys	1997	Identification of primary factors underlying overall satisfaction as being living material concerns like the cost of living and the provision of services; neighborhood satisfaction is not an important indicator of overall life satisfaction
Big Cities (2003)	Initially six, now including twelve of the biggest cities in New Zealand	Provide information to decision-makers to improve the QoL in major New Zealand urban areas	Surveys and data from secondary sources (councils, government agencies, etc.)	2001, 2003, 2007, 2010	Monitoring system of urban QoL that identifies urban issues and trends by setting a database of 68 indicators of QoL across 11 domain areas
Santos and Martins (2007)	Porto (Portugal)	Create a monitoring system of urban QoL	Results of survey to citizens, compared to statistical indicators	2003	High correlation of quantitative and qualitative approaches

Studies	Place	Aims	Methods	Period studied	Results
Pacione (2003)	Glasgow (Scotland, UK)	Development of a five-dimensional social geographical model for the measurement of urban QoL	Univariate analysis and principal component analysis to data from national census	Not specified	Identification of the nature, intensity and incidence of multiple deprivation within the city
Ulengin et al. (2001)	Istanbul (Turkey)	Model priorities, expectations and needs of inhabitants	Surveys submitted to modeling with Hierarchical Information Integration and conjoint analysis – multivariate analysis technique	Not specified	Identification of high opportunity of finding satisfactory jobs as the most preferred factor by citizens in evaluating urban QoL, followed by adequate infrastructure, rapid traffic flow and low cost of living and accommodation
Myers (1987)	Austin, Texas (USA)	Argue for the need of internal monitoring of QoL to identify local trends	Survey	1984	More highly educated citizens are more likely to perceive a decline in the community's QoL and to plan departure; employee retention is harmed by negative trends in QoL.
Zhu (2001)	20 best cities of Fortune Magazine (15 American and 5 abroad)	Develop a multidimensional measure to characterize the QoL and identify its best-practice frontier	Starting from the 13 factors analyzed by Fortune, DEA was applied with six inputs (negative evaluation items) and six outputs (positive evaluation)	1996	Development of a multidimensional QoL measure without a priori knowledge of factor relationships and identification of critical factors of QoL.
Türkesever and Atalik (2001)	Istanbul (Turkey)	Test measurement methods of QoL	Survey to residents on 18 attributes of QoL to which multiple linear regression was applied	Not specified	Identification of health, climate, crowding, sporting, housing conditions, travel to work, environmental pollution as major determinants of the satisfaction level
Senlier et al. (2009)	Kocaeli (Turkey)	Measure local perceptions of QoL and compare life satisfaction with the European cities	Survey to residents (following Urban Audit questions) + factor analysis and regression analysis	Not specified	Identification of security as the factor with the highest effect, followed by educational facilities, neighborhood relations, quality of environment and public transport

Studies	Place	Aims	Methods	Period studied	Results
Tesfazghi et al. (2010)	Kirkos sub-city of Addis Ababa (Ethiopia)	Measure QoL and its variability at small scale	Coefficient of variation applied to survey to residents and factor analysis applied to secondary data	2008	Large scale study can hide the variability of QoL at small scales
Sufian (1993)	World largest metropolitan areas – 98 cities (45 Countries)	Identify most discriminant factor in QoL based on the Urban Living standard index (Population Crisis Committee) in order to target action for QoL improvements	Discriminant analysis to nine indicators (public safety, food cost, living space, housing standard, communication, education, public health, peace and quiet and traffic flow)	1990	Identification of food as the most discriminant variable, followed by communication facility
Sirgy et al. (2010)	Flint Michigan (USA)	Develop a new measure of community well-being	Composite index constructed by averaging composite scores of 14 individual life domains, obtained from four surveys.	1978, 1990, 2001, 2006	Individual life domains influence resident's perception of community well-being, their commitment to the community and their overall life satisfaction
European Commission (2007)	European cities – Urban Audit	Collection of comparable statistics and indicators of QoL for European cities	Variables structured in nine dimensions of QoL and objective data collection (by national statistical offices) and subjective data collection (surveys)	3 campaigns (2003, 2007 e 2009) following pilot-project in 1999	A database of 396 variables for 284 cities, considering objective data, and of 29 variables for 75 cities, considering subjective data
Mercer (2010)	Worldwide	Present a ranking of cities intended for use by multi-national organizations and government agencies for expatriate compensation of employees	Quantitative assessment based on experts and consultants opinion on ten dimensions, weighted according to a framework resulting from a survey to highly qualified employees	Annual	A ranking of 309 cities

The Urban Audit project is somewhat different from the previous experiences described. In first place, it is a systematic study, meaning that data collection is repeated over time, allowing the construction of a time series. On the other hand, because this project aims at gathering comparable data, it allows comparisons between European cities in several different issues. However, the Urban Audit project does not include an analytical effort to synthesise the data and provide concise views of the cities that could allow readings more direct and with objective policy purposes. The data gathered is, to our knowledge, not fully explored, but presents an opportunity to be addressed the research described in this thesis.

2.3.5. The Urban Audit Project and its city profile

The Urban Audit Project is a program of the European Commission that aims to characterize the QoL in European cities. This program collects objective data, from national statistics offices, for all the cities involved in the study, and subjective data from surveys administered in a sample of cities. Objective data is currently structured in nine dimensions (demography, social aspects, economic aspects, civic involvement, training and education, environment, transport and travel, culture and leisure, innovation and technology). Each dimension includes several variables, totalizing 336 variables (see appendix A). Subjective data is collected by hearing citizens on their satisfaction towards several factors of QoL.

The Urban Audit program gathers information about cities, in a systematic and exhaustive way, being the most important initiative in the area in Europe and aiming to guide the definition of public European policies. The data collected for several urban aspects is classified in distinct variables, stressing disparities between cities, which is useful, and even crucial, to political decision-making. As explained in the website of the project (www.urbanaudit.org), this project responds to the fact that “QoL is crucial in attracting and retaining a skilled labour force, businesses, students, tourists and, most of all, residents in a city” making the assessment of current situation "a prerequisite for any improvement, development and future monitoring".

The Urban Audit started as a pilot study, in June 1999. At that time, the European Commission conducted a data collection of comparable indicators in European cities, where 450 variables were collected for the 58 largest cities. The cities included in the Urban Audit pilot phase were identified by the European Commission on a systematic and objective base: largest cities (ordered by population size) within the European Union (EU) member states (except London and Paris), as well as some cities from the smaller EU countries in order to ensure a good geographical representativeness across the EU. During the Urban Audit pilot phase, the data collection was first 'tested' in two cities: Bilbao (Spain) and Nuremberg (Germany). This pilot study included a list of 450 indicators regrouped in 21 domains: Population, nationality, household structure, labour market and unemployment, income disparities and poverty, housing, health, crime, employment, economic activity, civic involvement, levels of education and training (provision), levels of education and training (stock), air quality and noise, water, waste management, land use, travel patterns, energy use, climate /geography, culture and recreation (http://ec.europa.eu/regional_policy/urban2/urban/audit/src/ intro.html).

This study was remarkable for the fact that it showed, for the first time "the feasibility of obtaining and presenting information on a pan-European basis for a wide range of indicators at the town/city administrative level, as well as at the levels of the wider urban area and sub-city areas" (European Communities, 2004: 5). The directorate-general of the European Commission DG REGIO concluded then for the usefulness of Urban Audit as a "required tool for decision-making at European, national, regional and local level" (European Communities, 2004: 5).

Following this pilot study, the first full-scale European Urban Audit took place in 2003, for the then 15 countries of the European Union. In 2004, the project was enlarged and included the 10 new Member States plus Bulgaria, Romania and Turkey. The Urban Audit project involves all national statistical offices, as well as some of the cities themselves, and is coordinated by Eurostat. The second full-scale Urban Audit campaign took place in 2006 and 2007, and involved 321 European cities, in the 27 countries of the European Union, along with 36 additional cities in Norway, Switzerland and Turkey. Data collection currently takes place every three years, but an annual data collection is being planned for a smaller number of targeted variables (www.urbanaudit.org).

The project raised some methodological questions regarding variable definitions and estimation methods, that were addressed by an expert team of senior statisticians that assisted Eurostat and the National Urban Audit Coordinators in their tasks (European Communities, 2000: 6). For instance, the concept and definition of town/city needed refinement in order to present comparable urban indicators and two geographical units were initially identified: the administrative town/city and the functional urban region of the town/city – this including urban areas and their surroundings, which have some impact in terms of commuting, job concentration, traffic systems. Besides these two spatial levels (the town/city and the larger urban zones), a third one was identified: the sub-city districts.

In most cases, the data used by Urban Audit was obtained from censuses, different administrative and statistical registers and national and local databases. For the cases in which data was only available for a sample survey or did not comply with the definitions, statistical estimation methods needed to be applied to overcome the gaps in the database. In the Urban Audit project, different estimation methods have been used, with different levels of technical complexity: from “pragmatic” methods (where expert knowledge on local conditions has been incorporated within the estimation procedure) to computational tools for statistical estimation, no unique solution was adopted (European Communities, 2004: 54).

In 2007, the European Commission commissioned a report on the state of European cities based on the Urban Audit data. The document “has sought to exploit the wide range of data gathered by the Urban Audit as far as possible. It draws on key elements of the data set in chapters on population change, urban competitiveness, living conditions and the administrative power of cities” (European Commission, 2007: i). The conclusions of the report allowed the characterization of European cities. In what concerns population, for instance, it states that “in the period 1996-2001, a third of cities grew at a rate in excess of 0.2% per year, a third saw their populations remain stable and a third experienced a notable decline in population” and that “in general, Urban Audit cities in the Nordic countries grew at substantially faster rates than the national populations in the countries in question” (European Commission, 2007: ii). Concerning the economic aspects of cities, the document refers that “only 28% of Urban Audit core cities have employment rates higher than the average for the country where they are located (corresponding to 33% of all Urban Audit city residents)” and that “employment rates are particularly low (less than 50%) in many Polish, Belgian and southern Italian cities” (European Commission, 2007: vi). The analysis of cities competitiveness in an economic perspective shows that “most of Europe’s high performers are located in the north and the center of the Union” (European Commission, 2007: vii).

The website of Urban Audit is the interface with the public and provides information on each city including in the study, whether by providing a City Profile or by providing a comparison of cities for each of the variables considered. Partial datasets for each city are also available in the website, as well as the information on the structure of the city. The system also allows to construct partial rankings of the cities, but only for one variable each time and for different groups of cities, as shown in the example reproduced in Table 2.2.

For each city, the Urban Audit program establishes a city profile. This is a document produced for each city summarizing the most relevant variables to the public and its relative importance (identifying in which percentile is the city considered) in the total set of the cities. It includes a subset of aspects of QoL organized in seven of the nine dimensions considered in the Urban Audit Program, i.e., demography, social aspects, economic aspects, civic involvement, training and education, environment, transport and travel. Culture and leisure, as well as innovation and technology, are not part of the actual city profile designed by the Urban Audit, although the reasons for this decision are not

Table 2.2. – Example of rankings provided by Urban Audit site

Proportion of registered electorate voting in European elections		
Average : 47.07 High : 88.31 Low : 13.27		
Rank	**City**	**Score**
1	Gent (BE)	88.31
2	Brugge (BE)	87.58
3	Potenza (IT)	85.18
4	Antwerpen (BE)	85.07
5	Luxembourg (LU)	84.22
6	Bruxelles / Brussel (BE)	82.85
7	Bologna (IT)	82.78
8	Liège (BE)	82.67
9	Campobasso (IT)	82.44
10	Namur (BE)	82.28

clear in the presentation of the concept (see www.urbanaudit.org). A document prepared to assist the procedures in Urban Audit campaigns (European Communities, 2000), the Urban Audit Manual, points outs, as a task to the new participating cities, the preparation of a City Profile. This is composed by a qualitative description, prepared initially by the city authority and following a common format, that covers the economy of the city, socio-economic features, cultural attributes and governance. The city profile that is available for each city in the project website presents this description followed by a table with the variables for the seven dimensions mentioned above.

For instance, it can be read in the Porto (Portugal) city profile a text that follows the guidelines proposed by the Urban Audit Manual: "The city of Porto is located in the northern part of Portugal. It is the third largest city in Portugal with a population of 263,000. Porto is a busy industrial and service sector city. Some of the largest companies in the country are located in Porto. The Porto economy is based on the exports of machinery, clothing and other textile products, and port wine. The city has an executive body (câmara

Table 2.3. – City profile example of Porto (Portugal)

	CITY		QUINTILES Comparison with UA cities					
			Low				High	
INDICATORS	YEAR	SCORE	5th	4th	3rd	2nd	1st	CASES
DEMOGRAPHY								
Total resident population	2004	238,954			●			342
Total annual population change over 5 yrs.	2004	-2%	●					247
Percentage of households that are 1-person households	2001	25%		●				297
Percentage of households that are lone-parent households	2001	3%	●					273
Average size of households	2001	2.57				●		181
SOCIAL ASPECTS								
Average price per m2 for an apartment	2004	€1,423			●			150
Average price per m2 for a house	2004	€1,301			●			157
Percentage of households living in owned dwellings	2001	48%			●			305
Percentage of households living in social housing	2001	14%			●			192
Average living area in m2 per person								
Number of recorded crimes per 1,000 population	2004	69.97			●			223
ECONOMIC ASPECTS								
Unemployment rate	2001	9%			●			308
Unemployment rate – female	2001	9%			●			307
Employment rate	2001	64%				●		273
Activity rate	2001	70%				●		307
GDP per head (€)	2004	€13,679		●				148
Median disposable annual household income(€)	2001	€21,120				●		138
Percentage of households receiving less than half of the national average household income								
CIVIC INVOLVEMENT								
Percentage of registered electorate voting in city elections	2004	59%			●			193
TRAINING AND EDUCATION								
No. of children aged 0-4 in day care per 1,000 children 0-4	2001	785					●	234
% of working age population with only primary education	2001	1%					●	175
% of working age population with tertiary education	2001	0%			●			185
ENVIRONMENT								
Summer Smog: No. of days ozone (O3) exceeds 120µg/m3	2001	3		●				221
Number of days PM10 concentrations exceed 50 µg/m3	2001	109					●	201
Amount of solid waste collected (domestic and commercial) - tonnes per capita per annum	2004	0.70					●	237
Percentage of solid waste processed by landfill	2004	4%		●				213
Green space to which the public has access (m2 per capita)	2004	12		●				185
Population density (residents per km2)	2004	5,787					●	265
TRANSPORT AND TRAVEL								
Percentage of journeys to work by car	2001	45%		●				175
Average time of journey to work (mins.)	2001	36					●	177

municipal) and a legislative body (assembleia municipal), both composed of local elected members. Porto is also the capital of Porto district, where a civil governor (governador civil) represents the central government. The Larger Urban Zone (LUZ) includes the city of Porto and the areas of Vila Nova de Gaia, Matosinhos, Maia, Gondomar and Valongo. The LUZ includes over 1 million inhabitants”. This descriptive introduction is then followed with information on the seven dimensions (see Table 2.3).

Besides the objective data and information collected, and to evaluate the subjective perception of QoL by citizens, the Urban Audit has a set of indicators that complement the objective data. This data is obtained from surveys applied to large random samples of inhabitants of the cities studied. Due to the cost of collecting this data, only 31 cities were surveyed in 2003, but in 2006 and 2009 the sample increased to 75 cities.

The first time this evaluation model was implemented, 300 individuals randomly chosen in each of the 31 cities covered by the study were surveyed. In 2006, the number of citizens sampled grew, reaching 500. The last survey kept the number of individuals sampled and the cities involved (75), replacing only the German city of Frankfurt (Oder) by the equally German Rostock. A number of questions were identical in the three surveys, but in the last survey (2009), new issues were introduced, namely to assess the degree of satisfaction with public spaces and with the possibility of outdoor recreation. Public transport and the most serious urban problems identified by the citizens were also discussed. Finally, it also introduced a series of questions regarding the perception of poverty, health and confidence. The factors analyzed in the surveys relate mainly to health, employment and housing, poverty and economic situation, immigration and the presence of foreign people, security, main problems of citizens, pollution and climate change, administrative services, urban infrastructure and public transport. Appendix B shows the factors included in the perception surveys.

In 2009, the Urban Audit has commissioned a study to examine the responses of citizens, which included a series of correlations between variables. The results show, for example, that the perception of poverty is related to the possibility of finding a good job. Another strong correlation found in this study refers to the confidence that individuals have in their fellow citizens and the feeling of security. The perception of citizens of their city's commitment to fight climate change showed strong positive correlation with the perception that the city is clean and healthy and a negative correlation with the perception that air and noise pollution is high. Looking directly to the evaluation of urban management made by citizens, it is interesting to note that satisfaction with municipal facilities is directly related to positive perceptions about how the city spends its resources.

Urban Audit work has been subject to academic evaluation and work in various domains. Schwarz (2010), for instance, has used its data to characterize urban forms in Europe. Though being a main provider of data, the project can be critized for offering only limited analysis. In an article reflecting on the trajectories of European cities, namely on population change for 310 cities, Turok and Mykhnenko (2007: 167) refer that the conclusions of European Commission for the five-years timeframe 1996-2001 “were rather limited, with the main finding that contemporary population trends are very diverse”, not presenting “an assessment of the overall direction of urban change and whether the prospects were positive or negative”. On the other hand, Bovaird and Löffler (2003: 321), while analyzing some experience in QoL measurements in which Urban Audit is included, argue that information on the project is not targeted to the average citizen, in name of who the work is supposedly done.

2.4. Conclusions

The literature review has revealed that QoL is a pertinent issue in academic fieldwork, namely at its city level, as this is the level that circumscribes daily experiences of most citizens. Despite the theoretical considerations on the concept and dimensions of QoL not being a minor discussion, measurement efforts and empirical approaches dominate now the scientific ground. Some major points can be presented out of the reflections here explored which guided the research described in this thesis:

- QoL has to be addressed both in its objective and subjective components and it has to be understood as a multidimensional concept; consolidated research has now constructed a body of knowledge concerning the dimensions to use. The Urban Audit project respects these contributions, including the central dimensions described in the literature.
- Fewer consensuses can be found regarding the weighting system to adopt in what concerns the relative importance of the dimensions of QoL and the objectivity in the process; thought it may be argued that the contribution of each factor to the overall QoL is not the same, agreeing on quantitative weights to each dimension is an (almost) impossible task. On the other hand, weights can also be a matter of debate when the research intends to take into consideration the perspectives of different stakeholders (as in the Mercer case).
- Several examples of studies and monitoring systems of urban QoL can be presented, but those contributions are mostly isolated and independent from each other, not allowing the comparison of results or benchmarking processes among cities.
- Urban Audit data has the potential to allow systematic comparisons and integrated analysis but has not been explored in terms of the creation of synthetic indicators. The lack of interest by politicians on the Urban Audit data may result, in some way, from the fact that data is very extensive, making the reading of trends difficult and time-consuming, and therefore very hard to 'sell' to the average citizen. Composite indicator built from the Urban Audit could package information in a more readable format for politicians and general public. Comparison between cities allowed in the project site is very partial (only for each variable at one time) and does not allow to draw conclusions on the overall conditions of a city compared to another.

So, from our perspective, objective data collected by Urban Audit presents interesting opportunities in terms of comparability and usefulness to policy making and provides an opportunity for research. Given the purposes of the research presented in chapter 1, we have relied on Urban Audit to provide the data for our work. Urban Audit surveys have been explored in terms of correlation between variables but there has been little analysis over the factors that explain the citizens’ considerations over the expenditure of resources, a gap we also intend to overcome in this study.

3. Construction of composite indicators: issues and Data Envelopment Analysis contributions

The measurement of QoL has followed, as we have seen in the previous chapter, several methodologies. In most QoL research, the evaluations have been presented for each variable or dimension considered one at a time. Aggregating information in a single measure has not yet been fully explored. Composite indicators have been presented to assess QoL (as in the HDI case) or to assess urban QoL from given perspectives (as in the Mercer report case). But previous research has not searched for a synthetic view of the urban QoL in general, nor has presented an analysis of the trends of the overall level of QoL over time. On the other hand, the city level has not been explored thoroughly in comparable grounds, meaning that opportunities to rank cities or to share experiences in local management are scarce. A single measure for urban QoL is then desirable when the purpose is to present comparisons over time and between different cities, broadening the scope of the analysis.

Data Envelopment Analysis (DEA) is a methodology that allows to provide a single efficiency measure for each unit under assessment (cities in our study). DEA is a technique based on the use of linear programming, initially developed to measure the relative efficiency of similar organizational units, each of which using multiple resources (inputs) to produce multiple results (outputs). DEA have been widely applied to different contexts such as schools (Portela and Camanho, 2010) or banks (Lozano-Vivas and Pastor, 2010; Casu and Girardone, 2010; Avkiran and Morita, 2010), but experiences of measuring QoL using DEA are scare as noted in the previous chapter. Few studies using DEA to assess QoL are available in literature (Zhu, 2001; González, 2010; Hashimoto and Ishikawa, 2009).

Recent developments have studied the potential of the DEA technique to construct composite indicators, that is an aggregated measure of units' achievements (outputs). The most well-known composite indicators include the Human Development Index or the Technology Achievement Index and have been developed by organizations such as the United Nations, the European Commission, and the Organization for Economic Co-operation and Development (OECD). Composite indicators are constructed on the basis of different methodologies, and are recognized to be useful tools in policy analysis and public communication by allowing comparisons of countries or societies.

DEA provides the methodological ground on which we can root the fulfillment of our research purposes, as it is a technique that allows to construct composite indicators, also offering information on factors importance and best performing units (in a benchmarking perspective). The following sections will present DEA as a methodology that provides a meaningful measure of efficiency highlighting its advantages in the construction of composite indicators. In the research described in this thesis, urban QoL will be assessed by providing a measure of units efficiency, but also by means of composite indicators.

3.1. Composite indicators

Composite indicators are usually constructed to enable comparisons of performance of decision-making units (DMUs), such as countries. When the number of individual indicators considered in the analysis of DMUs becomes unmanageably large, often reflecting conflicting perspectives, a comprehensive performance evaluation is a difficult task. A composite indicator overcomes this limitation by providing a single aggregate measure of performance, which avoids the need to find common trends in many separate indicators. Therefore, composite indicators provide a starting point for performance assessments that can be extremely useful to guide discussions and attract public interest.

3.1.1. Constructing Composite Indicators

The construction of a composite indicator, that is formed when individual indicators are compiled into a single index on the basis of an underlying model, involves several stages: the selection of sub-indicators, the treatment of missing values, the specification of the weights for the sub-indicators, and the choice of the aggregation model. The strengths and weaknesses of composite indicators largely depend on the approaches followed in each of these stages. The steps of underlying the construction of a composite indicator do not always follow the same order, being a "concurrent effort during which selection can be altered, weights adjusted and variables rescaled in order to arrive at final index estimates" (Booysen, 2002: 118).

The selection of variables can follow different ways: theory-grounded, empirical analysis, pragmatism, intuitive approach or be based in political and policy reflections. This step has also to consider the fact that, being the goal of composite indicators to allow international comparison of well-being, "the components will have to be of universal significance and cross-cultural applicability" (Booysen, 2002: 119).

Looking for instance to the probably most well-known composite indicator, the Human Development Index (HDI) of the United Nations Program for Development, which is an universal and stabilized concept, we can understand the procedure of construction. It embodies wealth, health and education as core factors, allowing a comparison between countries and regions, thus enabling the assessment of the effectiveness of national and regional governmental policies (United Nations, 2005). The HDI is based on 3 indicators: longevity, measured by life expectancy at birth; educational level, measured by a combination of adult literacy (with two-third weighting) with the combined primary, secondary and tertiary gross enrolment ratio (with one-third weighting); and standard of living, measured by the Gross Domestic Product (GDP) per capita (PPP US dollars). From these indicators it can be obtained a synthetic index. The HDI is the simple mean (arithmetic) of the life expectancy indicators, the educational level indicators and the real adjusted GDP per capita indicators.

This example presents, in one hand, opportunity to reflect on the fact that comparability requires the use of standards methods in what concerns the selection and definition of variables data collection, as well as in the methodology adopted. Only with the fulfillment of these requisites can conclusions be drawn out of meaningful comparisons. On the other, the HDI is also an example of an aggregation and weighting model – simple arithmetic mean – that can be used in the construction of composite indicators. This means that equal weights – that some researchers, such as Babbie (1995), claim to be the norm in composite indicators construction – is assigned to all sub-indicators, but other options are available, such as using analyst's perception or multivariate techniques for weight selection (Booysen, 2002). The weights can be also selected with the aim to reflect policy priorities, to be consistent with theoretical frameworks, or to reward the factors deemed to be more influential to the perception of performance (OECD, 2008).

3.1.2. Issues on composite indicators

The aggregation and weighting stage are at the heart of most criticism surrounding composite indicators, arisen from the fact that "different weighting systems imply different results" (Booysen, 2002). And since there is an inherent subjectivity in the system choice (OECD, 2008; Cherchye et al, 2007; Cherchye et al., 2008; Booysen, 2002), composite indicators are far from being consensual and widely accepted. In fact, there is not a standard construction method, acknowledged by most institutions and academia.

Even when the composite indicator corresponds to concepts that are consolidated in the literature and is used in a generalized way, still its construction can be controversial. This is the case for the already mentioned HDI, where there is disagreement about the indicators included in the index, how to weight the scores within each dimension, and how to aggregate the weighted scores over the different dimensions. Despotis (2005), for instance, focused on the method of weighting/aggregation of different components and proposed the use of Data Envelopment Analysis to reduce the inherent subjectivity associated to the specification of weights. As stated by Despotis (2005), the advantage of the new measure proposed is that the weights result from an optimizing process, based on linear programming, so they are less arbitrary and contestable. This approach reflects the fact that it is possible to construct indices using several different methods applied to the same original data, all resulting in different rankings of the units assessed.

Differential weighting, which is, as we have seen, the main feature of DEA technique is a solution proposed to assess different types of societies, meaning that each society may use the weighting system that fits better its stage of development in the indicator considered. However, as stated before when referring the need for standard methods, this option “prohibits meaningful comparisons of index value” as this does not reflect on the same reality (Booysen, 2002: 128).

The continuing objections that have been raised to composite indicators are at the basis of a handbook jointly sponsored by the OECD and the European Commission - through its scientific arm, the Joint Research Centre. As stated, the “Handbook aims to provide a guide for constructing and using composite indicators for policy makers, academics, the media and other interested parties”, wishing to “contribute to a better understanding of the complexity of composite indicators and to an improvement of the techniques currently used to build them” (OECD, 2008: 3). Stating that composite indicators seem to be unavoidable, OECD prepared technical guidelines that aim at ensuring the scientific nature of composite indicators, starting to assert the importance of a “sound theoretical framework”, defending that the “framework should clearly define the phenomenon to be measured and its sub-components and select individual indicators and weights that reflect their relative importance and the dimensions of the overall composite” (OECD, 2008: 12).

The weighting process is, in the handbook of OECD, characterized as an important step in the construction of composite indicators, being the most divisive aspect the fact that “no matter which method is used, weights are essentially value judgments” (OECD, 2008: 21). Several approaches may be adopted, as we have previously said (such as statistical methods, experts’ opinions, policy priorities or theoretical factors), being the most adopted method to give equal weighting to all variables (OECD, 2008: 21) in order to minimize the subjectivity associated to the specification of weights. Disagreements on the weights that should be assigned to individual components of a composite indicator is common. Inevitably, the choice of weights will affect the value of the composite indicator and the ranks obtained, so if their specification is not robust, the credibility of the analysis will be undermined.

Another crucial stage in the process of constructing composite indicators is the aggregation option. From the simple additive aggregation – the most widespread being the summation of weighted and normalized individual indicators – to the geometric aggregation, several solutions have been adopted (OECD, 2008). The type of aggregation to be chosen is strongly related to the method used to normalize raw data.

Showing the existing divergence on several steps concerning the construction of composite indicators, such as the selection of variables or weighting and aggregation of components indices, Booysen is, however, clear in the defense of composite indicators, considering that "these indices remain invaluable in terms of their ability to simplify complex measurement constructs, to focus attention and to catch the eye, thus enhancing their political appeal" (2002: 146).

3.2. Contributions of DEA to the construction of Composite Indicators

As we have seen, several methodologies have been adopted in order to construct composite indicators (OECD, 2008; Hagerty et. al, 2001; Booysen, 2002). In that group, DEA presents as a main advantage the fact that subjectivity in the weight attribution is substituted by an endogenous attribution without the intervention of the researcher or policy maker. So, contrary to most indexes, that give equal weight to all variables (OECD, 2008; Booysen, 2002), DEA allows to construct composite indicators, without needing a subjective weighting (like experts opinion) or an agreed unique set of weights. DEA technique and discussion on weighting procedure will be explained more thoroughly in the following sections.

3.2.1. The DEA technique and its assumptions

The idea behind the DEA technique can be traced back to an article by Farrell (1957), in which he argues that the efficiency of a given unit should be assessed by comparison with other similar units actually observed, rather than comparing it with a theoretically defined standard. This view has led to the concepts of relative efficiency and empirical production function, which contrasts with the traditional economic approach, in which efficiency is compared to a function defined theoretically.

The DEA technique was developed two decades later by Charnes et al. (1978). DEA is a technique based on the use of linear programming, which measures the relative efficiency of similar organizational units (DMUs) to produce multiple results (outputs). Consider a set of *n* DMUs, j (j = 1,…n), where each one uses *m* inputs, x_{ij}, i (i = 1,… m) to produce *s* outputs, y_{rj} , r (r = 1,….s). For each DMU j_o evaluated, it is possible to obtain a measure of relative efficiency defined as the ratio between the weighted sum of all outputs and the weighted sum of all inputs.

The model proposed to evaluate the efficiency of DMU j_o, assuming constant returns to scale, is shown in (3.1) (Charnes et al., 1978).

$$\max e_{j0} = \frac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \qquad \text{j} = 1, \ldots \text{n}$$

$v_i \geq \varepsilon \qquad i = 1, \ldots m$

$u_r \geq \varepsilon \qquad r = 1, \ldots s \qquad (3.1)$

The weights identified by this model used in the evaluation of a particular unit may be different from optimal weights obtained in other models built to evaluate each of the remaining units. This flexibility of the technique in the choice of weights ensures that a unit is considered inefficient only when there is no set of weights that guarantees a more advantageous assessment. The technique provides then grounded evidence that the unit under assessment can improve its performance.

The value of ε is infinitesimal, which ensures that the weights are strictly positive. The value ε is used in the model to ensure that all inputs and outputs are considered in the evaluation of efficiency. However, as ε is infinitesimal, the model can lead to weights which are approximately zero.

The DEA model allows to distinguish between efficient and inefficient DMUs. The efficient DMUs are considered benchmarks (i.e., organizational units, which are examples of good performance) and define the efficient frontier. DEA defines the best practice frontier that serves as a benchmark for all inefficient DMU, to which the technique allows to set goals (targets) for performance improvement for each resource (input) and for each result (output), by comparison with the efficient DMUs. Additionally, the definition of DMU benchmarks for each inefficient unit can identify good practices that should be adopted by the inefficient units (Boussofiane et al., 1991).

The DEA models can be input or output oriented, the choice depending on the context of performance evaluation and the purposes of the assessment defined by the organizational unit. The model (3.1) maximizes the efficiency value of DMU j_o, subject to weight restrictions that ensure efficiency values less than or equal to 100% for all sample units.

Because the model (3.1) is fractional, it must be converted into linear model in order to be solved by linear programming techniques (see Charnes et al., 1978). The linearization of the model (3.1) lead to models (3.2) and (3.3). Model (3.2) is input-oriented and model (3.3) is output oriented.

$$\max e_{j0} = \sum_{r=1}^{s} u_r \; y_{rj0} \qquad (3.2.)$$

subject to $\sum_{i=1}^{m} v_i \; x_{ij0} = 1$

$$\sum_{r=1}^{s} u_r \; y_{rj} - \sum_{i=1}^{m} v_i \; x_{ij} \leq 0 \qquad j = 1, ..., n$$

$v_i \geq \varepsilon \quad i = 1, \ldots m$

$u_r \geq \varepsilon \quad r = 1, \ldots s$

$$\min h_{j0} = \sum_{i=1}^{m} v_i \; x_{ij0} \qquad (3.3.)$$

subject to

$$\sum_{r=1}^{s} u_r \; y_{rj0} = 1$$

$$\sum_{r=1}^{s} u_r \; y_{rj} - \sum_{i=1}^{m} v_i \; x_{ij} \leq 0 \qquad j = 1, ..., n$$

$v_i \geq \varepsilon \quad i = 1, \ldots m$

$u_r \geq \varepsilon \quad r = 1, \ldots s$

The formulations of the models (3.2) and (3.3) are designated by “weights formulations” of the DEA model, u_r and v_i being the variables of the model and corresponding to the weights assigned to inputs and outputs, respectively.

3.2.2. Returns to scale in DEA models

DEA models can assume constant returns to scale (CRS) or variable returns to scale (VRS). The returns to scale are a characteristic of the production technology frontier. Returns to scale indicate the rate at which production (outputs) increases, compared to an equally proportional increase of all inputs. This concept applies only to efficient DMUs. For inefficient DMU, the returns to scale are measured with reference to the projections on the frontier. Returns to scale can be categorized as follows (Banker et al., 1984):

- Constant returns to scale (CRS) refer to a proportional increase (or decrease) of the outputs compared to an increase (or decrease) in inputs;

- Increasing returns to scale (NDRS) refer to a greater increase (or decrease) of the outputs compared to a proportional increase in the inputs (or decrease).

- Decreasing returns to scale (DRS) refer to a smaller increase (or decrease) of the outputs compared to a proportional increase (or decrease) in the inputs.

The original DEA model described by Charnes et al. (1978) assumes constant returns to scales. Non-decreasing returns to scale (NDRS) models and non-increasing returns do scale (NIRS) models are referred as being Variable Returns to Scale (VRS) models.

3.2.3. Weighted Outputs in DEA models

Weight flexibility, presented as one of the major strengths of DEA analysis, has been under academic scrutiny as it can also present some disadvantages.

As stated before, the assignment of weights to inputs and outputs is done in order to maximize the ratio of the sums of weighted outputs to weighted inputs. Excepting for the fact that the weights have to be strictly greater than zero (see models 3.2. e 3.3.), weights are only implicitly restricted as to limit the efficiency of the DMU to a maximum of 1. An important consequence is the fact that weight flexibility also helps the DMU to target performance improvements or to spot good practices by identifying discriminative aspects in DMU's efficiency (Dyson and Thanassoulis, 1988).

However, weight flexibility also means that the model can assign such very low weights that inputs or outputs can be effectively excluded from the analysis. On the other hand, it may beneficiate a given DMU in its efficiency assessment only because this DMU performed extremely well in a given aspect, thus not providing a whole picture of the DMU's performance. Following this line of reflexion, a given DMU can be more inefficient than the assessment may lead to believe as the worst performance aspects have been ignored. Roll and Golany (1993: 103) have also argued for the need to derive a common set of weights, counteracting the flexibility of the model, to "serve as a yardstick to which the results of the ordinary DEA outcomes are compared". With unconstrained efficiency, a given DMU may present similar values to others only due to extreme sensitivity to the selection of weights and the assessment with common set of weights can point out DMU which resist to this analysis, proving effective efficiency.

Other researches (Allen et al., 1997) have stressed the fact that the weighting system adopted by the DEA model can be inconsistent with prior knowledge or accepted views on the importance of the inputs or outputs included in the analysis.

Due to the problems here stated, academic research has increasingly focused on the constraining methods of DEA flexibility in terms of weight assignment. "Weights restrictions and value judgements cover a considerable part of the DEA research literature without, however showing any signs of saturation" (Allen et al., 1997: 13). Summarizing the previous references, three problems can be identified when dealing with DEA weights:

- total flexibility of DEA to assign weights can lead to an assessment of DMU efficiency only on the bases of a small subset of their inputs and outputs, while ignoring the remaining inputs and outputs;

- because each DMU is assessed in its best possible light, optimal weights for each DMU mostly differ from each other, thus not allowing a comparison between DMU efficiency;

- when applying the method to real life problems, prior views of information or prior knowledge are not taken into consideration with a total flexibility in weight assignment.

It is possible to overcome these limitations by introducing additional constraints on the weights. The purposes and legitimacy of restrictions are hardly contestable, however there is not a consensus on the method adopted to constrain weight flexibility. The issue of imposing weight restrictions in the DEA model attracted considerable attention in the DEA literature. The first authors proposing the use of weights restrictions were Thompson et al. (1986) that aimed at increasing the discrimination of the results of a DEA problem to support the siting of a laboratory, where only six alternatives were under consideration. Allen et al. (1997) present an extensive review, presenting solutions that had been developed, such as direct restrictions on the weights (assurance regions or absolute weights restrictions), adjusting the observed input-output levels (such as the cone-ratio approach) or restricting virtual inputs and outputs.

Weights restrictions can give account for prior knowledge on the DMUs under assessment, understood as value judgements: “logical constructs, incorporated within an efficiency assessment study, reflecting the decision makers’ preferences in the process of assessing efficiency” (Allen et al., 1997: 14). These weights restriction may be used to incorporate prior views on the value of individual inputs and outputs, to relate these values or to incorporate prior views on the efficient and inefficient DMUs.

Weights may be subject to direct restrictions, such as in the case of assurance regions or absolute weights restrictions. Assurance regions of type 1 are restrictions introduced in the DEA model to incorporate into the analysis the relative ordering or values of the inputs/outputs. The bound values for this type of restriction is sensitive to the units of measure of the related factors, meaning that they are dependent on the scaling of the inputs and outputs (Allen et al., 1997).

Absolute weights restrictions are introduced in the analysis in order to prevent the inputs or outputs from being over emphasised or overlooked in final score, the value of the restriction being context dependent. The option for an output or input oriented model has consequences on the relative efficiency scores, meaning that bounds have to be set in light of the model orientation looked (Allen et al., 1997). This type of constraint may appear to be the simplest form of weight restriction, however, its use is limited to a few relatively simple cases (Dyson et al., 2001).

Virtual weights restriction, the most commonly used homogenous weights restrictions (Dyson et al., 2001), can be recommended by the fact that they do not need guidelines for deciding the numerical limits to the values placed on the weights (Pedraja-Chaparro et al., 1997), that is, little detailed information is required. Virtual input/output, the product of the input/output level and optimal weight for that input/output, is independent from the unit of measurement. The virtual inputs and outputs of a DMU reveal the relative contribution of each input and output to its efficiency score. Because there is a direct connection between the level of virtual and its importance in the efficiency rating, this option can help to identify strong and weak areas of performance of the DMU concerned.

The first study to apply restrictions to virtual weights in DEA models was that of Wong and Beasley (1990). These restrictions limit the proportion of the total virtual output of DMU *j* devoted to output *r*, i.e., the importance attached to that output. There are three approaches expressed by Wong and Beasley (1990) to use proportion constraint: weights chosen to evaluate a given DMU must be such that for that DMU (not necessary for others) the proportion constraint is satisfied; the weights chosen to evaluate a given DMU must be such that for all DMUs the proportion constraint is satisfied; and use the proportion constraint for an artificial DMU with the value of output measure being the average of the values for output measure over all DMUs, this last formulation being used namely for computational reasons.

Virtual weights restrictions, which are DMU specific, can be expressed as shown in (3.4).

$$\alpha_r \leq \frac{u_r y_{rj}}{\sum_{r=1}^{s} u_r y_{rj}} \leq \beta_r \qquad r = 1, \ldots, s \qquad (3.4)$$

In expression (3.4), the total virtual output of DMUj ($\sum_{r=1}^{s} u_r y_{rj}$) is included in the denominator as a standardization mechanism, that facilitates the assignment of the values for α_r and β_r, which should be between 0 and 1. These values may be intended to reflect prior views of experts on the relative importance of the individual outputs. Restrictions can be incorporated in order to force the model to consider all the outputs in analysis by assigning a minimum value to each.

A problem that has been identified with virtual weights restrictions is the fact that assessing all DMUs with the constraints is computationally expensive (Allen et al., 1997). However, if the bounds on virtual weights are only imposed in the assessed DMU, symmetry of the model will be destroyed, "that is, each unit becomes assessed on a different feasible region" (Dyson et al., 2001: 255). Asymmetry can be avoided by incorporating bounds for all DMU, but this is an approach computationally expensive "and is more likely to result in an infeasible problem than the incorporation of bounds for the assessed unit only" (Dyson et al., 2001: 255). So models of DEA with virtual weights restrictions may be infeasible, making impossible to calculate efficiency for some DMUs (Wong and Beasley, 1990). A disadvantage of using virtual weights restrictions is then that the large number of restrictions that must imposed in the multiplier program may increase the likelihood of infeasibility, which can be controlled in some cases by adjusting the proposed bounds on the weights (Estellita Lins et al., 2007).

3.2.4. Assessing DMUs with a common set of weights

Weight restrictions, discussed in the previous section, respond to some problems raised in literature, such as incorporating prior knowledge or avoiding analysis in which some inputs or outputs can be effectively ignored by the assignment of very low weights. Another problem raised by classical models of DEA is that it does not allow to compare DMUs as efficiency is not assessed in comparable standards. Weights restriction in order to make comparison between DMUs possible has also been a matter of academic research since Roll and Golany (1993), that proposed the assessment of DMUs within the same system of weights.

In unconstrained analysis, DMUs may present similar efficiency levels by the fact that the model has flexibility in choosing the most appropriate weights. So, in some cases, there may be a need for examining if operating conditions of DMUs are indeed similar (Roll and Golany, 1993) to discriminate really efficient DMUs. Deriving a common set of weights is the solution presented for this situation and it can be achieved by looking for central values for all the weights, by arranging the various factors in a descending order of importance or by maximizing the average efficiency of all DMUs (Roll and Golany, 1993).

Besides for this "control" function, setting a common set of weights is also a procedure that allows to establish a ranking of DMUs. Further developments on the notation of common set of weights were presented by Saati (2008) and Makui et al. (2008), following other important contributions such as the ones presented by Kao and Hung (2005), Jahanshahloo et al.(2005), Doyle and Green (1994), Karsak and Ahiska (2005) or Kuosmanen et al. (2006).

Common set of weights have been justified within DEA literature for the cases where the analysis of individual circumstances in what concerns the conditions of operation of the different DMUs is not necessary. Consensus on the value of weights is not easily reachable and this has been pointed out as a disadvantage of using common set of weights. However, several solutions that avoid the need for an external agreement on the set of weights to use have been presented, from looking for central values to linear programming. Ramón et al. (2011) propose as common set of weights the average profile of the profiles of weights provided in a cross-efficiency evaluation.

In many cases, common set of weights in DEA-approaches are the result of procedures that minimize the differences between the DEA efficiency score in a given set of DMUs. Cook and Zhu (2007: 215), for instance, proposed a goal programming model to construct a common-multiplier set that "minimizes the maximum discrepancy among the within-group scores from their ideal levels".

Makui et al. (2008) asserted the advantages of deriving a common set of weights by goal programming: the possibility to rank DMU on common basis, a better discrimination of the less efficient DMUs and the fact that it can be calculated by solving a single model. Despotis (2002) also proposed goal programming to derive a common set of weights, considering that it can help overcome the fact that DEA is weak in discriminating among efficient units. Despotis (2005) applied this procedure to the estimation of common weights for the three sub-indicators contained in the HDI, in a manner that the resulting efficiency scores are as close as possible to the DEA scores, this way allowing the comparison between countries.

3.3. Conclusions

In this chapter a review of the Data Envelopment Analysis technique is presented, showing the features of this linear programming model, its applicability and advantages for analyzing QoL. Besides allowing the estimation of efficiency, DEA can also be used to construct composite indicators, overcoming some of the limitations referred in the literature in what concerns these indexes, such as the weighting system.

To our knowledge, DEA has not been widely used and explored to assess QoL and construct composite indicator. But, as we have seen in this section, DEA is a methodology that overcomes some of the problems raised in the construction of composite indicator. This technique allows traditional approaches, such as giving equal weights or using judgment values following experts advices, but it can provide alternative procedures: an aggregation technique that is endogenously decided and by using a weighting system where subjectivity can be excluded and where all units under assess are assigned with weights that best favor their position. Few studies have applied DEA to field of QoL, such as the work of González et al. (2010). This study relies on DEA, arguing that it presents advantages, such as the fact of handling multiple indicators, not imposing functional form on the relationship between them, and also by providing information of the improvements that need to be made.

Composite indicators can then be constructed with the classical model of DEA, but do not allow to provide ranking or meaningful comparisons as units are not assessed with common standards. However, new developments in DEA have focused on these limitations and, as we have seen, literature has presented solutions for these situations, such as using a common set of weights.

Our work intends to develop a procedure to evaluate urban QoL using Data Envelopment Analysis, providing an efficiency measure of cities performance and constructing composite indicators, exploring the advantages of DEA in what concerns the weighting procedures that can be adopted. Next chapters will present composite indicators constructed with DEA to assess urban QoL in Europe. In the first case, cities will be assessed at their best light, thus emphasizing their strengths and weakness. In the second composite indicator, cities will be assessed on comparable standards, allowing the construction of a ranking and the establishment of benchmark strategies.

4. Urban quality of life composite indicator

In this chapter, we present composite indicators of QoL, constructed with DEA. Two different composite indicators are presented. As discussed in the literature review on urban QoL and in what concerns the construction of composite indicators, weighting is one the most sensible issues, as no agreement has been reached on the value to attribute to different dimensions of QoL. We will address this question by constructing a composite indicator of urban QoL using DEA.

As we have seen in the presentation of this methodology, DEA can provide new solutions to the weighting issues, as it reduces the subjectivity in the process by endogenously deciding on the weights that best favor the city in analysis. But because this assessment is made on individual systems of weight for each city under analysis, cities cannot be compared. So, a next step is required if cities are to be paired: deriving a common set of weights, as seen in the literature of DEA, that allows to rank cities assessed in comparable standards.

The composite indicator presented will then, in a first place, reflect cities QoL at their best light, focusing on which factors explain the score obtained. In a second step, another composite indicator will allow the construction of a ranking of cities according to their QoL score, thus enabling meaningful comparisons.

4.1. Indicators for urban quality of life

This section describes the data selected to construct the composite indicator of QoL. Every city has features that incorporate the dimensions of QoL, some of which can be quantified. The values or score each city has in each of these features give rise to indicators that can objectively measure QoL. An assessment of QoL should identify in which indicators cities perform better, those being the factors that induce QoL in that given context. For our DEA approach, will use, as stated before, data provided by the European program Urban Audit to construct the indicators to be used as outputs for our analysis.

As we have seen in chapter 2, the Urban Audit project provides comprehensive data on urban QoL, but it has not been used to provide synthetic images of cities, as no integrated analysis has been developed. Global comparisons between European cities are not provided and benchmarking was not undertaken.

On the other hand, we believe that using Urban Audit data responds to several concerns posed by the selection of variables in constructing composite indicator (OECD, 2008; Hagerty et al., 2001; Booysen, 2002), as it guarantees some fundamental aspects such as validity, reliability, comparability and data availability. On the other hand, because this data responds to clear public policy purposes, it can allow the construction of a usable index (Hagerty et al., 2001; Booysen, 2002). Finally, this data is gathered within the framework of a consolidated program by statistical organizations, such as the Eurostat, also being constantly revised in terms of its scope and variables by experts reasoning.

Given the aim to provide an overall perspective of European cities QoL, the Urban Audit City Profile will be the basis for the construction of the composite indicators. The option for the City Profile answers to the obvious difficulty to deal with the 336 variables considered in Urban Audit database, thus choosing a more operational and reduced set of data, that results from field work experience. These variables reflect the central core of QoL, as it is understood by the Urban Audit project, as we have seen in chapter 2. However, the concept used by this European project does not include the components of culture and leisure and innovation and technology. As we believe these dimensions are important for QoL assessment, we have also included these two dimensions in this study. As Picavet (2010: 1128) puts it, reasoning on the ethics of operational research, “it is especially important to select goals and parameters of interest in a relevant way if the expert if to offer proper guidance to a human community”. We then have a city profile in which all the nine dimensions of QoL used in the Urban Audit are considered.

Following this approach, we looked at the indicators chosen by the City Profile for each dimension. For the purpose of our work, we chose only the ones we considered to be indicative of QoL (ex. percentage of households living in owned dwellings), such that higher values represent better QoL. We excluded indicators that may suggest an improvement in QoL up to a critical point, but whose contribution may be doubtful beyond that threshold, such as population density or immigrants as a percentage of total population. Indicators which were negatively related to QoL (e.g., percentage of households receiving less than half of the national average household income) were transformed into positive aspects of QoL (ex. percentage of households receiving more than half of the national average household income), by using a complementary indicator, to satisfy the basic DEA assumption that more output is better. Thus we have built a new concept of the city profile, based on a different selection of indicators that, clearly and objectively, reveals QoL.

The result is a total of 29 QoL indicators, which correspond to the outputs of the DEA model. These outputs are distributed by the nine dimensions, as shown in Table 4.1.

Being a vast and relatively recent project, the Urban Audit suffers a major limitation related to data unavailability for several variables in many cities. Even though there was a data collection in 2006, this work deals with the 2003 campaign because it followed national census in a significant number of countries, thus relying on more precise data. Data from 2006 has more missing values and relies more on estimations, losing in precision what it gains in timeliness. Before applying DEA to our sample and in order to avoid bias in the analysis that could be introduced by missing data, we decided to include in our study only the cities with a minimum of ten valid observations in the 29 outputs considered. A total of 50 cities were eliminated from the original database of the Urban Audit program.

Table 4.1 – Outputs considered in the DEA model (composite indicator)

Dimensions	Output | Indicators
Demography	(O1) Growth of Population over two years in percentage of resident population
	(O2) Percentage of households with more than one person
	(O3) Percentage of households that are not lone-parent household
Social Aspects	(O4) Average price for an apartment (in euros per m^2)
	(O5) Average price for a house (in euros per m^2)
	(O6) Percentage of households living in owned dwellings
	(O7) Percentage of households not living in social housing
	(O8) Average area of living accommodation (m2 per person)
	(O9) Life expectancy at birth (years)
	(O10) Population per recorded crime
Economic Aspects	(O11) Employment rate (%)
	(O12) Female Employment Rate (%)
	(O13) Activity rate (%)
	(O14) Median disposable annual household income (in euros)
	(O15) % of households receiving more than half the national average household income
Civic involvement	(O16) Percentage of registered electorate voting in city elections
Training and Education	(O17) Percentage of children aged 0-4 in day care
	(O18) Percentage of resident population with secondary education
	(O19) Percentage of resident population with tertiary education
Environment	(O20) No. days with ozone O3 concentrations below 120 microgram/m^3 (per year)
	(O21) No. days with particulate matter concentrations below 50 microgram/m^3 (per year)
	(O22) Percentage of solid waste processed by landfill
	(O23) Green space to which public has access (m2 per 10000 inhabitants)
Transport and travel	(O24) Percentage of journeys to work not done by car
	(O25) Average time saved in journeys to work in relation to the time reference of 75 min
Information society	(O26) Percentage of households with a PC
Culture and recreation	(O27) Cinema attendance (per year per capita)
	(O28) Number of museum visitors (per year per capita)
	(O29) Number of theatre seats per 1000 inhabitants

In the other cities, missing values were substituted by the minimum value observed in the output considered. A consensual way to deal with missing values has not yet been reached in the DEA literature. Several solutions to model missing values have been discussed, such as the proposal of Kuosmanen (2002) to replace missing outputs by zero, or the approach of Smirlis et al. (2006) that suggest the replacement of missing values by approximations in the form of interval in which the unknown missing values are likely to belong. For the purpose of this work, we have chosen to replace the missing observations with the minimum value observed in the database for that variable. This ensures that cities with no data available are not benefited in the performance assessment in relation to their counterparts. The missing values were not replaced by zero because this would hinder the assessment of cities with missing values in the variables that represent a dimension (e.g., output 26 in the information society dimension or output 16 in the civil involvement dimension). In a total of 5974 observations considered to be valid, 32% resulted from the substitution of missing values. The variables for which the problem of missing data was more acute were outputs 14 and 15 (related to households income), output 22 (percentage of solid waste processed by landfill), and output 26 (percentages of households with a PC).

Finally, we explored the existence of outliers in the sample by identifying results that seem unlikely in the dataset. It is known that in the presence of outliers, the location of the DEA frontier could be severely affected due to its sensibility to extreme observations. This required the removal of two more cities from the original database. Our sample is then constituted by 206 cities, belonging to twenty five countries.

The construction of both composite indicators implies comparing QoL at the city level only based on the outputs. This is equivalent to assume that all cities have the same input levels, which can be represented in a DEA formulation as a single “dummy” input equal to one for all DMUs. This is a legitimate option considering that indicators are normalized so that higher values are not connected to the urban scale size.

4.2. DEA model underlying the construction of the QoL Composite Indicators

Recent research, namely conducted by Cherchye (2004; 2008), has revealed DEA as a methodology with interesting characteristics in what concerns the construction of composite indicators, especially in the aggregation and weighting stages, that are crucial to the validity and acknowledgement to these measures. The main difference between a traditional DEA efficiency analysis and the construction of a composite indicator using DEA is that the latter only looks at achievements, without taking into account the resources used. The underlying idea of using a DEA model to obtain a composite indicator is to merge the variables (i.e., the outputs of the DEA model) in a single summary measure of performance, considering a “dummy” input. The advantage of DEA in this case is to allow each unit to select its own weighting system for the evaluation of performance, recurring to optimization procedures that emphasize the unit’s strengths. The linear programming model for deriving the composite indicator of each unit under analysis is shown in (4.1). As stated by Cherchye et al. (2007: 121), model (4.1) is equivalent to the original DEA input oriented model of Charnes et al. (1978), with all indicators considered as outputs and a “dummy input” equal to one for all DMUs, and weights u_r, $(r = 1,...,s)$ being the variables of model (4.1).

$$
\begin{aligned}
& CI_0 = \max \sum_{r=1}^{s} u_r y_{rj_0} && (4.1)\\
& s.t. \\
& \sum_{r=1}^{s} u_r y_{rj} \le 1 && \mathrm{j} = 1,...,\mathrm{n} \\
& u_r \ge 0 && \mathrm{r} = 1,...,\mathrm{s}
\end{aligned}
$$

Applied to the field of composite indicators, this method is identified as the “benefit of the doubt” approach and was first implemented by Cherchye et al. (2004). This approach steamed from the underlying ideas of the benefit of the doubt approach originally proposed by Melyn and Moesen (1991) to evaluate macroeconomic performance. Cherchye et al. (2008) provided an application of this methodology to the Technology Achievement Index – a measure of eight achievements with equal weight, introduced by the United Nations in order to express the way in which a country is creating and diffusing new or existing technologies and building a human skill base for technological innovation.

The rational basis of benefit of the doubt weighting has a straightforward explanation: since it is difficult to identify a priori a set of weights that all units would agree that reflects adequately the relative importance of each sub-indicator, we let each unit select its own weights, such that its composite indicator is as high as possible compared to the composite indicator of other units evaluated with similar weights. If we impose an upper bound of one to the highest composite indicator obtained across all units, a value of the composite indicator equal to one signals best performance (i.e., benchmark units). If using the weights selected to optimize the composite indicator of the unit under assessment another unit gets a higher value for the composite indicator than the unit under evaluation, it must be concluded that that unit outperforms the one being assessed.

The DEA model to derive the composite indicator of each city overcomes, as stated before, the problems posed in the weighting phase in the constructions of composite indicators by recurring to optimization procedures. These determine the weights that give the highest possible score for each unit assessed, keeping the scores of all other units less than or equal to one when evaluated with similar weights.

As previously discussed, these weights can be different for every unit j_0 being analyzed. Each unit final weights are assigned such that it will attain the best possible score when compared to peer units that are temporarily assigned the same set of weights. If the city assessed does not obtain an efficiency score of one using this procedure, this means that its peers perform better even when all the weights are set to maximize the score of the focus city. So, this is not only a sound justification for the weights assigned, but also no city can complain that its score would have been better if a different set of weights were used.

The composite indicator score CI_0 of city j_0 is between 0 (worst) and 1 (best). A composite indicator equal to one signals best observed performance, and lower values signal potential for improvement, which may be achieved by following the best practices observed in peer cities. Although model (4.1) is very powerful to derive an overall, objective, summary measure of performance, the non-negativity restrictions on the weights (u_r) allow for extreme scenarios as some outputs can be effectively excluded from the analysis by being assigned very low weights. As discussed in chapter 3, restrictions to weight are uncontestable and several solutions have been presented by researchers.

The alternative that is more in line with the logic of traditional DEA models is to add the restrictions in respect to all DMUs being compared by using assurance regions. This implies that the weights chosen to evaluate DMU j must be such that its proportional constraint is satisfied, and when the same set of weights is applied to all other DMUs, their proportional constraints must also be satisfied. In composite indicators, however, the common approach is to use restrictions to virtual weights only to the DMU being assessed. Our approach can be considered to be a hybrid solution, as we have imposed the restrictions to all DMUs but using the traditional formulation of virtual weights restrictions.

We used this approach to derive the composite indicator of urban QoL, but imposed minimum assumptions in relation to the relative importance of the outputs. In order to reduce the need for detailed assumptions/choices, we specified the weight restrictions on a more aggregate level. Specifically, as the outputs were classified in nine dimensions (see Table 4.1.), we specified the restrictions with respect to the percentage share of each dimension. In order to avoid having dimensions that do not contribute to the construction of the composite indicator, we specified a virtual weight for all dimensions greater or equal to 1.5%, as shown in expression (4.2).

$$\frac{\sum_{r \in D_Z} u_r y_{rj}}{\sum_{r=1}^{s} u_r y_{rj}} \geq 1.5\% \qquad z = 1,..9 \quad j = 1,\dots,n \qquad (4.2)$$

The advantage of specifying a low value for the parameter on the right-hand side of the inequality is to allow for flexibility in the selection of the weights, such that each city will still be permitted to show itself in a favorable light. In addition, from the composition of the virtual weights at the optimal solution for the DMU under assessment, it will be possible to identify the strengths and weaknesses of each city. This procedure also allows improving significantly the discrimination power of the DEA model. Using model (4.1) without weight restrictions to build a composite performance indicator for the sample of 206 European cities, only 14 cities were classified as inefficient, with the remaining 192 receiving a score equal to 1. Conversely, adding the restrictions in (4.2) to model (4.1), the discrimination power of the model increased dramatically with only four cities classified as fully efficient.

The assessment of QoL using model (4.1) with the weight restrictions (4.2) provides an evaluation of cities performance where diversity is accounted for, i.e., the cities that excel at given dimensions are credited for that, and their overall score reflects their good performance in given aspects.

The existing literature reveals that summary indexes, such as a composite indicator for European cities QoL, is bound to conceal important aspects of the complex phenomenon represented by the indicator. However, we believe it is an essential tool to enable direct comparisons between the QoL of cities. It also allows the implementation of benchmarking procedures, leading to the identification of best practices that can be spread across cities. So, the next step of our analysis consisted on deriving an overall ranking of QoL at the city and country levels. To be able to compare cities and countries performance, the assessment should be done on the same basis, this meaning that it would be desirable to evaluate all cities with a common set of weights. Subsequently, the countries performance can be obtained as the average performance of their cities. To implement this approach, we used the goal programming model shown in (4.3). This model finds a set of weights that minimizes the deviations (z_j) in relation to the composite indicator score obtained in the previous stage of the assessment (CI_0), based on model (4.1) with restrictions (4.2).

$$
\begin{aligned}
& Min \sum_{r=1}^{s} z_j \\
& s.t. \\
& \sum_{r=1}^{s} u_r y_{rj} + z_j = CI_0 \qquad && \mathrm{j} = 1,...,\mathrm{n} \\
& u_r \geq 0 && \mathrm{r} = 1,...,\mathrm{s} \\
& z_j \geq 0 && \mathrm{j} = 1,...,\mathrm{n}
\end{aligned}
\tag{4.3}
$$

Having presenting the data and the DEA models involved in the construction of composite indicators for urban QoL this chapter will now explore the results and finding for the models with endogenous weights.

4.3. Results for the Composite indicator of quality of life

4.3.1. Assessment of cities quality of life

The composite indicator is an useful tool when the aim is to consider all the DMU in a global perspective, providing an overview of the QoL of cities. For instance, in the perspective of the European Union, this composite indicator can be useful to identify where intervention is most needed to increase the QoL of European cities. This analysis allows to value the dimension or dimensions in which the city has a good performance, thus distinguishing the high performers from the rest of the group.

The performance assessment using the DEA model (4.1), with the restrictions (4.2), with the output indicators subject to weight restrictions for all DMUs, only 4 cities [Luxembourg (Luxembourg), Helsinki (Finland), Weimar and Dresden (Germany)] achieved the maximum score of the composite indicator of QoL (corresponding to 100%). The average score for the sample analyzed was 51%. See appendix C for the complete list of the scores obtained for all cities.

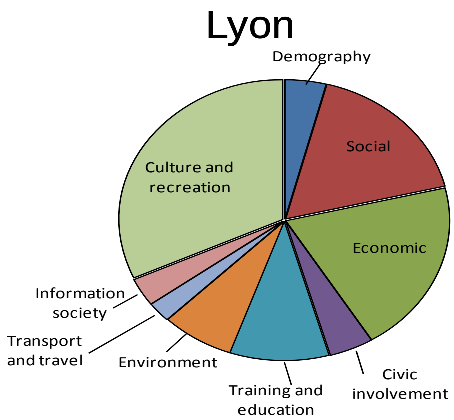
When we look at the cities that are the best performers, more specifically to the 20 best cities, listed in table 4.2, we can conclude that the majority belongs either to Germany (7), Belgium (3) or Netherlands (3). Although none of these German, Dutch or Belgian cities are the capital of their country, it is also a remarkable fact that the other cities (6) are all capital cities of their country, except Gozo. In the 20 cities with the worst performances, the presence of Eastern countries stands out, with cities belonging mainly to Romania (7), Italy (6) and Poland (3). These cities demand more attention when a global perspective of European cohesion is at stake.

Table 4.2 – Best and worst cities according to the QoL assessment

Best QoL (top 20)		Worst QoL (bottom 20)	
Countries	**Cities**	**Countries**	**Cities**
Germany	Dresden	Romania	Targu Mures
	Weimar		Sibiu
	Freiburg im Breisgau		Craiova
	Frankfurt am Main		Timisoara
	Darmstadt		Bucaresti
	Nurnberg		Arad
	Dortmund		Oradea
Netherlands	Groningen	Italy	Bari
	Arnhem		Napoli
	Gravenhage		Trieste
Belgium	Brugge		Palermo
	Antwerpen		Reggio di Calabria
	Liège		Taranto
Luxembourg	Luxembourg	Poland	Suwalki
Portugal	Lisbon		Katowice
Finland	Helsinki		Zory
Sweden	Stockholm	UK	Lincoln
Malta	Gozo		Wrexham
Austria	Wien	Germany	Moers
Cyprus	Lefkosia	Bulgaria	Burgas

This methodology can be particularly interesting for the analysis of the strengths and weaknesses of the cities. The optimization procedure underlying the derivation of the composite indicator using DEA selects the weights that show the city under assessment in the best possible light. Therefore, the best dimensions are given higher virtual weights, and the others are given less weight, with the minimum virtual weight restricted to be 1.5% for all dimensions. Figure 4.1 shows the pie chart characterizing the performance in Lyon, the city selected for illustration. This city has a score of 46% for the QoL indicator. Lyon shows relatively well balanced performance, with culture and recreation, economic and social corresponding to the best dimensions, followed by training and education, and environmental aspects.

Figure 4.1 – Contributions of different dimensions for the composite indicator of QoL for Lyon



4.3.2. Quality of life ranking of European cities

The analysis can go further to make direct comparisons among cities more fair and balanced. This requires the selection of a common set of weights to evaluate all cities, which was done using the goal programming model (4.3). Table 4.3 shows the dimensions that were given higher weights using the goal programming model. To make the interpretation of the relative importance of the dimensions easier, table 4.3 reports the virtual weights that represent the common framework used for the comparisons (i.e., the variables u_r of model (4.3) multiplied by the average value of the indicator y_r for all cities analyzed).

Table 4.3 – Relative importance of the dimensions with common weights

Dimensions	Virtual weights
Demography	0.02
Social	0.06
Economic	0.01
Civic involvement	0.02
Training and education	0.05
Environment	0.02
Transport and travel	0.04
Information society	0.06
Culture and recreation	0.15

The values reported in Table 4.3. show that in the evaluation of QoL with a common set of weights, the most important dimension is culture and recreation. Social aspects and information society follow, as well as training and education and transport and travel dimensions. Demography, economic aspects, civic involvement and environment are the less expressive dimensions.

Using a common set of weights in the assessment of QoL, cities can be put side by side and compared. This also enables the construction of a ranking of cities (see Appendix D for complete ranking). The cities in the 90th and 10th percentile of the ranking are presented in Table 4.4.

An examination of these results shows that, in the top of the list, German cities are highly represented (10), followed by capital cities (6) and urban centers from Netherlands (3) and Belgium (2). At the bottom of the list, Romanian (7), Italian (6), Bulgarian (4) and Polish (2) cities stand out.

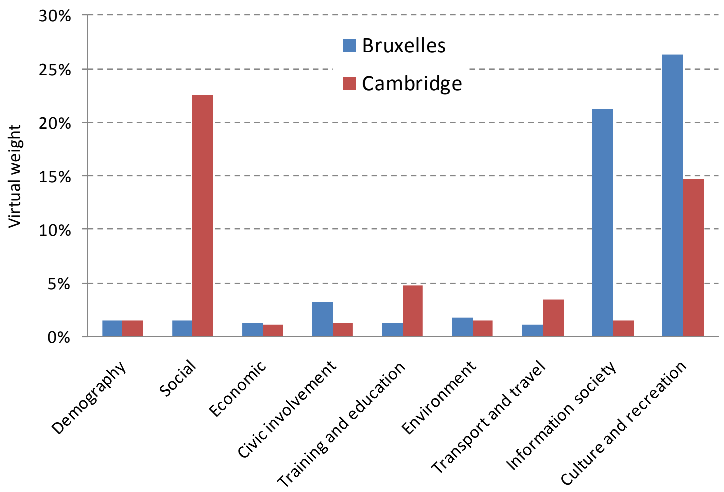
Concerning direct comparisons of cities when equal weights are assigned to the dimensions, we illustrate how the profiles of the cities can be contrasted. Figure 4.2 shows the profile of two cities selected for illustration: Bruxelles (Belgium) and Cambridge (UK). These cities have a QoL score of 59% and 52%, respectively. Note that the sum of the virtual weights shown for all the dimensions of each city is equal to the QoL score.

Table 4.4. – Ranking of cities QoL based on common weights

Top of the ranking		Bottom of the ranking	
City	QoL indicator	City	QoL indicator
Helsinki (Finland)	100%	Varna (Bulgaria)	23%
Weimar (Germany)	100%	Targu Mures (Romania)	22%
Luxembourg (Luxembourg)	100%	Timisoara (Romania)	22%
Dresden (Germany)	99%	Napoli (Italy)	22%
Frankfurt am Main (Germany)	91%	Ruse (Bulgaria)	22%
Groningen (Netherlands)	90%	Burgas (Bulgaria)	21%
Freiburg im Breisgau (Germany)	88%	Plovdiv (Bulgaria)	21%
Nurnberg (Germany)	83%	Arad (Romania)	21%
Wien (Austria)	80%	Suwalki (Poland)	21%
Dortmund (Germany)	80%	Craiova (Romania)	21%
Arnhem (Netherlands)	77%	Bucaresti (Romania)	21%
Antwerpen (Netherlands)	75%	Liepaja (Latvia)	21%
Liége (Belgium)	74%	Bari (Italy)	21%
Regensburg (Germany)	74%	Trieste (Italy)	21%
Lisboa (Portugal)	74%	Palermo (Italy)	21%
Gravenhage (Netherlands)	74%	Oradea (Romania)	21%
Stockholm (Sweden)	73%	Sibiu (Romania)	20%
Karlsruhe (Germany)	73%	Wrexham (UK)	20%
Darmstadt (Germany)	72%	Zory (Poland)	19%
Munchen (Germany)	72%	Taranto (Italy)	17%
Amsterdam (Netherlands)	71%	Reggio di Calabria (Italy)	16%

The capital of Belgium is an example of a city with two strong dimensions (information society and culture and recreation). It also performs better than Cambridge in civic involvement. The British urban center is stronger than the "capital of Europe" in the social aspects dimension, followed by training and education and transport and travel dimensions. The performance concerning the other three dimensions (demography, economic aspects and environment) is similar in the two cities.

Figure 4.2. – Contribution of different dimensions for the composite indicator at the city level (with common weights)



Finally, the methodology applied to the construction of a composite indicator of city QoL can have a secondary outcome, leading to a global evaluation for countries, as shown in Table 4.5. For each country, the QoL indicator was obtained as the average score of the composite indicator of its cities using the common weights. This ranking shows some countries with poor performance in terms of urban QoL, such as the ex-communist countries: Bulgaria (22%), Romania (22%) and Poland (28%).

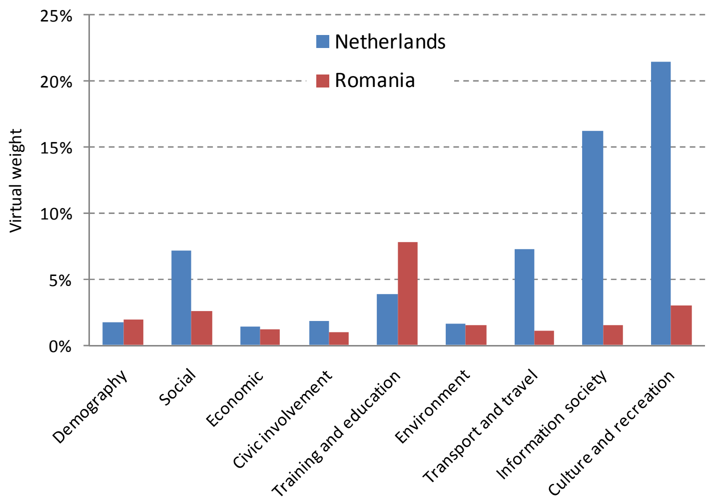
But western countries like France, United Kingdom and Italy have also some weaknesses in their urban QoL, and present a relatively low average value of the QoL composite indicator (below 40%). If we do not consider the country appearing at the top of the list, since it reflects the value of a single city, we find that the countries with best urban practices are all from Old Europe: Belgium (66%), Netherlands (63%), Germany (62%) and Finland (60%). But these national performances are not uniform: the high standard deviation shows that bad and good practices co-exist in those countries.

Table 4.5. – QoL indicator at country level (with common set of weights)

Country	QoL Indicator		No. cities assessed
	Mean	SD	
Luxembourg	100%	-	1
Belgium	66%	9%	6
Netherlands	63%	17%	10
Germany	62%	18%	35
Finland	60%	29%	4
Austria	59%	20%	3
Malta	54%	15%	2
Denmark	53%	2%	4
Cyprus	52%	-	1
Estonia	51%	0%	2
Sweden	51%	15%	4
Hungary	49%	3%	4
Slovakia	48%	6%	3
Spain	44%	10%	8
Portugal	42%	18%	5
Czech Rep.	42%	5%	5
Slovenia	38%	5%	2
UK	37%	11%	23
France	36%	6%	26
Lithuania	30%	5%	3
Latvia	30%	13%	2
Poland	28%	5%	22
Italy	28%	8%	18
Romania	22%	1%	8
Bulgaria	22%	1%	5

Similarly to the comparison of strengths and weaknesses of cities supported by the graphical representation of virtual weights, we can represent the countries profile. Figure 4.3 shows an example of the profile for Netherlands and Romania, two countries that rank very differently in our list. Netherlands is strong in the culture and recreation aspect and, to a lesser extent, in the Information Society. Social aspects and Transports and Travel are dimensions where Netherlands also perform relatively well. The major strength of Romania in terms of QoL is training and education, a dimension very important in the overall score of the country.

Figure 4.3. – Contribution of different dimensions for the composite indicator at country level (with common weights)



4.4. Conclusions

These models of DEA present, to our belief, some new features that can project new developments in the construction of composite indicators, as rankings and inter-units comparison become possible. Inner subjectivity is reduced, still avoiding extreme flexibility, and comparability of results are guaranteed. These two situations are, to our view, contributions that can promote new directions to the field.

By using DEA to construct our composite indicator of QoL, we respond, in a first moment, to the concerns posed by OCED in its Handbook, thus using a methodology recognized as valid. Secondly, by imposing a minimum weight to each dimension, still allowing flexibility in the DEA model to show each city at its best light, we guarantee the multidimensionality of the concept. If total flexibility was allowed to the model, DEA could choose a weighting system that would exclude dimensions of the analysis by assigning values of nearly zero weight to any of them. Our approach guarantees the assessment of all the dimensions and improves discrimination in results, providing an assessment of each city. It may also be used to identify its strengths and weakness, and explore its evolution over time.

But comparability of the results between cities in this step should be considered with cautions, as these comparisons suffer from the limitation of having scores of cities obtained with different weighting systems. However, by using goal programming, we overcome this situation. We still do not intervene in the weighting system, thus avoiding the introduction of subjectivity factors in the analysis (that could be criticized by the local managers of the cities under assessment and undermine the acceptance of our proposals), and enable robust comparisons between cities. A ranking of cities, assessed by a common set of weights, can be presented to local managers and policy makers.

Given these results, DEA has, to our view, proven to be a methodology useful in this field, as it successfully enabled addressing the objectives of our research. Namely, we presented an assessment of urban QoL in which the balance of factors is not driven by a-priori weighting. The DEA technique also allowed to identify the factors that induce QoL and of the best practices that can be copied in benchmarking strategies.

5. Quality of Life as perceived by qualified human resources

Urban QoL is considered a fundamental asset in city competitiveness, given its importance to high qualified human resources. As explained in chapter 1, QoL is an essential resource in city economy as it can attract skilled people and workers and, consequently, becomes an important factor in firm location decisions. This is why a comprehensive evaluation of QoL, by means of a composite indicator, should focus on the perspective of these stakeholders. This perspective has influence on the variables selection for the analysis and the weighting system adopted for the dimensions considered in the construction of a composite indicator. As described in chapter 3, our solution will be the incorporation of a value judgment in the DEA assessment. Following Mercer's report on quality of living, that assesses urban contexts from the perspective of qualified human resources, we will illustrate our approach, based on the construction of a composite indicator with data provided by the Urban Audit. This measure will use DEA with a weighting system that adapts Mercer's perspective concerning urban QoL.

5.1. Weighting the preferences of qualified human resources

The firm Mercer presents every year a quality-of-living report that it is said to be "objective, neutral and unbiased" (Mercer, 2010). It aims to help firms to evaluate the compensation of expatriate workers and includes a ranking of 380 cities worldwide. This evaluation is largely cited and recognized as a useful operational tool for firms. This recognition is an important rationale to justify the use of Mercer's framework in our study. The report is based on the evaluation of field researchers and consultants, that work in the Mercer's network of offices worldwide. Global analysts compare the data collected, corresponding to the answers to questionnaires, in order to ensure consistency among all the cities surveyed.

Each city is evaluated for 39 variables (see Appendix E), structured in ten QoL dimensions which impact in the final score is not identical for all. The weights attributed to each dimension resulted from a pilot study conducted by Mercer, which questioned expatriates on the importance that each of the 39 variables should be given. The weights are constructed to resemble how different categories in relation to one another of the 39 issues are ranked by individuals. The dimensions used in the report, and their respective weight, are: political & social environment (23.5%), economic environment (4%), socio-cultural environment (6.4%), medical & health considerations (19%), schools & education (3.4%), public services & transports (13%), recreation (9%), consumer goods (10.7%), housing (5.1%) and natural environment (5.9%). Note that the weight for each question of the different dimensions is not reported in the Mercer report.

This selection of indicators, aggregated in dimensions, and their respective weights, provided us a framework of analysis that can be used with data from the Urban Audit. Being a consolidated and acknowledged information on the preferences of qualified human resources, the Mercer framework of analysis, in what concerns the dimensions and respective weights, provides a valuable outline for the assessment of European cities QoL. Considering the dimensions and variables used by Mercer, a selection of the relevant data provided by Urban Audit was done and consequently only the variables related to the ones used by Mercer were used for the study of European cities. So, for each Mercer variable, we selected one or more variables from the Urban Audit that were the best proxies (see Table 5.1).

Table 5.1. - Variables of Urban Audit selected for DEA model considered to be the proxies of Mercer's dimensions and variables

Variable	Mean	St.Dev.	Min.	Max.
Political and Social Environment (W1=28.3%)				
Total number of recorded crimes within the city per 100 inhabitants [complement to 100]	88,4	8,2	74,5	99,3
Number of murders and violent deaths per 100000 inhabitants [complement to 100]	91,7	8,2	81,1	100
Number of car thefts per 1000 inhabitants [complement to 100]	91,6	7,7	80,2	99,9
European elections participation ratio	0,3	0,2	0,1	0,9
National elections participation ratio	0,6	0,2	0,4	1
City elections participation ratio	0,5	0,2	0,2	1
Number of annual tourist overnight stays in registered accommodation per year per capita	2,3	4,3	0,1	44,9
Economic Environment (W2=4.8%)				
Number of jobs in financial intermediation or in business activities per 1000 inhabitants (NACE Rev. 1 J-K)	70,1	57,5	9,7	359,9
Medical and Health issues (W3=22.9%)				
Male life expectancy at birth	70,2	3,7	66,4	77,8
Female life expectancy at birth	76,6	3,6	72,5	83,9
Number of infant deaths per year per 100000 inhabitants [complement to 100]	93,3	4,5	75,6	100
Number of deaths under the age of 65 due to heart diseases and respiratory illness per year per 10000 inhabitants [complement to 100]	92,4	5,6	78,3	98,7
Number of deaths under the age of 65 per year per 10000 inhabitants [complement to 100]	74,5	13,2	27,8	91,5
Number of hospital beds per 1000 inhabitants	8,5	4,9	1	30,7
Number of doctors per 1000 inhabitants	2,6	2,6	0,5	12,8
Number of dentists per 10000 inhabitants	5,5	3,9	0,7	16,7
Number of persons directly employed by the local administration in health and social services per 1000 inhabitants	5,2	11,5	0	57,7
Number of days with sulphur dioxide SO2 concentrations not exceeding 125 microgram/m 3 (causes Winter smog)	363,4	2,3	360	365
Number of days with ozone O3 concentrations not exceeding 120 microgram/m3 (causes Summer Smog)	338,3	29,7	297	365
Number of days with nitrogen dioxide NO2 concentrations not exceeding 200 microgram/m 3	349,4	21,7	318	365
Number of dwellings connected to a sewerage treatment system per 100 inhabitants	30,5	18,5	4,5	63,6
Total amount (in tons) of solid waste collected per year per capita	3,1	34,2	0,1	518,7
Schools and Education (W4=4.1%)				
Number of children aged 0-4 in day care per 1000 inhabitants	12	10,5	2,3	46,1
Number of Students registered in the final year of compulsory education per 1000 inhabitants	11	4,3	5,9	29,6
Number of Students in upper and further education per 1000 inhabitants	57,1	30,1	21,5	153
Number of Students in higher education per 1000 inhabitants	72,4	72,2	0	336,9
Number of residents qualified at ISCED level 1 per 1000 inhabitants	73,8	80	1,9	272
Number of residents qualified at ISCED levels 5 and 6 per 1000 inhabitants	140,7	65,8	52,9	322,9
Public Services and Transport (W5=15.7%)				
Number of air passengers using nearest airport (millions)	3,5	11,3	0	113,4
Number of dwellings lacking basic amenities per 100 inhabitants [complement to 100]	96	4,5	87,6	100
Number of jobs in transport or communication per 1000 inhabitants	29	20,7	0	152
Number of private cars registered per 100 inhabitants	34,7	13	18,6	83,8
Number of dwellings connected to a potable drinking water system per 100 inhabitants	27,7	21,2	0	63,4
Recreation (W6=10.9%)				
Number of jobs in trade, hotels or restaurants per 100 inhabitants	8,1	3,8	2,1	20,2
Cinema tickets sold per year per capita	2,3	2,5	0	16,5
Number of museum visitors per year per capita	1	2	0	20,6
Number of theaters per 100000 inhabitants	1,7	2,3	0	21,1
Number of public libraries per 100000 inhabitants	7,1	8,4	0,2	60
Housing (W7=6.2%)				
Number of houses per 100 inhabitants	11,8	9,6	0,4	37,2
Number of apartments per 100 inhabitants	29,6	14,1	0	59,3
Number of households owning their own dwelling per 100 inhabitants	20,1	8,9	0,9	36,3
Number of households in social housing per 100 inhabitants	86,7	11,7	69,1	100
Average price of a house per m 2 (e)	808,9	825,8	86,7	3784
Number of empty conventional dwellings per 1000 inhabitants	27,7	30,8	0,4	175,7
Average area of living accommodation (m 2 per person)	26,7	11	13,1	48,7
Natural Environment (W8=7.1%)				
Average temperature of warmest month (◦F)	68	7,1	58,5	93,2
Average temperature of coldest month (◦F)	34	11,1	19	78,1
Rainfall (liter/m 2) [complement to the maximum value observed]	3	1,3	0	4,2
Number of days without rain per annum	176,2	64	108	333
Number of hours of sunshine per day	4,6	1,4	3,1	8,9

In this selection, indicators which were negatively related to QoL were transformed into positive aspects of QoL, by using the complement to 100 (see variables in the political and social environment, medical and health issues and public services and transport dimensions) or by using the complement to the maximum value observed (see variables in the natural environment dimension), in order to satisfy the basic DEA assumption that higher output values are better. On the other hand, variables discriminated by gender or age were also eliminated. In the case several variables were interrelated, only one of them was selected to avoid redundancy (e.g. from the three variables concerning airports flows - total passengers of airport, incoming passengers and outgoing passengers, we only used the total number of air passengers). We kept variables that could mean a negative aspect in a worldwide context, but that in the European context are positively related to QoL. This is, for instance, the case for number of days without rain, that can be problematic in deserted areas.

From the original ten dimensions considered by Mercer, only 8 were considered in our database: the “Consumer Goods” and “Socio-Cultural Environment” dimensions were excluded. These two dimensions were not considered because the first one concerns the scarcity of food or other items and the second dimension refers to limitations of personal freedom and censorship to the Media. In the European context, all cities analyzed have similar features concerning these dimensions, so they are not discriminative.

Having selected the relevant variables for our study, we then selected the period of analysis. As in the construction of composite indicators described in the previous chapter and for the same reasons there pointed, we used the 2003 campaign. Nevertheless, we still found in this dataset a significant number of variables with missing values. Concerning the treatment of missing values, there are two possibilities: to remove the observation with missing data from the analysis, or to impute values to replace the missing records. In our empirical analysis we adopted the following procedure: the cities with missing data in more than 50% of the variables were removed from the analysis. This reduced the original database of 284 cities to 246 cities.

In the remaining cities, as in the construction of composite indicators presented in the previous chapter, the missing values were replaced by the minimum value observed for the corresponding variable. Although standard procedures of imputation usually involve a substitution by the mean/median/mode, or according to regression analysis, we did not follow these approaches in order to guarantee that cities with no data available are not benefited in the performance assessment in relation to their counterparts. In a total of 12 300 observations considered to be valid, 25% resulted from the substitution of missing values. The variable with the largest number of missing records is the “Number of residents qualified at ISCED level 1 per capita” (48%) while the variable with less missing records is the “Number of infant deaths per year” (2%). The dimension whose number of missing values is the highest is “Schools and Education”, with 32% of missing records, and the dimension with less missing records is “Economic Environment”, with 16%. This means that the urban audit database has a serious limitation concerning missing data, so the results obtained for the composite indicator of the cities reported in this paper should be interpreted with caution, as a city classified with low composite indicator of QoL may have been penalized by the unavailability of data in the Urban Audit database.

The final set of variables considered for this study is presented in table 5.1, as well as the weights assigned to each dimension, which are based on the Mercer framework. Note that the weights of the two dimensions of Mercer not considered in our study, that sum 11%, were proportionally distributed by the eight dimensions considered.

5.2. Quality of Life composite indicator with external weights assignment

As we have explained in chapter 3, composite indicators can be constructed using a DEA model with weights restrictions. Given our aim to incorporate in the analysis the perspective of highly qualified human resources, the dimensions should be given different weights, according to their relative importance for the stakeholders in question. Since we are interested in weighing the dimensions of the QoL indicators in the same way Mercer does, we need to introduce additional weight constraints to the composite indicator model (4.1) presented in the previous section. Although expert opinion is available on the relative importance of the QoL dimensions, as previously stated, we do not know the specific weights that should be attributed to each specific sub-indicator within each dimension.

Model (4.1) is sufficiently flexible to allow imposing restrictions on the weights to be assigned to each dimension of QoL. We specified the restrictions with respect to the percentage share of each dimension according to the Mercer criteria. As argued by Cherchye et al. (2008) and explained before in this thesis, restrictions to virtual output weights, associated to each of the dimensions of QoL considered in our study, are particularly interesting in the context of composite indicators estimation, as these do not depend on the measurement units and directly reveal how the respective dimension contributes to the composite indicator score. However, if the restrictions were imposed to all DMUs being assessed, the DEA model would become infeasible. Therefore, we modified the implementation of the weight restrictions, and only added restrictions to the DMU being assessed, leaving free the relative virtual values of the other DMUs, as suggested by Wong and Beasley (1990).

Such restrictions can be expressed as shown in (5.1)

$$\frac{\sum_{r \in D_z} u_r y_{rj0}}{\sum_{r=1}^{s} u_r y_{rj0}} = w_z \qquad z = 1, \ldots, 8 \qquad (5.1)$$

In our case study, the weights w_z assigned to each dimension are those reported in table 5.1.

5.3. Quality of Life in the perspective of qualified human resources

The composite indicator of QoL in the perspective of qualified human resources shows that 55 of the 246 European cities studied achieved the maximum relative score of the composite indicator of QoL (100%). The full list of cities and their value of the composite indicator is presented in the Appendix F. The best cities, presented in Table 5.2, are mainly from the South of Europe (main cities of Portugal, Spain, Italy and South of France) as well as cities from Germany. Emblematic urban centers from the UK are also considered to be attractive for highly qualified human resources, as well as few cities from Denmark and Netherlands.

Table 5.2. – Best cities in QoL indicator for qualified human resources

Country	Cities
Cyprus	Lefkosia
Czech Republic	Prague
Denmark	Aalborg, Aarhus, Copenhagen, Odense
France	Bordeaux, Montpellier, Poitiers, Toulouse
Germany	Bonn, Düsseldorf, Darmstadt, Dresden Erfurt, Frankfurt, Freiburg im Breisgau, HalleanderSaale, Hamburg, Karlsruhe Magdeburg, Mainz, Munich, Nürnberg Ratisbon, Schwerin, Wiesbaden
Italy	Bologna, Cagliari, Firenze, Milan, Rome Torino,Trento,Venezia
Netherlands	Armsterdam, Arnhem, Eindhoven Groningen, Utrecht, Gravenhage
Portugal	Funchal, Lisbon, Oporto
Spain	Barcelona, Madrid
Sweden	Jönköping, Stockholm
United Kingdom	Bristol, Cambridge, Edinburgh, London Manchester, Newcastle, Stevenage

Looking at the bottom of the ranking, shown in Table 5.3, we can note the presence of Greek cities and also urban centers from the Eastern countries, like

Slovakia, Bulgaria, Slovenia and Lithuania. The Irish cities are also ranked poorly, showing that those urban centers do not perform well in the dimensions considered to be important from the perspective of qualified human resources.

Table 5.3. – Cities with lowest Composite Indicator

Country	Cities (CI)
Austria	Linz (40%)
Belgium	Charleroi (41%)
Bulgaria	Pleven (32%), Ruse (41%), Varna (41%)
France	Paris (41%)
Greece	Irakleio (40%), Kalamakata (41%), Kavala (40%)
	Larisa (39%), Patra (40%), Volos (40%)
Ireland	Cork (36%), Dublin (40%), Galway (33%)
	Limerick (33%)
Lithuania	Kaunas (41%), Panevezys (40%)
Poland	Zory (39%)
Slovenia	Banska Bystrica (41%), Bratislava (41%), Ljubljana (41%)
	Kosice (40%), Maribor (41%), Nitra (39%)

As previously said, DEA is a methodology that provides useful information to guide performance improvements, as it allows the identification of benchmark cities. Urban centers with a low QoL score can look at their peers and copy best practices in the dimensions and variables with potential for improvement. Looking at Dublin (Ireland), with a QoL score of 40%, Table 5.4 illustrates, for some variables, the type of information that can be obtained, namely the peer cities .

The benchmarks selected for the evaluation of this city are Frankfurt (Germany) and Lisbon (Portugal). Concerning the dimension that account for the political and social environment, Dublin can look at Frankfurt to improve performance in terms of participation in European and National elections. In what concerns city elections participation ratio, Dublin can look at the Portuguese capital, which presents a higher level of participation.

Table 5.4. – Dublin peers

			Peers	
		Observed in Dublin	Frankfurt	Lisbon
Dimensions	**Outputs**			
Political and social environment	European elections participation ratio	0.360	0.419	0.418
	National elections participation ratio	0.558	0.770	0.628
	City elections participation ratio	0.349	0.460	0.550
Medical and Health considerations	Number of hospital beds per 1000 inhabitants	0.009	0.011	0.015
	Number of doctors per 1000 inhabitants	0.003	0.002	0.011
	Number of dentists per 10000 inhabitants	0.0005	0.0009	0.0008
	Number of days with nitrogen dioxide NO2 concentrations not exceeding 200 microgram/m^3	350	365	365
Schools and Education	Number of Students in upper and further education per 1000 inhabitants	0.022	0.055	0.046
	Number of Students in higher education per 1000 inhabitants	0.055	0.074	0.233
Recreation	Number of public libraries per 100000 inhabitants	0.0001	0.00004	0.0006
Housing	Number of apartments per 100 inhabitants	0.107	0.451	0*
	Number of empty conventional dwellings per 1000 inhabitants	0.0004	0.0004	0.0714
Natural Environment	Average temperature of warmest month (◦F)	19	20.7	22.8
	Average temperature of coldest month (◦F)	8	1.3	10
	Number of hours of sunshine per day	4	4.3	7.4

In terms of the medical and health dimension Lisbon is also an inspiring example for Dublin concerning the number of hospital beds and doctors per capita. The Irish capital can also copy Lisbon strategies in what concerns the enrollment of students in higher education institutions and in the number of libraries per capita. Lisbon is also a city to look at when assessing the availability of housing (represented by the number of empty dwelling variable), whereas Frankfurt has a high number of apartments per capita.

Finally, despite the importance of the natural environment in the estimation of QoL scores, benchmarking in this dimension is not a possible practice. In fact, when looking to improve QoL, decision-makers cannot alter natural conditions, e.g. number of hours of sunshine per day. However, the existence of targets in this dimension may reveal that political decision makers should search ways to compensate the disadvantages of cities’ natural conditions.

5.3.1. Comparing DEA results with MERCER results

Having constructed a ranking in the same logic as the ranking proposed by Mercer, a comparison of the position of cities involved in both evaluations becomes possible. This comparison aims to validate the methodology used in this paper and to explore its advantages and disadvantages over the Mercer approach.

As previously said, our study uses 2003 data of Urban Audit. The comparison is done with the ranking provided by Mercer in 2009 for the 34 European cities that appear both in the Urban Audit and Mercer. Our option for the last known Mercer Quality of Living survey (for 309 cities worldwide) takes into consideration the fact that no structural changes happened in Europe over this period and that the major transformations are likely to have taken place in the Information Society area, a dimension not considered by Mercer. It is important to note that in the world ranking provided by Mercer, the European cities are positioned above the 113th place (in a total of 309), while in our analysis the European cities are ranked between 1 and 246. Therefore, it is only relevant to compare the relative positions of the cities evaluated.

In order to compare the relative position of cities in both the Mercer ranking and in the results provided by our analysis (Table 5.5) we computed the Spearman correlation. The correlation coefficient obtained was 0.408, which is statistically significant (p=0.017). Despite the differences in the data underlying the construction of the Mercer indicator and the DEA composite indicator, the two rankings should be seen as complementary.

Although different in the nature of the data they analyze, both rankings can be useful to the characterization of European cities. Being broader in its worldwide scope, Mercer's report provides useful insights on how experts and consultants feel the reality of a given city.

Table 5.5. – Composite indicator analysis vs Mercer analysis

Cities	QoL ranking	QoL score	Mercer ranking	Mercer score
Düsseldorf	1	100%	6	107%
München	1	100%	7	107%
Frankfurt am Main	1	100%	8	107%
Copenhagen	1	100%	11	106%
Amsterdam	1	100%	13	106%
Stockholm	1	100%	20	105%
Nürnberg	1	100%	23	104%
Hamburg	1	100%	28	103%
London	1	100%	38	102%
Milan	1	100%	41	101%
Barcelona	1	100%	42	101%
Lisbon	1	100%	44	100%
Madrid	1	100%	48	100%
Rome	1	100%	55	99%
Prague	1	100%	71	94%
Leipzig	75	97%	68	95%
Berlin	79	97%	16	105%
Warsaw	83	96%	85	87%
Budapest	89	95%	74	91%
Lyon	90	95%	37	102%
Glasgow	104	93%	56	99%
Tallinn	110	91%	92	84%
Birmingham	119	90%	57	99%
Bucharest	132	85%	108	78%
Vilnius	184	72%	79	89%
Luxembourg	205	46%	19	105%
Riga	209	45%	90	85%
Brussels	210	45%	14	105%
Helsinki	211	44%	30	103%
Sofia	220	42%	113	75%
Ljubljana	225	41%	78	89%
Bratislava	230	41%	88	85%
Paris	233	41%	33	103%
Dublin	240	40%	25	104%

The approach based on the DEA composite indicator is based on objective data available from national statistics institutes, which facilitates the assessment of QoL to any local decision maker or planner wishing to intervene in this matter.

One advantage of the DEA composite indicator approach is that it enables the assessment of cities QoL with lower costs, as no additional information is required from consultants and experts beyond what is provided by the Urban Audit project. Furthermore, the DEA composite indicator can be seen as a complement for Mercer's evaluation aiming at rewarding expatriated workers within Europe, as the number of European cities with data available is larger. Similarly, the Mercer ranking can be used to compare the QoL of European cities with their worldwide counterparts.

Looking at the results of both rankings reported in Table 5.5, it is possible to conclude that the majority of cities that scored 100% in our composite indicator is also in the top of the Mercer ranking (above position 71). In the lowest positions, although we find similarities, some disparities stand out for a few cities which scored better in Mercer's ranking.

The explanation for the differences is not obvious because the original database and the scores for each dimension are not available in Mercer's ranking, not allowing a close comparison. However, missing values in our database (which were replaced by the minimum value observed) may account for some disparities between the rankings. This is probably the case for Luxembourg, Dublin, Paris and Brussels, since, for instance, the values for the dimension economic environment were missing and thus these cities could not be credited for good economic performance.

5.4. Conclusions

This chapter presented a composite indicator with a system of weighting for the dimensions that results from experts' opinion. As we have seen in chapter 3, restrictions to weights in DEA models are justified when the analysis intends to give due account to prior knowledge available. We maintained, however, flexibility of DEA within each dimension, with the model freely assigning weights to the output variables.

The ranking of the composite indicator of QoL presented for 246 European cities has significant similarities with the Mercer ranking, having the advantage of relying on data available at the European level, which is routinely collected by the national statistical institutes. We enlarged the scope of Mercer's assessment by bringing more European cities into the analysis. Besides providing useful information for local decision-makers and urban planners, it can also be used as an extension of Mercer's evaluation that aims to guide the compensation of qualified human resources for changes in QoL when moving from one city to another.

Different comparisons can be done between the results presented in this chapter and the ones described in the previous chapter. From our point of view, the most relevant comparisons are between composite indicators constructed with a weighting system that assess cities based on the common standards. Comparing results presented in Table 5.2. with results presented in Table 4.4., we can observe a large number of cities with a QoL composite indicator score of 100% when the perspective of human resources is at stake. Cities from southern Europe (Portugal, France, Italy and Spain), which do not achieve high scores in the composite indicator that measures QoL in a global perspective, perform better in what concerns qualified workers. In both composite indicators, cities from Eastern countries rank low. However, in the perspective of qualified human resources, we also find cities from Greece and Ireland with the lowest composite indicator. With these results, we have shown that the evaluation of QoL from the perspective of different stakeholders can be achieved by changing the weighting system of the DEA model.

6. Cities’ efficiency in the promotion of quality of life given the national economic context

In this chapter, we will address the issue of local management by assessing cities’ performance in their ability to induce QoL given the wealth of the country. A measure of European cities’ efficiency will be provided with a DEA model to which new weights restrictions were imposed. Considering that QoL is, in the citizen’s perspective, a multidimensional concept, equal weight was given to all dimensions in order to assess QoL in a balanced approach. Following our purpose to evaluate the ability of local authorities to promote QoL given the economic condition of the country, the measure of efficiency is presented having GDP as the input for the DEA model.

6.1. Urban quality of life and national wealth

For the analysis of cities efficiency in terms of their ability to promote QoL given the economic condition of the country, we defined the GDP per capita as the input of the DEA model. The model developed for this purpose is intended to suggest directions for improvement that may be followed by local administrators.Outputs considered in this approach are the same described in section 4.1, that is, the 29 variables of the City Profile, described by the Urban Audit, for the sample of 206 European cities.

However, to account for the fact that cities are influenced by the different levels of the wealth of their countries, we need to put in perspective the fact that cities cannot be assessed without consideration of national conditions. One possibility would be to introduce national Gross Domestic Product (GDP) per capita of each city as the input, which allows to clearly assess the capacities of local authorities to induce QoL given the national context of their cities.

We did not choose an input focused in urban or administrative dimensions such as the budget of local administrations for cities management, as this option would have presented two kinds of problems: there is not a single model in the European cities for governance separation between local and central administrations, which has obvious implications on the revenues that each city can expect for its budgetary expenses; secondly, not all the outputs considered in the city profile depend exclusively in cities characteristics. Therefore, a value that clearly can be compared at European level and that can be expected to induce QoL is GDP per capita. GDP per capita has previously been used in the literature as an input of a DEA assessment, such as in Wu et al. (2005). In our study, this was the only input variable used to evaluate the cities efficiency in the promotion of QoL.

6.2. Data Envelopment Analysis model to evaluate city efficiency

Since QoL is perceived by citizens as a multidimensional concept, it is important that the improvements suggested lead to a balanced equilibrium between all QoL dimensions, without focusing only on a subset of dimensions in detriment of others. So, we imposed equal virtual weights to each of the nine dimensions of QoL, thus following the suggestion of recognized scholars debated in chapter 2. In this case, as in the construction of the composite indicator of QoL for qualified human resources, the only flexibility allowed in the DEA model concerned the selection of weights for the indicators within each dimension.

However, with this weight specification, if the restrictions were imposed to all DMUs being assessed, the DEA model would become infeasible. Therefore, we modified the implementation of the weight restrictions, and only added restrictions to the DMU being assessed, leaving free the relative virtual values of the other DMUs, as suggested by Wong and Beasley (1990). The model used is shown in (6.1). This model corresponds to an output oriented model, assuming variable returns to scale, as formulated first by Banker *et al.* (1994). The use of this formulation is required because the outputs specified for the assessment of cities' QoL correspond to ratios or percentages (Hollingsworth and Smith, 2003). The optimal solution of the linear programming model (6.1) enables calculating the efficiency score of city j_0, which is given by $1/h_0$.

$$h_0 = Min \sum_{i=1}^{m} v_i x_{ij_0} + \varpi \tag{6.1}$$

$$s.t.$$

$$\sum_{r=1}^{s} u_r y_{rj_0} = 1$$

$$-\sum_{r=1}^{s} u_r y_{rj} + \sum_{i=1}^{m} v_i x_{ij} + \varpi \geq 0 \qquad \mathrm{j = 1,...,n}$$

$$\sum_{r \in Dz} u_r y_{rj_0} = \frac{1}{9} \qquad \mathrm{z = 1,...,9} \tag{6.1.a}$$

$$u_r \geq 0 \qquad \mathrm{r = 1,...,s}$$

$$v_i \geq 0 \qquad \mathrm{i = 1,...,m}$$

$$\varpi \text{ is free}$$

In this model, as the virtual weight restriction (6.1.a) is only imposed to the DMU being assessed, the denominator of the general formulation of this type of weight restrictions (see 3.4) is always equal to one, so the specification of the virtual restrictions reduces to expression (6.1.a), as both α_r and β_r were considered equal to 1/9.

Note that using this formulation it is possible that a DMU considered inefficient by model (6.1) may have as peers DMUs that are also inefficient when evaluated with model (6.1), although they are deemed to be efficient in an evaluation using the unrestricted DEA model. This is explained by the fact that the peers for the DMU under assessment are not subject to weight restrictions, which are only imposed to the DMU under assessment.

6.3. Results for the evaluation of city efficiency in the promotion of quality of life

Applying the DEA model (6.1) to our sample, with national GDP per capita as the input, 19 cities (listed in Table 6.1) were considered fully efficient in terms of the achievement of good QoL standards given the national economic context (see Appendix G for complete list). In order to discriminate between the most efficient cities, we can use a complementary measure given by the number of times that those cities are peers for others in the DEA assessment. When this measure is considered, Dresden and Helsinki are the cities that are more frequently selected by others as benchmarks.

Looking at the efficient cities listed in Table 6.1, we realize that Germany (4 cities) is highly represented, as well as capital cities (6 cities). The presence of cities from Eastern Europe stands out, especially from Bulgaria (but also from Romania, Slovakia and Estonia). This does not mean that these cities are the best in terms of QoL, but that the values of the QoL indicators are good and well balanced across all dimensions, given the level of GDP.

Table 6.1. – List of cities with the maximum efficiency score in the assessment contextualised by GDP.

Cities	No. of times as peers
Dresden (Germany)	74
Helsinki (Finland)	71
Frankfurt am Main (Germany)	30
Nitra (Slovakia)	30
Tartu (Estonia)	29
Groningen (Netherlands)	22
Bratislava (Slovakia)	20
Luxembourg (Luxembourg)	15
Cluj-Napoca (Romania)	9
Freiburg im Breisgau (Germany)	8
Ruse (Bulgaria)	4
Timisoara (Romania)	3
Tallinn (Estonia)	2
Varna (Bulgaria)	1
Schwerin (Germany)	0
Wien (Austria)	0
Plovdiv (Bulgaria)	0
Burgas (Bulgaria)	0
Sofia (Bulgaria)	0

The cities where intervention may be more in need are shown in Table 6.2. These correspond to the cities below the 10th percentile, and are mainly from Italy (9) and France (6), with UK, Spain and Germany having two cities each in the bottom of the list. We can conclude that these cities, all western urban centers and belonging to old EEC, present low levels of QoL, given their national economic context (when compared, for example, to Eastern cities).

Table 6.2. – List of cities below the 10th percentile in the efficiency assessment

City	Efficiency score
Verona (Italy)	25%
Limoges (France)	25%
Dijon (France)	25%
Catania (Italy)	25%
Le Havre (France)	25%
Trieste (Italy)	24%
Nice (France)	24%
Reims (France)	24%
Bari (Italy)	24%
Marseille (France)	24%
Palermo (Italy)	24%
Napoli (Italy)	24%
Taranto (Italy)	23%
Ajaccio (Italy)	23%
Reggio di Calábria (Italy)	23%
Portsmouth (UK)	21%
Moers (Germany)	19%
Múrcia (Spain)	18%
Frankfurt (Oder) (Germany)	17%
Wrexham (UK)	16%
Santander (Spain)	10%

Using this methodology, we can identify a relevant group of cities with relatively low efficiency scores, thus presenting an opportunity for the development of operational tools aimed at improving QoL. In these cities, the output variables can be targeted to higher standards observed in other cities, constituting the benchmarks.

To understand the opportunities presented by this methodology of evaluation of cities efficiency, we can use Milan (Italy, capital of the North) as an illustrative example and point out where to look to improve the city performance. Table 6.3. presents the original values of the input and output indicators of Milan, which has an efficiency score of 25%. The values of the output indicators for the peers, i.e., the efficient cities to which Milan is compared in the estimation of efficiency, are also shown. The outputs for which Milan has missing data were omitted from Table 6.3. The values of the output indicators signaled by an asterisk indicate that the city has originally missing data on that indicator, which was replaced by the minimum value observed in the sample. The value of λ shown in Table 6.3. for each of the peers, obtained from the optimal solution to dual model of formulation (6.2), provides an indicator of the degree of similarity between the city under assessment (Milan), and the corresponding peer.

Table 6.3. – Peer cities for Milan

		Observed in Milan	Peers			
			Frankfurt (λ = 0,128)	Erfurt (λ = 0,017)	Helsinki (λ = 0,818)	Tartu (λ = 0,037)
PIB per capita	**I1**	27119	27756	27756	27619	13539
Demography	**O1**	2	**12**	7	0*	0*
Social aspects	**O6**	55	16	30	44	**67**
Economic aspects	**O11**	94	**95**	85	91	**95**
	O12	94	**96**	85	93	61*
	O13	45	51	**54**	**54**	42
Education	**O17**	56	45	60	**80**	51
Environment	**O20**	323	**339**	297*	297*	297*
	O22	4	3	**100**	0*	44
	O23	11	23	**191**	16	0*

The analysis of the data reported in Table 6.3. shows where the best practices for each of the outputs considered can be found. In this illustrative case, considering the environment dimension and looking specifically to green space (O23) and treatment of solid waste (O22), Milan can improve its performance applying the policy of Erfurt (Germany). And in what concerns air pollution (O20), the capital of North Italy has lessons to learn from Frankfurt am Main (Germany). In the training and education dimension, Italian policy-makers have to study Helsinki (Finland) strategy to include a bigger number of children between ages 0 and 4 in day care institutions (O17). In what concerns the activity rate (O13), Erfurt and Helsinki show an inspiring performance for Milan. This city can also use Frankfurt am Main as an example for improving its female employment rate (O12) and employment rate (O11). Tartu (Estonia) is an example to follow in what concerns percentage of households living in owned dwellings (O6). Finally, in the demography dimension, Frankfurt and Erfurt (to a lower extension) are examples for Milan in what concerns population change over a period of two years (O1).

6.4. Conclusions

In this chapter we presented an assessment of the cities performance in their ability to induce QoL given the wealth of their country. This contextualized approach reveals a new perspective in terms of the socio-economic development of European cities: cities from richest countries are not necessarily the most efficient in using GDP to promote QoL and urban centers in countries with less performers economies can provide solutions with good and well balanced values of the QoL indicators.

The results presented in this chapter also show how local management can be improved with benchmarking strategies using DEA technique to identify the cities that perform better given national economic conditions, thus identifying current experiences of good urban administrative practices promoting QoL that can be copied by other cities.

These results present a different perspective in the analysis in urban QoL from the approaches of the two previous chapters. Here, we do not look only at cities' achievements, but contextualize the evaluation within a more macro-level, the national one. And we bring, for instance, a new perspective on the cities from

Eastern countries, that ranked low in the composite indicators presented in chapter 4 and 5. When we consider GDP, these urban centers present high levels of efficiency, showing that in the promotion of QoL, they are able to obtain a good return from the economic national context.

7. Grasping perceptions of citizens on local management

Given our purpose to present an evaluation of cities' QoL and having established in chapter 2 the importance attributed to the subjective assessment, the perspective of citizens cannot be ignored. What citizens think of urban management is an essential aspect in the equation of QoL. This chapter will present an explanation of citizens evaluation of local management, accounted by the judgment of local expenditure, identifying which factors contribute the most. As in the other assessments presented in this work, the Urban Audit program provides the data used.

Our purpose is to deepen the understanding of QoL, namely by trying to explain citizens perception on what improves or worsens QoL local expenditure. This objective will be accomplished by logistic regression, a statistical technique concerned with describing the relationship between a binary response variable and one or more explanatory variables.

7.1. The perception of citizens on urban issues

To assess the perception of citizens on the efficiency of local management, in what concerns QoL, our study used data provided by the surveys administered in 2006 and 2009 by Urban Audit, whose results were published the following year. Following the assessment of citizens' perception, Urban Audit presented reports on the subjective aspects of QoL, where 29 variables (see Appendix B) were identified in the 2010 report. Because the campaign of 2004 involved only 31 cities, the data collected in this year was not considered for this study.

According to each question, the variables are grouped into three types (level of satisfaction, agreement to sentences or frequency of behaviors), being associated with a four-level scale according to the intensity of the response. The results presented by Urban Audit correspond to the assignment of a final value to each variable, resulting from the subtraction of the frequencies of the two negative levels of the scale to the frequencies observed the two positive levels. For instance, for the variable "clean city" and using the city of Madrid (Spain) as an example, 10% of citizens strongly agreed, 45% somewhat agreed, 35% somewhat disagreed and 10% strongly disagreed. The final score for Madrid for this variable is equal to 10% [(10+45) – (35+10)].

Regarding the aim of this study, the variable related to good/bad allocation of resources is defined as the dependent variable. In fact, the answers of citizens to this question can provide an image of the citizens' perception regarding the quality of urban management in the promotion of QoL. Citizens judge the allocation of resources done by local managers as good or bad based on a criterion that cannot be separated from their concept of QoL: a good management is likely to induce QoL, whilst a bad management will probably lead to its deterioration. Research has shown that public spending has effects in QoL (Gabriel et al, 2003) and has also linked satisfaction with local management to the perception on QoL: the global satisfaction measures of local government were demonstrated to be predictive of global community satisfaction (Sirgy et al, 2000). Thus, to a certain extent, the variable good/bad "responsible expenditure of resources" can be considered a "proxy" of the perception of QoL.

The independent variables are then variables that presumably indicate which factors lead citizens to judge how good or bad the allocation of local resources is. Six variables of Urban Audit surveys data were excluded, because they were not directly linked to local management, particularly those relating to health care services, the employment market, emigration issues and personal socio-economic difficulties of citizens.

The new variables introduced in 2009 which follow a different kind of questioning were also eliminated from our study, as they do not assess perception directly (like minutes spend in reaching workplace, means of transport use, frequency of public transport use and reasons not to use public transport, as well as the identification of the 3 most important issues in the cities). With these eliminations, a solid core set of variables from 2006 e 2009 is guaranteed, thus enabling the use of the 2006 data to validate the model calibrated with the data from 2009. We also withdrew from the sample the city of Rostock, as it was not included in the 2006 surveys. Our final sample is then constituted by 18 variables (see table 7.1.) evaluated in 74 cities in two years (2006 and 2009). The dependent variable is "Responsible expenditure of resources by city", which can assume values of 0 (when the difference between the two positive levels of perception and the two negative levels is less than or equal to zero) or 1 (when that difference is positive), all the 17 others being potential independent explaining variables.

Table 7.1. – Variables selected for the logistic regression

Type of variable	Description
Dependent variable	Responsible expenditure of resources by city
Potential independent variable	Public transport
	Sports facilities
	Cultural facilities
	Beauty in neighborhood
	Public spaces
	Green spaces
	Outdoor recreation opportunities
	Good housing at a reasonable price
	Trust in people
	Poverty as a problem
	Efficient administrative services
	Air pollution
	Noise
	Clean city
	Healthy city
	Safety in the city
	Safety in neighborhood

7.2. Logistic Regression

The logistic regression can be used with the purpose to explain one nominal or ordinal dependent variable by using nominal, ordinal or continuous independent variables. This methodology has become standard in any data analysis trying to describe the relationship between a response variable and one or more explanatory variables. This technique allows to better understand the effects of the independent variables, not simply predicting if an event will occur or not, but also the probability of the event. The main difference between a regression model and a linear progression model is that the outcome variable is binary or dichotomous (Hosmer and Lemeshow, 2004). Generally, this variable results from *n* independent and identical trials with two possible outcomes for each, referred to as “success” and “failure.” These are generic labels, and the “success” outcome need not be a preferred result.

Data are unbalanced if $y = 1$ occurs relatively few times or if $y = 0$ occurs relatively few times. This limits the number of predictors for which effects can be estimated precisely. When the purpose is not to predict events few events per predictor variable can be used (Vittinghoff et al., 2006). Nevertheless, the rule of thumb is that logistic models should be used with a minimum of 10 events per independent variable. Several simulation studies developed by Peduzzi et al. (1996) showed an increasing bias and variability, unreliable confidence interval coverage, and problems with model convergence, as that number declines below 10. The reasonable conclusion led to the consolidated practice of using a minimum of 10 events per predictor variable. This guideline is approximate, but should be followed closely (Agresti, 2007).

Another precaution that should be followed when constructing a model is the collinearity effect, that can appear in models with several predictors that can overlap with each other. Deleting such redundant predictors should be an initial procedure to reduce standard errors of other estimated effects (Agresti, 2007).

Being a simplification of a complex reality, models do not always describe the reality intended. “However, a simple model that fits adequately has the advantages of model parsimony. If a model has relatively little bias, describing reality well, it provides good estimates of outcome probabilities and of odds ratios that describe effects of the predictors" (Agresti, 2007: 141). The summary of the predictive power of a binary regression model can be provided by a classification table, that cross classifies the dichotomous outcome *y* with a prediction of whether *y* is equal to 0 or 1. And, since there is no guarantee that the model fits the data in any logistic regression model, tests, like the Qui-Square, should be run in order to check if the model fits.

If one considers the potential independent variables presented in Table 7.1., it is easy to conclude that some overlapping exists between their underlying concepts. In fact, given the ongoing nature of the urban living and experiences, a good or bad perception of a particular factor is not easily isolable. For instance, the variable "Efficient administrative services" can give account of the level of satisfaction with "Sports facilities" and "Outdoor recreation opportunities". Moreover, the concept of "Clean city" is more comprehensive than the sole concept of cleanliness and surely includes the notions of beauty, health and safety. This fact recommends the adoption of a multiple regression model. On the other hand, the option for a dichotomous dependent variable - good (positive) or bad (negative) spending of resources - requires the use of multiple logistic regression model (Hair et al., 1995).

The evaluation process of citizens for each city was then modeled through a logistic regression (Agresti, 2002; Freund & Wilson, 1998), where the dependent binomial variable represented the assessment of citizens: good (1) or bad (0) allocation of resources. The results of the statistical tests and also the Nagelkerke R^2 value showed that the logistic regression was a good option in modeling the assessment of local management.

As explained, the number of predictors has to be limited to a maximum of 10 outcomes of each type for every predictor. According to this guideline, our reasonable number of predictor variables should be seven or, at most, eight (note that the study includes 74 cities). Consequently, 9 variables of our initial set of 17 possibly independent variables have to be eliminated. The selection of the variables that were kept in this study was the consequence of the results obtained with the logistic regression with a single independent variable and also from the analysis of collinearity, as presented in the following section.

7.3. Developing an explanatory model

The selection of explanatory variables for the multiple logistic regression model was done gradually and in several steps. Initially, the variables explaining the largest proportion of variation of the dependent variable were selected, under the condition of being significant from a statistical point of view. Accordingly, single logistic regressions using each one of the 17 potential independent variables were tested. Adopting a significance level of 5%, two variables were identified as not significant and therefore removed from further analysis. These were: "Cultural facilities" and "Good housing at a reasonable price." In other words, it seems that from the point of view of citizens, local efficiency in improving the QoL is not achieved by culture or by housing prices.

In a second step, and in order to reduce the effects of collinearity, we searched for variables showing a strong correlation (Pearson correlation coefficient above 0.85). Four variables strongly related to four others were removed (in each pair, it was discarded the variable that exhibiting the lowest correlation pattern with all the other variables). Thus, the variables "Public spaces", "Trust in people", "Safety in neighborhood" and "Air pollution" were excluded. At the end of this procedure 11 variables (out of the previous 15) remained (see Appendix H for table with complete results of Pearson correlation coefficients).

Additionally, a paradox was detected: the positive association between seeing poverty as a problem and simultaneously having a good impression of local management. It was decided to eliminate the variable “Poverty as a problem”, since the sociological explanation for this fact is not evident (are the resources well spent because they are not "wasted" with the poor or does a good impression of local management make citizens more susceptible to the problem of poverty?).

Following the suggestion of Peduzzi et al. (1996), an additional effort had to be done in order to reduce the set of independent variables (from 10 to 8 variables, at most). So, a qualitative assessment of the variables showed that the variables "Noise" and "Green spaces" are closely related to the concept of "Healthy city". In terms of elimination criteria, those two variables are, presumably, a good choice. Additionally, a single logistic model using each one of the 10 remaining variables was built. A ranking following the value of Nagelkerke R^2 (which is comparable to the R^2 in multiple regression) was then constructed in order to identify those variables that most explain the variation observed in dependent variable (see table 7.2.).

Table 7.2. – Ranking of factors following R^2 of Nagelkerke.

Independent Variable	R^2 Nagelkerke
Efficient administrative services	50.2%
Clean city	32.6%
Public transports	29.5%
Beauty in neighborhood	27.1%
Safety in city	24.4%
Sports facilities	23.1%
Outdoor recreation opportunities	19.1%
Healthy city	18.3%
Noise	16.1%
Green spaces	14.8%

Based on the common results of these two analyses, the elimination of both variables "Noise" and "Green spaces" was decided.

Finally, a multiple logistic regression using the first 8 variables of table 7.2. was carried out. The results are presented in table 7.3.

Table 7.3. – Results of significance level in logistic regression

Variable	Significance level
Efficient administrative services (EAS)	0,000
Clean city (CC)	0,003
Public transports	0,029
Beauty in neighborhood	0,131
Safety in city	0,911
Sports facilities	0,719
Outdoor recreation opportunities	0,399
Healthy city	0,495

These results led to the conclusion that the only three factors explaining citizens perceptions of the good or bad allocation of local resources are (at the 5% significance level): “Efficient administrative services”, “Clean city” and “Public transports”.

Multiple logistic models including, successively, these three variables and groups of two were built. In all these models the variable "Public transport" was not statistically significant. Accordingly, the final logistic regression model, in which Y is the dependent variable (good or bad “Responsible expenditure of resources by city”) only includes “Efficient administrative services” and “Clean city” as independent variables.

The model is given by

$$P(Y) = \frac{e^{(-1.930+0.091EAS+0.024CC)}}{1+e^{(-1.930+0.091EAS+0.024CC)}} \qquad (7.1)$$

with *P(Y)* taking values between 0 and 1, and *EAS* being the explanatory variable “Efficient administrative services” and *CC* “Clean city”. If *P(Y)* is closer to 1 than to 0, then *Y*, the dependent variable - good or bad “Responsible expenditure of resources by city”, takes the value of 1 (meaning “good responsible expenditure of resources by city”). If *P(Y)* is closer to 0 than to 1, then *Y* takes the value of 0 (meaning “bad responsible expenditure of resources by city”).

Therefore, the variables that explain, to a certain extent, the meaning and intensity of citizens’ awareness of local management in promoting QoL are: “Efficient administrative services” and “Clean city”. The results of the final logistic regression are presented in Table 7.4.

Table 7.4. – Results of the logistic regression

	Coefficient	Significance level
Efficient administrative services	0.091	0.000
Clean city	0.024	0.008
Constant	-1.930	
Nagelkerke R2	0,591	

For each outcome of the citizens’ evaluations of the local management (0 or 1), the cases classification table (Table 7.5.) cross tabulates the expected agreement between model predictions and actual results in each city. For example, the model predicted a bad evaluation (0) for 35 cities, in which 28 were effectively bad classified by citizens and seven had a result of (1). The proportion of correct “bad” evaluation is 82,4%. The percentage of correct “good” evaluation is 82,5%.

Table 7.5. – Classification of cases and estimation of the logistic regression parameters for 2009 data

		Responsible expenditure of resources by city predicted		
		0,00	1,00	Percentage correct
Responsible expenditure of resources by city observed	0,00	28	6	82,4
	1,00	7	33	82,5
Overall percentage	82,4			

7.4. Model validation

Having defined an explanatory model for the subjective assessment of local management based on 2009 data from the Urban Audit, the next step was the validation of this model. To meet this objective, the regression model (7.1) was applied to the 2006 data, in order to predict the perception on the good or bad allocation of resources in the management of each city.

Then, we firstly realized a chi-square test of independence using predicted values and those actually observed in 2006. Based on the results, the null hypothesis of independence between two variables was rejected ($p < 0,05$). This result is a good indication that the estimates provided by the model with data obtained from 2009 fit the data previously observed in 2006.

Secondly, the classification table provided (Table 7.6.) shows a good percentage of prediction. For instance, based on the results of 2009, the model predicted for the 2006 campaign 36 cities with a bad (0) evaluation, for which 27 were effectively assigned a bad evaluation from citizens, and 38 cities with a good (1) evaluation, for which 29 effectively received a good assessment. The overall percentage of correct prediction is 75,7%.

Table 7.6. – Classification of cases and estimation of the logistic regression parameters for 2006 data

		Responsible expenditure of resources by city predicted		
		0,00	1,00	Percentage correct
Responsible expenditure of resources by city observed	0,00	27	9	75,0
	1,00	9	29	76,3
Overall percentage	75,7			

The model results indicate that the explanatory model of 2009 is compatible with the 2006 data. Thus, we provide local managers with a tool to program local expenditures when their aim is to fit citizens' perception concerning good local investment.

7.5. Conclusions

In this chapter, logistic regression was applied to Urban Audit survey's data in order to explain what factors citizens associate with good local management, assessed by the perception on the responsible expenditure of resources. The results showed that citizens' perception of the quality of local management is explained by the perception they have on the administrative services and about the cleanliness of the city.

Access to culture, as measured by the existence of equipments, does not seem to influence the subjective assessment of the residents of a given city concerning the quality of local management. Also the functioning of the housing market is not relevant in the equation drawn by the citizens. Moreover, although they have certainly some meaning for citizens, issues like the beauty of the city and availability of equipment for sports or outdoor activities are not highly relevant to judge local management.

This explanatory model was also proven to be a predictor of the perception of citizens. Our results showed significant association between the expected assessment in the 2006 data, given the evaluation of citizens of the administrative services and cleanness of the city, and the observed one. This means it can help local decisors to plan future actions that seek to intervene in issues of urban management according to the perceived QoL.

8. Concluding remarks and future research

Urban QoL is an issue of undeniable importance for local policy-makers and for citizens. The relevance of QoL in policies and academic research is expected to grow, given the increasing number of people now living in urban contexts. This is why, in this particular issue, scientific research should offer knowledge to support local, national and supranational policies that aim to increase QoL. This thesis is a contribution to this desirable relationship, providing clear and synthetic information on urban QoL that can be used to design and implement interventions by local managers or national decisors.

The research described in this thesis brings about an effort to measure, evaluate and compare urban QoL, given different perspectives. In a first moment, it looks at each city, emphasizing the best it can offer by proving an evaluation that highlights its best features. This information is important to any local decisor that wants to understand the strengths and weaknesses of its cities, but it does not provide comparable information on cities. This is why, in a second moment, we focused on an evaluation performed on common standards to help local managers to situate their city in a more global context.

Local interventions aiming at increasing QoL can also target to different stakeholders. For instance, the importance of qualified human resources, and their perception of QoL, cannot be ignored in the evaluation of cities competitiveness. In new economies, attracting human capital means attracting firms and investment and thus economic development for cities. This thesis presents an evaluation of QoL in the perspective of qualified human resources, showing what are the cities best prepared to attract this skilled workforce and providing information for each specific urban context that can be used in policies aiming at investments and economic developments.

Cities can also be analyzed in terms of local management by relating the achievements in terms of urban QoL with the national wealth. We provide a measure of cities' efficiency in terms of QoL, given the national GDP, thus showing which cities perform best taking into consideration the national economic context.

Because we have different perspectives in the analysis, the same city can present very diverse results. For instance, Ruse and Varna (from Bulgaria) present a low QoL composite indicator, either in a global perspective (presented in chapter 4), either from the perspective of qualified human resources (presented in chapter 5). But, when we measure their efficiency, considering national GDP, these two cities present a score of 100%. Interesting, though, is the fact that cities from Germany are always well represented in the best positions, whatever the perspective adopted. And some of them appear with the best results in all the analysis: it is the case of Dresden, Frankfurt am Main and Freiburg im Breisgau and also of Groningen (from Netherlands).

As we have seen, improvements in this field can lead to a growing competitiveness of cities, but making the right decisions is not an easy task. Thus, benchmarking is an opportunity for cities to learn with other experiences, establishing performance targets that can be reproducible in order to improve QoL for citizens. In these evaluations we proposed, we also identify best practices to help benchmarking strategies.

This research provides another tool to support local managers: an explanation on the factors that citizens associate with a good allocation of public resources. Any plan of public local investment that puts citizens in the heart of the intervention should know what is best valued by them in order to organize responsible expenditures.

An important asset of this research is that it relies on data that is available to all and recognized as a sound and reliable characterization of QoL. The Urban Audit project is a major contribution to the knowledge of QoL but lacks a more readable and operational frame to help local decisors. With this research we hope to have made sense of this vast information, presenting it in the form of composite indicators and efficiency measures. We expect this approach can not only help local decisors, but also support any European policy funds distribution with the goal to promote regional cohesion in urban matters, either by rewarding good QoL or by compensating good practices.

This work shows that DEA is a methodology that can be used to assess QoL of cities and to support decision making by local authorities. As DEA is a methodology that enables each city to obtain the best possible score by a weight assignment that emphasizes the best dimensions, subjective bias in the assessment of efficiency can be avoided. On the other hand, this approach makes clear that when a city is classified as inefficient, it means that its peers presented better performance, and that the result does not depend on subjective weight assumptions which could be criticized.

Following a recent line of research in the field of composite indicators with DEA, we have also shown that the establishment of a ranking of cities is possible, through the construction of a composite indicator that only looks at the output achievements assessed on the basis of a common set of weights. This approach, using goal programming, makes the comparison of cities possible as it is based on equal parameters regarding the relative importance of the dimensions of QoL. This approach, besides contributing to the actual debate on composite indicators and weights restrictions, has allowed improving the discrimination of the DEA model and thus provides a more precise picture of cities performance.

Another composite indicator of QoL, using Urban Audit data, was presented, adapting Mercer’s dimensions and weighting system. The best cities to live in, from the perspective of highly qualified human resources, were shown. Also in this case, this methodology has allowed identifying the benchmarks that cities with low QoL should follow in order to improve their performance, by copying best practices.

As said before, cities are increasingly competing for investments and qualified human resources. But with this study of cities performance we show how cities, competing for investment and human capital (that may be more attracted by efficient cities), can cooperate in order to attain higher levels of development. Thus, with a DEA approach to urban QoL, we can provide a useful framework to the concept of "co-opetition" (a combination of the words competition and cooperation), introduced as a major challenge for European cities by Gérard Collomb, former president of the network Eurocities, in an interview to the publication Futuribles (Collomb and Haentjens, 2009).

With DEA it is also possible to identify the most efficient cities in terms of maximizing QoL, taking into account the national economic conditions. Weight restrictions were further tightened, to guarantee a balanced equilibrium between all QoL dimensions. This approach enables an assessment of cities performance in a balanced multidimensional frame, given the national wealth, and assigns peers for the cities considered inefficient.

Notwithstanding the importance of objective factors to promote QoL, the subjective evaluation of citizens who are recipients of political action should be taken into account and assessed by any instrument of urban planning. We presented an explanatory model, based on the logistic regression methodology, for the perception of local management efficiency by the citizens. Moreover, this explanatory model was also proven to be a predictor of the perception of citizens. This means it can help local decisors to plan future actions that seek to intervene in issues of QoL according to what is the perception of residents of European cities.

Some limitations of this study can be pointed out. Possibly due to the fact that it is still a recent project, Urban Audit is still faced with a significant number of cases with missing data. The more this project can overcome the absence of information, the more operative will become this new tool we explored for assessing urban QoL.

The results of cities performance assessment here presented would obviously be different if other assumptions, namely in terms of the weighting system or the perspective of different stakeholders, had been adopted. But the main purpose of this work is achieved by the demonstration of the potential of the DEA methodology in the analysis of urban performance. What is also demonstrated is that the models here presented can be easily adjusted, in terms of the weighting system, in accordance with other perspectives of urban QoL from different stakeholders, thus opening a door to a vast field of work.

Another future line of research should now focus in the combination of both approaches adopted in this work: the objective assessment, made possible by data of Urban Audit, and the subjective assessment, using the Urban Audit surveys to European citizens. This means that research could assess the relationship between the perception of good QoL and the objective indicators of QoL collected by Urban Audit. This work will possible after 2011, when national census throughout European countries will coincide in time with the administration of surveys to citizens.

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APPENDIX

APPENDIX A

List of variables of Urban Audit (2003) by dimensions

Demography
Total Resident Population
Male Resident Population
Female Resident Population
Total Resident Population 0-4
Male Resident Population 0-4
Female Resident Population 0-4
Total Resident Population 5-14
Male Resident Population 5-14
Female Resident Population 5-14
Total Resident Population 15-19
Male Resident Population 15-19
Female Resident Population 15-19
Total Resident Population 20-24
Male Resident Population 20-24
Female Resident Population 20-24
Total Resident Population 25-54
Male Resident Population 25-54
Female Resident Population 25-54
Total Resident Population 55-64
Male Resident Population 55-64
Female Resident Population 55-64
Total Resident Population 65-74
Male Resident Population 65-74
Female Resident Population 65-74
Total Resident Population 75 and over
Male Resident Population 75 and over
Female Resident Population 75 and over
Residents who are Nationals
Residents who are Nationals of other EU Member State
Residents who are not EU Nationals
Nationals born abroad
Total Number of Households
One person households (Total)
Lone parent households (Total)
Lone parent households (Male)
Lone parent households (Female)
Lone pensioner (above retirement age) households Total
Lone pensioner (above retirement age) households Male
Lone pensioner (above retirement age) households Female
Households with children aged 0 to under 18
Nationals that have moved into the city during the last two years
EU Nationals that have moved into the city during the last two years
Non-EU Nationals that have moved into the city during the last two years
Social aspects
Number of dwellings
Number of houses
Number of apartments
Number of households living in houses
Number of households living in apartments

Social Aspects
Households owning their own dwelling
Households in social housing
Households in private rented housing
Number of homeless persons
Average price for an apartment per m2
Average price for a house per m2
Annual rent for social housing per m2
Average annual rent for an apartment per m2
Average annual rent for a house per m2
Dwellings lacking basic amenities
Average occupancy per occupied dwelling
Empty conventional dwellings
Non-conventional dwellings
Average area of living accommodation (m2 per person)
Life expectancy at birth
Male life expectancy at birth
Female life expectancy at birth
Infant Mortality per year
Male Infant Mortality per year
Female Infant Mortality per year
Number of live births per year
Number of live births per year (Male)
Number of live births per year (Female)
Number of deaths per year under 65 due to heart diseases and respiratory illness
Number of deaths per year under 65 due to heart diseases and respiratory illness (Male)
Number of deaths per year under 65 due to heart diseases and respiratory illness (Female)
Total deaths under 65 per year
Total deaths under 65 per year (Male)
Total deaths under 65 per year (Female)
Total deaths per year
Total deaths per year (Male)
Total deaths per year (Female)
Number of hospital beds
Number of hospital patients
Number of doctors (FTE)
Number of dentists (FTE)
Total number of recorded crimes within city [country for national data]
Number of murders and violent deaths
Number of car thefts
Economic Aspects
Total Economically Active Population
Male Economically Active Population
Female Economically Active Population
Total Economically Active Population 15-24
Male Economically Active Population 15-24
Female Economically Active Population 15-24
Total Economically Active Population 55-64
Male Economically Active Population 55-64
Female Economically Active Population 55-64
Residents Unemployed
Male Residents Unemployed
Female Residents Unemployed
Residents Unemployed 15-24
Male Residents Unemployed 15-24
Female Residents Unemployed 15-24

Economic Aspects
Residents Unemployed 55-64
Male Residents Unemployed 55-64
Female Residents Unemployed 55-64
Unemployed continuously for more than six months, 15-24
Male unemployed continuously for more than six months, 15-24
Female unemployed continuously for more than six months, 15-24
Unemployed continuously for more than one year, 55-64
Male unemployed continuously for more than one year, 55-64
Female unemployed continuously for more than one year, 55-64
Residents in Self Employment
Male residents in Self Employment
Female residents in Self Employment
Residents in Paid Employment
Male residents in Paid Employment
Female residents in Paid Employment
Total Full-Time Employment
Male Full-Time Employment
Female Full-Time Employment
Total Part-Time Employment
Male Part-Time Employment
Female Part-Time Employment
Total Full-Time Employment 15-24
Full-Time Employment 15-24 Male
Full-Time Employment 15-24 Female
Total Full-Time Employment 55-64
Full-Time Employment 55-64 Male
Full-Time Employment 55-64 Female
Total Part-Time Employment 15-24
Part-Time Employment 15-24 Male
Part-Time Employment 15-24 Female
Total Part-Time Employment 55-64
Part-Time Employment 55-64 Male
Part-Time Employment 55-64 Female
Gross Domestic Product of city / region / country
Total resident population of area [country] relating to reported GDP
Total employment of area [country] relating to reported GDP
All companies
Companies with headquarter within the city [country] quoted on national stock exchange
New business registered in reference year
ec2014v Companies gone bankrupt in reference year
Total net office floorspace 1st January
Vacant net office floorspace 1st Jaunuary
Total employment / jobs (work place based)
Employment (jobs) in agriculture, fishery (NACE Rev. 1: A-B) & ESA95 A3
Employment (jobs) in mining, manufacturing, energy (NACE Rev. 1: C-E)
Employment (jobs) inconstruction (NACE Rev. 1: F)
Employment (jobs) in trade, hotels, restaurants (NACE Rev. 1: G-H)
Employment (jobs) in transport, communication (NACE Rev. 1: I)
Employment (jobs) financial intermediation, business activities (NACE Rev. 1: J-K)
Employment (jobs) in public admin., health, education, other (NACE Rev. 1: L-P)
Employment (jobs) in Nace Rev. 1 C-F (ESA95 A3)
Employment (jobs) in Nace Rev. 1 G-P (ESA95 A3)
Employment (jobs) – employees
Employment (jobs) - self employed
Median disposable annual household income
Household Income: Quintile 4 (income with 20% households above, 80% below)

Economic Aspects
Household Income: Quintile 3 (income with 40% households above, 60% below)
Household Income: Quintile 2 (income with 60% households above, 40% below)
Household Income: Quintile 1 (income with 80% households above, 20% below)
Total Number of Households with less than half of the national average income
Total Number of Households reliant on social security benefits (>50%)
Individuals reliant on social security benefits (>50%)
Civic Involvement
European Elections: Total electorate (eligible)
European Elections: Total electorate (registered)
European Elections: Total votes counted
National Elections: Total electorate (eligible)
National Elections: Total electorate (registered)
National Elections: Total votes counted
City Elections: Total electorate (eligible)
City Elections: Total electorate (registered)
City Elections: Total votes counted
City Elections: Electorate aged less than 25
City Elections: Total votes counted by voters aged less than 25
Total number of elected city representatives
Number of Male elected city representatives
Number of Female elected city representatives
Total Municipality Authority Income
Municipality Authority Income derived from local taxation
Municipality Authority Income transfered from national or regional government
Municipality Authority Income derived from charges for services
Municipality Authority Income derived from other sources
Total Municipality Authority Expenditure
Total number of persons directly employed by the local administration
Number of persons directly employed by the local administration in central administration
Number of persons directly employed by the local administration in education
Number of persons directly employed by the local administration in health and social services
Number of persons directly employed by the local administration in public transport
Number of persons directly employed by the local administration in other
Training and Education
Number of children 0-4 in day care
Number of children 0-4 in private day care
Number of children 0-4 in public day care
Number of children 0-4 in other day care e.g. Church
Total students registered for final year of compulsory education
Students leaving compulsory education without having a diploma
Students continuing education after completing compulsory education
Male students continuing education after completing compulsory education
Female students continuing education after completing compulsory education
Students in upper and further education (ISCED level 3-4)
Male students in upper and further education (ISCED level 3-4)
Female students in upper and further education (ISCED level 3-4)
Students in higher education (ISCED level 5-6)
Male students in higher education (ISCED level 5-6)
Female students in higher education (ISCED level 5-6)
Total number of residents qualified at ISCED level 1
Number of Male residents qualified at ISCED level 1
Number of Female residents qualified at ISCED level 1
Total number of residents qualified at ISCED level 2

Training and Education
Number of male residents qualified at ISCED level 2
Number of female residents qualified at ISCED level 2
Total number of residents qualified at ISCED levels 3 and 4
Number of male residents qualified at ISCED levels 3 and 4
Number of female residents qualified at ISCED levels 3 and 4
Total number of residents qualified at ISCED levels 5 and 6
Number of male residents qualified at ISCED levels 5 and 6
Number of female residents qualified at ISCED levels 5 and 6
Environment
Average temperature of warmest month
Average temperature of coldest month
Rainfall (litre/m2)
Number of days of rain per annum
Total number of hours of sunshine per day
Winter Smog: Number of days sulphur dioxide SO2 concentrations exceed 125 microgram/m3
Summer Smog: Number of days ozone O3 concentrations exceed 120 microgram/m3
Number of days nitrogen dioxide NO2 concentrations exceed 200 microgram/m3
Number of days particulate matter PM10 concentrations exceed 50 microgram/m3
Concentration of lead Pb in ambient air in microgram/m3
Number of residents exposed to outdoor day noise levels above 55 dB(A)
Number of residents exposed to sleep disturbing outdoor night noise levels above 45 dB(A)
Total carbon dioxide CO2 emissions
Total carbon monoxide CO emissions
Total methane CH4 emissions
Total non-methane volatile organic compounds NVOC emissions
Total sulphur dioxide SO2 emissions
Total nitrogen dioxide NO2 emissions
Total number of annual tests (on all parameters) on drinking water quality
Number of annual determinations which exceed prescribed concentration
Total consumption of water
Number of dwellings connected to potable drinking water system
Number of dwellings connected to sewerage treatment system
Number of water rationing cases, days per year
Number of scheduled water cuts, days per year
Annual amount of solid waste (domestic and commercial)
Annual amount of solid waste (domestic and commercial) processed by landfill.
Annual amount of solid waste (domestic and commercial) is processed by incinerator
Annual amount of solid waste (domestic and commercial) that is recycled
Annual amount of solid waste (domestic and commercial) given to other disposal
Annual amount of toxic waste
Total land area (km2) according to cadastral register
Water and wetland
Green space area
Land used for agricultural purposes
Land area in mineral extraction
Land area in industrial and manufactory use
Land area in road network use
Land area in rail network use
Land area in ports use
Land area in airports use
Land area in water treatment use
Land area in waste disposal use
Land area in commerce, finance and business use
Land area in recreational, sports and leisure use

Environment
Land area in housing/residential use
Unused areas, including contaminated or derelict land areas
Urban area subject to special /physical planning conservation measures
Green space to which the public has access
Population within 15 minutes walking distance of urban green areas
Total petrol and gasoline use for private heating
Total petrol use for private and commercial transport
Total electricity use
Total electricity use by the transport sector
Total electricity use by the industrial sector
Total electricity use by the domestic sector
Total electricity use by the commercial (service) sector
Total natural gas use
Transport and Travel
Percentage of journeys to work by rail/metro
Percentage of journeys to work by car
Percentage of journeys to work by bus
Percentage of journeys to work by tram
Percentage of journeys to work by motor cycle
Percentage of journeys to work by bicycle
Percentage of journeys to work by foot
Percentage of journeys to work by other modes
Average time of journey to work (minutes)
Average speed of inner-city car traffic (km/hour) during the rush hour
Average waiting time for a bus (minutes) in the rush hour
People commuting into the city
People commuting out of the city
Length of public transport network (km)
Total kilometre driven in public transport (per day)
Public transport supply: Number of places times kilometre driven
Number of private cars registered
Road accidents resulting in death or serious injury
Average number of occupants of motor cars
Accessiblity by air (EU27=100)
Accessiblity by rail (EU27=100)
Accessiblity by road (EU27=100)
Multimodal accessibility (EU27=100)
Information Society
Number of households with a PC
Percent of population over 15 years who regularly use the Internet
Number of telephony main lines within the city [country for national data]
Households with broad band access
Percentage of households with Internet access at home
Computers per 100 pupils at primary education level
Computers per 100 pupils at secondary education level
Number of students of ICT at university level or equivalent
Number of public Internet access points (PIAPs)
Official city Internet web site (Yes/No)
Number of visits to official city Internet web site
Number of administrative forms available for download from official web site
Number of administrative forms which can be submitted electronically
Number of local units manufacturing ICT products
Number of persons employed in manufacture of ICT products
Number of local units providing ICT services

Information Society
Number of persons employed in provision of ICT services
Number of local units producing content for the Information Society
Number of persons employed in production of content for the Information Society
Culture and Recreation
Concerts (per year)
Concert attendance (per year)
Number of concert seats
Number of cinema seats (total capacity)
Cinema attendance (per year)
Number of museums
Number of museum visitors (per year)
Number of theatres
Number of theatre seats
Theatre attendance (per year)
Number of public libraries (all distribution points)
Number of books and other media loaned from public libraries (per year)
Total annual tourist overnight stays in registered accommodation
Number of available beds
Number of air passengers using nearest airport
Number of air passengers using nearest airport: Total arrivals
Number of air passengers using nearest airport: Domestic arrivals
Number of air passengers using nearest airport: Total departures
Number of air passengers using nearest airport: Domestic departures

APPENDIX B

List of variables in Urban Audit surveys

Variables
Satisfaction with public transport
Satisfaction with health care services offered by doctors and hospitals
Satisfaction with sports facilities such as sport fields and indoor sport halls
Satisfaction with cultural facilities such as concert halls, theatres, museums and libraries
Satisfaction with the beauty of streets and buildings
Satisfaction with public spaces such as markets, squares, pedestrian areas
Satisfaction with green spaces such as parks and gardens
Satisfaction with outdoor recreation such as walking, cycling or picnicking
In this city, it is easy to find a good job
The presence of foreigners is good for this city
Foreigners who live in this city are well integrated
In this city, it is easy to find good housing at a reasonable price
Generally speaking, most people in this city can be trusted
In this city, poverty is a problem
Administrative services of this city help efficiently
In this city, air pollution is a big problem
In this city, noise is a big problem
This city is clean
This city spends its resources in a responsible way
This city is committed to the fight climate change
This city is a healthy place to live
You have difficulties paying bills at the end of the month
You feel safe in this city
You feel safe in your neighbourhood
Minutes per day spent to go to work or training place
Means of transport used to go to work or training place
Frequency of using public transport
Reasons for not using public transport
Most important problems for this city

APPENDIX C

List of cities assessed and respective QoL composite indicator score

Cities	CI QOL Score
Dresden	100%
Luxembourg	100%
Weimar	100%
Helsinki	100%
Groningen	95%
Freiburg im Breisgau	94%
Frankfurt am Main	93%
Darmstadt	88%
Brugge	86%
Nürnberg	84%
Lisboa	83%
Stockholm	83%
Gozo	82%
Wien	81%
Antwerpen	81%
Dortmund	81%
Arnhem	79%
Lefkosia	78%
Liège	78%
s' Gravenhage	76%
Utrecht	76%
Amsterdam	75%
Regensburg	74%
München	73%
Edinburgh	73%
Karlsruhe	73%
Eindhoven	73%
Madrid	72%
Erfurt	71%
Mülheim a.d.Ruhr	71%
Mainz	71%
Frankfurt (Oder)	71%
Schwerin	70%
Oulu	69%
Gent	69%
Cambridge	68%
Bonn	68%
Barcelona	67%

Cities	CI QOL Score
Bruxelles / Brussel	67%
Montpellier	65%
Kosice	64%
Usti nad Labem	63%
Leipzig	63%
Tallinn	62%
Rotterdam	62%
London	62%
Toulouse	62%
Bratislava	61%
Santiago de Compostela	61%
Augsburg	61%
Budapest	61%
Pecs	61%
Düsseldorf	61%
Caen	60%
Tartu	60%
København	60%
Praha	60%
Magdeburg	59%
Köln	59%
Charleroi	59%
Rennes	59%
Berlin	59%
Nitra	59%
Heerlen	58%
Valletta	57%
Graz	57%
Bristol	57%
Bremen	56%
Umeå	56%
Aarhus	56%
Hamburg	55%
Göttingen	55%
Metz	55%
Manchester	55%
Glasgow	55%
Hannover	55%
Odense	54%
Miskolc	54%
Bochum	54%
Brno	54%
Halle an der Saale	54%

Cities	CI QOL Score
Ostrava	53%
Valencia	52%
Vilnius	52%
Vitoria/Gasteiz	52%
Bielefeld	52%
Bologna	52%
Enschede	52%
Göteborg	52%
Nyiregyhaza	51%
Bordeaux	51%
Aalborg	51%
Grenoble	50%
Plzen	50%
Funchal	50%
Milano	50%
Nancy	49%
Wuppertal	49%
Nantes	49%
Poitiers	49%
Essen	48%
Riga	48%
Jönköping	48%
Belfast	48%
Firenze	48%
Santander	47%
Trento	47%
Sevilla	46%
Lyon	46%
Liverpool	46%
Tampere	46%
Kaunas	46%
Linz	46%
Nice	46%
Dijon	45%
Warszawa	45%
Aberdeen	45%
Ljubljana	45%
Amiens	44%
Wiesbaden	44%
Besançon	44%
Ruse	43%
Lille	43%
Newcastle upon Tyne	43%

Cities	CI QOL Score
Clermont-Ferrand	43%
Maribor	43%
Strasbourg	43%
Oporto	42%
Orléans	42%
Rouen	42%
Limoges	41%
Coimbra	41%
Poznan	41%
Murcia	41%
Sofia	40%
Trier	40%
Ancona	40%
Turku	40%
Panevezys	40%
Mönchengladbach	40%
Saint-Etienne	39%
Setubal	39%
Tilburg	39%
Roma	39%
Le Havre	39%
Leeds	38%
Birmingham	38%
Marseille	38%
Bradford	38%
Worcester	38%
Portsmouth	38%
Wroclaw	37%
Gdansk	37%
Torino	37%
Opole	36%
Stevenage	36%
Torun	36%
Sheffield	36%
Venezia	36%
Cagliari	36%
Jelenia Gora	36%
Catania	35%
Exeter	35%
Cardiff	35%
Nowy Sacz	34%
Rzeszow	34%
Lublin	34%

Cities	CI QOL Score
Kielce	34%
Lodz	34%
Ajaccio	33%
Genova	33%
Reims	33%
Gorzow Wielkopolski	33%
Varna	33%
Zielona Gora	33%
Liepaja	33%
Konin	33%
Cluj-Napoca	33%
Plovdiv	33%
Olsztyn	33%
Leicester	32%
Bialystok	32%
Derry	32%
Szczecin	32%
Verona	32%
Bydgoszcz	32%
Katowice	31%
Targu Mures	31%
Moers	31%
Burgas	31%
Zory	30%
Sibiu	30%
Bari	29%
Suwalki	29%
Craiova	29%
Trieste	29%
Timisoara	29%
Napoli	29%
Arad	29%
Oradea	29%
Palermo	28%
Bucuresti	28%
Reggio di Calabria	27%
Taranto	27%
Lincoln	26%
Wrexham	23%

APPENDIX D

Ranking of cities constructed with common set of weights

Cities	CI QOL Score with common set of weights
Helsinki	100%
Weimar	100%
Luxembourg	100%
Dresden	99%
Frankfurt am Main	91%
Groningen	90%
Freiburg im Breisgau	88%
Nürnberg	83%
Wien	80%
Dortmund	80%
Arnhem	77%
Antwerpen	75%
Regensburg	74%
Liège	74%
Lisboa	74%
s' Gravenhage	74%
Stockholm	73%
Karlsruhe	73%
Darmstadt	72%
München	72%
Amsterdam	72%
Mainz	71%
Utrecht	70%
Brugge	69%
Bonn	67%
Erfurt	67%
Gozo	65%
Edinburgh	64%
Madrid	64%
Eindhoven	64%
Schwerin	63%
Gent	63%
Oulu	63%
Mülheim a.d.Ruhr	63%
Leipzig	61%
Augsburg	60%
Düsseldorf	60%

Cities	CI QOL Score with common set of weights
Bruxelles / Brussel	59%
Köln	59%
Magdeburg	58%
Rotterdam	58%
Berlin	58%
Graz	56%
Hamburg	55%
København	55%
Barcelona	54%
Bremen	54%
Bratislava	54%
Odense	54%
Hannover	54%
Bochum	54%
Aarhus	53%
Göttingen	53%
Budapest	52%
Cambridge	52%
Pecs	52%
Charleroi	52%
Lefkosia	52%
Halle an der Saale	52%
Tartu	51%
Metz	51%
Tallinn	51%
Bielefeld	51%
Glasgow	50%
Aalborg	50%
Praha	48%
Nitra	48%
London	48%
Wuppertal	48%
Miskolc	47%
Heerlen	47%
Umeå	47%
Bristol	47%
Essen	47%
Nyiregyhaza	46%
Bordeaux	46%
Manchester	45%
Enschede	45%
Göteborg	45%
Grenoble	44%

Cities	CI QOL Score with common set of weights
Santiago de Compostela	44%
Ostrava	44%
Warszawa	43%
Nantes	43%
Brno	43%
Valletta	43%
Bologna	43%
Tampere	43%
Nancy	43%
Liverpool	42%
Valencia	42%
Kosice	42%
Nice	41%
Ljubljana	41%
Linz	41%
Vitoria/Gasteiz	40%
Funchal	40%
Milano	40%
Firenze	40%
Lyon	40%
Jönköping	40%
Riga	39%
Amiens	39%
Belfast	39%
Caen	39%
Dijon	39%
Aberdeen	39%
Plzen	39%
Newcastle upon Tyne	38%
Montpellier	38%
Wiesbaden	38%
Lille	38%
Trento	37%
Poitiers	37%
Santander	37%
Sevilla	37%
Poznan	36%
Clermont-Ferrand	36%
Strasbourg	36%
Trier	36%
Orléans	35%
Usti nad Labem	35%
Vilnius	35%

Cities	CI QOL Score with common set of weights
Mönchengladbach	35%
Turku	34%
Maribor	34%
Frankfurt (Oder)	34%
Coimbra	33%
Le Havre	33%
Bradford	33%
Gdansk	33%
Birmingham	33%
Oporto	33%
Marseille	32%
Leeds	32%
Worcester	32%
Ancona	32%
Setubal	32%
Wroclaw	32%
Murcia	32%
Tilburg	32%
Portsmouth	32%
Saint-Etienne	32%
Stevenage	31%
Rennes	31%
Roma	31%
Toulouse	31%
Sheffield	31%
Opole	30%
Besançon	30%
Rouen	30%
Kaunas	30%
Torun	29%
Cardiff	29%
Rzeszow	29%
Derry	29%
Venezia	29%
Jelenia Gora	29%
Catania	28%
Torino	28%
Lublin	28%
Moers	28%
Limoges	28%
Olsztyn	28%
Leicester	28%
Lodz	28%

Cities	CI QOL Score with common set of weights
Kielce	27%
Nowy Sacz	27%
Cagliari	27%
Ajaccio	27%
Szczecin	26%
Bialystok	26%
Exeter	26%
Genova	25%
Panevezys	25%
Gorzow Wielkopolski	25%
Katowice	25%
Bydgoszcz	25%
Reims	24%
Cluj-Napoca	24%
Lincoln	24%
Sofia	24%
Zielona Gora	24%
Konin	23%
Verona	23%
Varna	23%
Targu Mures	22%
Timisoara	22%
Ruse	22%
Napoli	22%
Plovdiv	21%
Arad	21%
Liepaja	21%
Suwalki	21%
Craiova	21%
Bucuresti	21%
Burgas	21%
Trieste	21%
Palermo	21%
Bari	21%
Oradea	21%
Sibiu	20%
Wrexham	20%
Zory	19%
Taranto	17%
Reggio di Calabria	16%

APPENDIX E

List of Mercer factors by dimension of Quality of Life

Political and Social Environment
Relationship with other countries Internal stability Crime Law enforcement Ease of entry and exit
Economic Environment
Currency Exchange regulations Banking services
Socio-Cultural Environment
Limitations on personal freedom Media and censorship
Medical and Health Considerations
Hospital services Medical supplies Infectious diseases Water potability Waste removal Sewage Air pollution Troublesome and destructive animals and insects
Schools and Education
Schools
Public Services and Transport
Electricity Water availability Telephone Mail Public transport Traffic congestion Airport
Recreation
Variety of restaurants Theatrical and musical performances Cinemas Sport and leisure activities
Consumer Goods
Food (Meat and Fish) Food (Fruit and Vegetables) Daily consumption items Alcoholic beverages Automobiles

Housing
Housing Household appliances and furniture Household maintenance and repair
Natural Environment
Climate Record of natural disasters

APPENDIX F

Composite indicator of Quality of life in the perspective of qualified human resources

Cities	efficiency
Oporto	100%
Funchal	100%
Madrid	100%
Barcelona	100%
Lisboa	100%
Montpellier	100%
Lefkosia	100%
Roma	100%
Milano	100%
Torino	100%
Toulouse	100%
Bologna	100%
Firenze	100%
Aarhus	100%
Venezia	100%
Odense	100%
Cagliari	100%
Jönköping	100%
Trento	100%
London	100%
Praha	100%
Amsterdam	100%
Bordeaux	100%
Edinburgh	100%
Manchester	100%
Bristol	100%
Newcastle upon Tyne	100%
Utrecht	100%
Eindhoven	100%
Arnhem	100%
Poitiers	100%
Cambridge	100%
Stevenage	100%
Hamburg	100%
München	100%
Stockholm	100%
Frankfurt am Main	100%
Düsseldorf	100%

Cities	efficiency
Nürnberg	100%
Dresden	100%
s' Gravenhage	100%
Bonn	100%
Karlsruhe	100%
Wiesbaden	100%
Halle an der Saale	100%
Magdeburg	100%
Freiburg im Breisgau	100%
Erfurt	100%
Mainz	100%
Groningen	100%
Aalborg	100%
Darmstadt	100%
Regensburg	100%
Schwerin	100%
Weimar	100%
Rotterdam	100%
Göteborg	99%
Belfast	99%
Trier	99%
Caen	99%
Göttingen	99%
Exeter	99%
Augsburg	99%
Pecs	98%
Nantes	98%
Aberdeen	98%
Santiago de Compostela	98%
Leeds	98%
Hannover	98%
Köln	98%
Malmö	98%
Grenoble	97%
Leipzig	97%
Cardiff	97%
Umeå	97%
Nancy	97%
Berlin	97%
Brno	97%
Tilburg	97%
Bremen	96%
Warszawa	96%

Cities	efficiency
Rennes	95%
Nice	95%
Bielefeld	95%
Ancona	95%
Budapest	95%
Lyon	95%
Plzen	94%
Dijon	94%
Clermont-Ferrand	94%
Worcester	94%
Essen	94%
Portsmouth	94%
Tartu	94%
Orléans	94%
Strasbourg	94%
Enschede	93%
Katowice	93%
Mülheim a.d.Ruhr	93%
Palma di Mallorca	93%
Glasgow	93%
Heerlen	93%
Coimbra	92%
Rouen	92%
Dortmund	91%
Nyiregyhaza	91%
Tallinn	91%
Frankfurt (Oder)	90%
Bochum	90%
Oviedo	90%
Leicester	90%
Perugia	90%
Trieste	90%
Lille	90%
Limoges	90%
Birmingham	90%
Reims	90%
Mönchengladbach	90%
Sheffield	90%
Verona	89%
Liverpool	89%
Besançon	89%
Wuppertal	89%
Aveiro	88%

Cities	efficiency
Amiens	87%
Valencia	86%
Olsztyn	86%
Bucuresti	85%
Bradford	85%
Fort-de-France	85%
Usti nad Labem	85%
Miskolc	84%
Pamplona/Iruña	84%
Zielona Gora	84%
Las Palmas	84%
Pointe-a-Pitre	84%
Poznan	84%
Bari	83%
Potenza	83%
Campobasso	83%
Zaragoza	83%
Vitoria/Gasteiz	83%
Santander	82%
Ajaccio	82%
Marseille	82%
Le Havre	82%
Málaga	82%
Logroño	82%
Sevilla	81%
Catania	80%
Ostrava	80%
Opole	80%
Genova	80%
Saint-Etienne	80%
Rzeszow	80%
Krakow	79%
Murcia	79%
Derry	79%
Valladolid	79%
Wroclaw	78%
Braga	78%
Ponto Delgada	78%
Setubal	78%
Cluj-Napoca	77%
Badajoz	77%
l'Aquila	76%
Gorzow Wielkopolski	76%

Cities	efficiency
Saint Denis	76%
Wrexham	75%
Torun	75%
Palermo	75%
Lodz	75%
Gravesham	75%
Napoli	75%
Jelenia Gora	74%
Gdansk	73%
Timisoara	73%
Lublin	72%
Vilnius	72%
Catanzaro	72%
Szczecin	71%
Bydgoszcz	66%
Konin	66%
Arad	65%
Kielce	65%
Targu Mures	65%
Oradea	64%
Sibiu	63%
Alba Iulia	62%
Bialystok	62%
Nowy Sacz	61%
Piatra Neamt	61%
Cayenne	61%
Craiova	59%
Bacau	59%
Suwalki	57%
Giurgiu	55%
Braila	53%
Calarasi	52%
Luxembourg	46%
Gent	46%
Liepaja	45%
Antwerpen	45%
Riga	45%
Bruxelles / Brussel	45%
Helsinki	44%
Liège	44%
Tampere	44%
Turku	43%
Brugge	43%

Cities	efficiency
Oulu	43%
Vidin	43%
Burgas	42%
Sofia	42%
Ioannina	42%
Thessaloniki	42%
Linz	41%
Banska Bystrica	41%
Ljubljana	41%
Kalamata	41%
Kaunas	41%
Maribor	41%
Ruse	41%
Bratislava	41%
Charleroi	41%
Varna	41%
Paris	41%
Kosice	40%
Patra	40%
Volos	40%
Panevezys	40%
Irakleio	40%
Kavala	40%
Dublin	40%
Nitra	39%
Zory	39%
Larisa	39%
Cork	36%
Galway	33%
Limerick	33%
Pleven	32%

APPENDIX G

Ranking of cities with equal weights to all dimensions and considering national economic context

Cities	Efficiency considering GDP
Freiburg im Breisgau	100%
Frankfurt am Main	100%
Dresden	100%
Schwerin	100%
Bratislava	100%
Tallinn	100%
Groningen	100%
Luxembourg	100%
Helsinki	100%
Wien	100%
Tartu	100%
Plovdiv	100%
Varna	100%
Burgas	100%
Nitra	100%
Ruse	100%
Sofia	100%
Timisoara	100%
Cluj-Napoca	100%
Darmstadt	99%
Nürnberg	99%
Bucuresti	98%
Amsterdam	97%
Dortmund	97%
Arad	96%
Targu Mures	96%
Eindhoven	95%
Utrecht	95%
Erfurt	93%
Kosice	93%
Arnhem	92%
s' Gravenhage	92%
Madrid	90%
Oradea	89%
Craiova	89%
Sibiu	89%
Praha	87%

Cities	Efficiency considering GDP
Leipzig	87%
Rotterdam	84%
Brno	81%
Heerlen	79%
Oulu	78%
Plzen	78%
Lefkosia	73%
Ostrava	72%
Usti nad Labem	71%
Riga	70%
Kaunas	67%
Santiago de Compostela	65%
Valencia	65%
Panevezys	65%
Sevilla	59%
Vilnius	58%
Pecs	53%
Mülheim a.d.Ruhr	53%
Budapest	51%
Valletta	51%
Bruxelles / Brussel	50%
Liepaja	50%
Gozo	50%
Miskolc	49%
Nyiregyhaza	49%
Brugge	49%
Liège	48%
Antwerpen	47%
Gent	47%
Charleroi	47%
Warszawa	46%
Poznan	45%
Rzeszow	44%
Opole	44%
Wroclaw	44%
Gdansk	44%
Olsztyn	44%
Lublin	44%
Torun	43%
Lisboa	43%
Coimbra	43%
Zielona Gora	43%
Nowy Sacz	43%

Cities	Efficiency considering GDP
Bialystok	43%
Kielce	43%
Szczecin	43%
Jelenia Gora	42%
Lodz	42%
Maribor	42%
Funchal	42%
Katowice	42%
Konin	42%
Ljubljana	42%
Bydgoszcz	42%
Gorzow Wielkopolski	42%
Suwalki	41%
Oporto	41%
Setubal	40%
Vitoria/Gasteiz	37%
Barcelona	36%
Stockholm	34%
Weimar	33%
Edinburgh	33%
København	33%
Umeå	33%
München	32%
Mainz	32%
Odense	32%
Karlsruhe	32%
Aarhus	32%
Augsburg	32%
Belfast	32%
Rennes	32%
Berlin	32%
Aberdeen	32%
Bonn	32%
Wiesbaden	32%
Aalborg	32%
Enschede	32%
Regensburg	32%
Derry	32%
Halle an der Saale	32%
Jönköping	32%
Bielefeld	32%
Hamburg	32%
Bremen	32%

Cities	Efficiency considering GDP
Mönchengladbach	32%
Magdeburg	31%
Göteborg	31%
Hannover	31%
Bochum	31%
Wuppertal	31%
Cambridge	31%
Trier	31%
Stevenage	31%
Köln	31%
Newcastle upon Tyne	31%
Düsseldorf	31%
London	31%
Essen	30%
Manchester	30%
Sheffield	30%
Leeds	30%
Linz	30%
Lincoln	30%
Liverpool	30%
Bristol	30%
Tilburg	30%
Glasgow	30%
Exeter	30%
Saint-Etienne	30%
Graz	30%
Zory	29%
Bradford	29%
Birmingham	29%
Worcester	29%
Cardiff	27%
Leicester	27%
Göttingen	27%
Toulouse	26%
Caen	26%
Bologna	26%
Trento	26%
Tampere	26%
Poitiers	26%
Montpellier	26%
Bordeaux	26%
Torino	26%
Firenze	26%

Cities	Efficiency considering GDP
Besançon	26%
Turku	26%
Lyon	26%
Nantes	26%
Venezia	26%
Clermont-Ferrand	25%
Milano	25%
Ancona	25%
Genova	25%
Rouen	25%
Roma	25%
Orléans	25%
Lille	25%
Metz	25%
Nancy	25%
Strasbourg	25%
Cagliari	25%
Amiens	25%
Grenoble	25%
Verona	25%
Limoges	25%
Dijon	25%
Catania	25%
Le Havre	25%
Trieste	24%
Nice	24%
Reims	24%
Bari	24%
Marseille	24%
Palermo	24%
Napoli	24%
Taranto	23%
Ajaccio	23%
Reggio di Calabria	23%
Portsmouth	21%
Moers	19%
Murcia	18%
Frankfurt (Oder)	17%
Wrexham	16%
Santander	10%

APPENDIX H

Pearson Correlation Coeficient for possible independent variables

Pearson Correlation	Public_transport	Sports_facilities	The_beauty_of_streets_and_buildings_in_your_neighborhood	Public_spaces_such_as_markets_squares_pedestrian_areas	Green_spaces_such_as_parks_and_gardens	Outdoor_recreation	In_poverty_is_a_problem	Generally_speaking_most_people_in_can_be_trusted	You_feel_safe	You_feel_safe_in_your_neighbourhood	In_air_pollution_is_a_big_problem	In_noise_is_a_big_problem	CITY_NAME_is_a_clean_city	CITY_NAME_is_a_healthy_city_to_live_in	efficiency_adm_services
Public_transport															
Sports_facilities	0,673														
The_beauty_of_streets_and_buildings_in_your_neighborhood	0,755	0,751													
Public_spaces_such_as_markets_squares_pedestrian_areas	0,776	0,746	0,921												
Green_spaces_such_as_parks_and_gardens	0,732	0,624	0,827	0,839											
Outdoor_recreation	0,732	0,773	0,817	0,853	0,838										
In_poverty_is_a_problem	0,267	0,442	0,416	0,353	0,276	0,401									
Generally_speaking_most_people_in_can_be_trusted	0,542	0,687	0,701	0,66	0,553	0,617	0,466								
You_feel_safe_in	0,542	0,651	0,741	0,692	0,569	0,605	0,51	0,867							
You_feel_safe_in_your_neighbourhood	0,557	0,662	0,754	0,691	0,56	0,624	0,386	0,837	0,953						
In_air_pollution_is_a_big_problem	0,492	0,55	0,624	0,625	0,55	0,567	0,358	0,638	0,638	0,666					
In_noise_is_a_big_problem	0,532	0,678	0,723	0,695	0,644	0,678	0,368	0,723	0,674	0,671	0,866				
CITY_NAME_is_a_clean_city	0,565	0,584	0,729	0,699	0,637	0,573	0,457	0,612	0,655	0,615	0,696	0,718			
CITY_NAME_is_a_healthy_city_to_live_in	0,46	0,592	0,654	0,653	0,492	0,531	0,274	0,739	0,763	0,755	0,754	0,74	0,743		
efficiency_adm_services	0,566	0,671	0,673	0,69	0,533	0,65	0,414	0,548	0,548	0,529	0,38	0,575	0,474	0,477	