MEASURING QUALITY OF LIFE IN MUNICIPALITIES WITH VALUE EFFICIENCY ANALYSIS: THE IMPORTANCE OF THE GEOGRAPHIC LEVEL OF ANALYSIS

Eduardo González
Universidad de Oviedo
Facultad de Económicas, Av. Cristo s/n 33071 Oviedo (Spain)
e-mail: efidalgo@uniovi.es

Ana Cárcaba
Universidad de Oviedo
Facultad de Económicas, Av. Cristo s/n 33071 Oviedo (Spain)
e-mail: acarcaba@uniovi.es

Juan Ventura
Universidad de Oviedo
Facultad de Económicas, Av. Cristo s/n 33071 Oviedo (Spain)
e-mail: ventura@uniovi.es

Abstract

There is a growing literature on the assessment of quality of life conditions in geographically and/or politically divided regions. Sometimes these territories are countries within a specified supranational structure, as the European Union, for instance, and sometimes they are regions within countries. There is also some research that focus on the municipal level of analysis measuring the quality of life of cities. At the end what the researcher obtains is, at best, an average of conditions of life in the specified territory. However, if results are intended to have policy implications for action caution should be paid to variance in living conditions within the regions. In this paper we attempt to quantify the relative importance of three different geographic levels of analysis in assessing the quality of life of the Spanish population. The geo-political division in Spain puts in the first place the regions, called *comunidades autónomas*, which are then divided into provinces and, finally, these provinces are divided into municipalities. What we are interested in evaluating is how much of the quality of life conditions of an average person living in a given municipality is explained by the province and region in which the municipality is located. In order to obtain that result, we first construct a composite indicator of quality of life for the 643 largest municipalities of Spain using 19 variables which are weighted by means of Value Efficiency Analysis (VEA). VEA is a refinement of DEA (Data Envelopment Analysis) that imposes some consistency in the weights of the indicators used to construct the aggregate index. The indicators cover aspects related to consumption, social services, housing, transport, environment, labour market, health, culture and leisure, education and security. We then make a variance decomposition of the VEA scores to assess the importance of the three levels of geo-political administration. The results show that the municipal level is the most important accounting for a 52% of the variance in QoL. Regions explain some 38% while provinces only account for a moderate 10%. Therefore, political action at the regional and municipal level would seem to have the largest impact on QoL indicators.

Keywords: quality of life, municipalities, regions, DEA, VEA, variance components analysis
Jel Classification: R00, O18, H75, C60

1. **Introduction**

The local government or municipal level of the Administration in Spain is becoming increasingly relevant in the political debate of the last few years. Once the transfer of competences to the autonomous regions has been almost completed, the next challenge is to develop mechanisms that provide municipalities with the necessary resources to meet the most basic demands of the population. The living conditions of the municipality in which the citizen lives have an enormous impact on her personal quality of life and therefore should be a primary concern of public policies. A desirable goal of territorial cohesion policies is to achieve equity in living conditions throughout the length and breadth of the country. Unfortunately, as we show in this paper that goal is still far from being achieved.

Many decisions that affect the final QoL of the population are taken at the regional level. Health, education and social services have been decentralized to the autonomous regions governments and a new model of financing is now being implemented to provide the required resources at this level of the administration. But many other services are the competence of local governments. Street cleanliness, local police, urban development, fire prevention, parks and gardens, etc. are examples of variables that have considerable impact on QoL but are managed at a local level. At an intermediate geo-political level, the provincial authorities also have competencies that include coordination of some inter-municipal services.

On the empirical ground, measuring quality of life in municipalities entails two big problems. First, a relevant set of indicators capable of approaching all the dimensions of quality of life must be available. These dimensions must be related to the economic, social, environmental and urban development of the municipality. Second, the indicators must be aggregated in a sensible manner to construct a composite index of quality of life that allows ranking municipalities and reporting overall improvement possibilities. The *Handbook on Constructing Composite Indicators* (OECD, 2008) revises several different methodologies that have been used in the literature and applied to different empirical settings. One of them is Data Envelopment Analysis (DEA)[1], which has the advantage of producing objective weights without the intervention of the researcher. In this paper we will rely on a recent extension of DEA called Value Efficiency Analysis (VEA) that is able to produce a more consistent set of weights.

DEA is a reasonable method to aggregate the indicators of quality of life because it can easily handle multiple dimensions without imposing much structure on the relationships between those dimensions. However, DEA also has some important drawbacks that limit its empirical application. One of the most important limitations of DEA is its low discriminating power, especially when many dimensions are taken into account and the sample size is limited (Ali, 1994). In fact, the DEA score is a weighted index of positive and negative variables and each municipality has an extreme degree of flexibility to choose the weights. Each municipality is free to select its own weights and is compared with the achievement that other municipalities would attain with those particular weights. We believe that some flexibility is desirable to express differences in specific municipality features but not to the extent of allowing total disparity.

VEA imposes some reasonable coherence among the weights selected by each municipality. It adds to the DEA program a constraint on how the weights can be chosen by the different municipalities in the sample and, as a result, it significantly improves both the discriminating power of DEA and the consistency of the weights on which the evaluation is based upon. Once the quality of life scores are computed, we will proceed to decompose their variance into its three geo-political possible sources of variation: municipality, province and region. This decomposition would indicate the relative importance of each of these three levels of analysis in the assessment of QoL. Relevant policy implications can be easily derived from the results of this variance decomposition.

2. The measurement of quality of life

At the individual level, quality of life or welfare comes from the consumption of a series of economic and social goods (food, health attention, amenities, etc.) and also from intangible factors such as personal emotions or attitudes towards life. While proposals to mix both tangible and intangible drivers of QoL into combined indicators are promising, most past research has focused on either the measurement of objective QoL conditions or the assessment of subjective well being. Aggregate QoL indicators at varying territorial levels have been regularly derived from the observation of tangible drivers. These measures can be a critical input to policy decision making if they are oriented towards achieving the maximum possible level of aggregate welfare. For example, resources available at the national level can be distributed to regions in order to equate quality of life conditions across the territory. Also, the deployment of resources at sub-regional levels, such as municipalities, can even have a greater impact in the living conditions of the population.

Not surprisingly, social welfare has always been a central topic of study in Economic sciences. However, its measurement has traditionally limited to very aggregate and monetary based variables taken from national accounting, such as GDP. In contrast, QoL is related to many dimensions of life some of which are difficult to measure and report in national accounts. In order to provide an appropriate representation of all those dimensions a growing body of literature, known as the social indicators approach, has evolved using a series of economic, environmental and social indicators without the need to assign them monetary values for aggregation. At the local government level of analysis the main problem with this approach is the poor development of statistical sources that collect comparable data across municipalities (Zarzosa, 2005).

The social indicators approach faces two important empirical challenges. First, a complete set of indicators for all the relevant underlining dimensions of quality of life must be listed and measured. Second, a sound aggregation methodology must be applied to raw indicators in order to obtain a reasonable index of quality of life. With respect to the indicators to be used, the lists vary widely across studies and the main reason is data availability. Also, as we already mentioned, different studies deal with different territorial levels of analysis (nations, counties, regions). However, the underlying dimensions of welfare that most authors attempt to approach with available indicators can be outlined as: Consumption, Social services, Housing, Transport, Environment, Labour market, Health, Education, Culture and leisure and Security.

One or more indicators can be used to account for each of the underlying dimensions of quality of life. The indicators that we use in this paper are representative of the 10 dimensions outlined above. For example, we use the unemployment ratio to approach current conditions in the labour market. The socio-economic level of the population and the commercial market share are used as indicators of purchasing power that account for consumption. Housing is approached by the per capita size of the houses and their living conditions. What is important is to use indicators that can approach each dimension and that are comparable across the municipalities in the sample.

With respect to the second empirical problem, the aggregation methodology, several approaches have been proposed in the literature. The Handbook on Constructing Composite Indicators (OECD, 2008) revises the pros and cons of many of them[2]. From these, the Data Envelopment Analysis (DEA) approach, first employed by Hashimoto and Ishikawa (1993)[3], has the nice advantage of generating a specific set of weights for each observation within the sample. Although, DEA was initially developed to measure efficiency in production, some non-standard uses of this technique have been proposed in the literature focusing on the properties of DEA as a powerful aggregating tool. The aggregation is done by comparison of the indicators of each observation to the best practices observed in the sample, which form a referent or best-practice frontier. While the application of DEA to the measurement of quality of life is still scant, we can cite several studies that have used this methodology in different settings (Hashimoto and Isikawa, 1993; Hashimoto and Kodama, 1997; Despotis, 2005a,b; Marshall and Shortle, 2005; Murias, Martínez, and Miguel, 2006; Somarriba and Pena, 2009).

We believe that the DEA methodology has important advantages over alternative aggregation methods. First, it uses information on the underlying determinants of quality of life. Second, it does not impose a functional form on the relationship between the variables and does not require any assumption on market equilibria. Third, final scores are obtained by comparison to a frontier from the best municipalities observed in the sample, on the basis of a comparative assessment of the indicators. A fourth advantage of DEA is that it provides each municipality with information on the improvements that should be made on each indicator in order to reach the quality of life frontier. Furthermore it informs of the municipalities that act as frontier references for each of the underperforming municipalities detected in the sample. For these reasons in this paper we rely on the DEA methodology to compute scores of quality of life for the Spanish municipalities.

3. Methods

To compute the VEA scores of quality of life we must first obtain the DEA frontier for the municipalities in the sample. The DEA frontier identifies the municipalities that would be considered as the best referents under certain (conservative) assumptions. DEA was developed to measure relative efficiency by comparison of data on inputs and outputs of productive units. In this paper we will use the same setting of comparison but the inputs will be the drawbacks associated with living in a city and the outputs would be the advantages[4]. Even though there are many variants of DEA mathematical programs, in this paper we follow the traditional specifications of Charnes et al. (1978) and Banker et al. (1984). The Charnes et al (1978) DEA model with an output orientation requires solving the next mathematical program for each DMU *i* in the sample[5]:

$$\begin{aligned} & \min \frac{\sum_{m=1}^{M} v_m x_{im}}{\sum_{s=1}^{S} u_s y_{is}} \\ & s.a: \\ & \frac{\sum_{m=1}^{M} v_m x_{jm}}{\sum_{s=1}^{S} u_s y_{js}} \geq 1 \quad , \quad \forall j \\ & u_s, v_m \geq 0 \quad , \quad \forall s, m \end{aligned} \tag{1}$$

where x_{im} represents the consumption of input *m* by DMU *i*, y_{is} represents the production of output *s* by DMU *i*, v_m is the shadow price of input *m,* and u_s is the shadow price of output *s*. The program finds the set of shadow prices that minimizes the production cost of unit *i* with respect to the value of its outputs, conditioned to obtain ratios larger or equal to 1 for all the other DMUs in the sample. If DMU *i* is on the frontier optimal shadow prices will give the minimum possible value for the ratio, i.e. 1. Underperformers would only attain values greater that 1 for the objective function. Fractional program (1) involves some computational complexities. Thus, it is preferable to solve the following equivalent linear program:

$$\begin{aligned} & \min \sum_{m=1}^{M} v_m x_{im} \\ & s.a: \\ & \sum_{s=1}^{S} u_s y_{is} = 1 \\ & \sum_{s=1}^{S} u_s y_{js} - \sum_{m=1}^{M} v_m x_{jm} \leq 0 \quad , \quad \forall j \\ & u_s, v_m \geq 0 \quad , \quad \forall s, m \end{aligned} \tag{2}$$

This program finds the shadow prices that minimize the cost of DMU *i*, but normalizing the output value to 1. If DMU *i* is on the best practice frontier it will obtain a cost equal to 1, while if it is below the frontier it will obtain a value greater than 1. In the last case the solution to the linear program must also identify at least another DMU within the sample that obtains the minimum cost of 1 with the shadow prices that are most favourable to DMU *i*. Program (2) is solved for every DMU in the sample, and each of them will obtain its most favourable set of shadow prices for inputs and outputs and the corresponding scores of quality of life. For an easier interpretation, it is common to use the inverse of the objective function in (2) as the performance score. Therefore, the score is bounded within the (0,1] interval and values lower than 1 reflect the distance to the best practice frontier.

Banker et al. (1984) relax the constant returns to scale assumption modifying linear program (2) to allow for variable returns to scale in the production technology:

$$
\begin{aligned}
& \min \sum_{m=1}^{M} v_m x_{im} + e_i \\
& s.a: \\
& \sum_{s=1}^{S} u_s y_{is} = 1 \\
& \sum_{s=1}^{S} u_s y_{js} - \sum_{m=1}^{M} v_m x_{jm} - e_i \le 0 \quad , \quad \forall j \\
& u_s, v_m \ge 0 \quad , \quad \forall s, m
\end{aligned}
\tag{3}
$$

where the intercept e_i is added to relax the CCR condition that forced the objective function to pass through the origin in (2). In program (3) that condition will only be satisfied if e^*_i=0. For values greater or smaller than 0 the reference in the frontier for the DMU will be located in a local zone with decreasing or increasing returns to scale, respectively. Most productive activities are subject to variable returns to scale and this is the reason why most empirical applications use the BCC program to measure technical efficiency of production. In the case of using DEA programs to measure QoL, we find no scale reasons that recommend applying the CCR or the BCC model. However, all our indicators of drawbacks and advantages are ratios and this fact calls for a BCC specification of the DEA model (Hollingsworth and Smith, 2003). Thus, we consider that the BCC frontier is the most appropriate to evaluate quality of life in municipalities.

A distinctive feature of DEA is the absolute flexibility in the way the linear program can assign weights (shadow prices) for each particular DMU in the sample. Recall that the program is solved independently for each DMU and, then, shadow prices for inputs and outputs may be completely different from one DMU to another. The main argument to defend extreme weight flexibility in DEA is the convenience to obtain an evaluation of the performance of each DMU under its most favourable scenario. This is like asking the Mayor of each municipality to select the weights for the indicators that would show a higher level of QoL for her municipality. Then the QoL score will be computed using those weights for all the other municipalities within the sample and the one that achieved the highest value would be normalized to 1 (frontier). If the municipality under analysis has a value lower than the one on the frontier, it would obtain a score lower than 1, and the difference would reflect the distance to the frontier and, therefore, the possibilities for improvement. The extreme flexibility may be object of criticism because it often produces an extreme inconsistency in the values of the shadow prices across DMUs. To avoid this inconsistency the DEA literature has suggested some solutions to restrict the range of acceptable values for those weights (Thompson et al. 1986; Dyson and Thanassoulis, 1988; Allen et al. 1997; Roll et al. 1991; Wong and Besley, 1990; Pedraja et al. 1997; Sarrico and Dyson, 2004).

In turn, the problem of weights restriction methods is that they require making value judgements about the range of shadow prices that is considered appropriate. In order to facilitate the implementation of weight restrictions in practice Halme et al. (1999) proposed an alternative methodology under the name Value Efficiency Analysis (VEA). The objective of VEA is to restrict weights using a simple piece of additional information that must be supplied to the DEA program. The most notable difference between VEA and conventional methods of weights restriction is that instead of establishing appropriate ranges for shadow prices, an outside expert is asked to select one of the DEA-efficient DMUs as his Most Preferred Solution (MPS). Once the MPS is selected, the standard DEA program is supplemented with an additional constraint that forces the weights of the DMU under evaluation (*i*) to take the MPS (*o*) to the frontier. In other words, the new linear program requires that the optimal shadow prices selected by DMU *i* must also be good for the MPS. Keeping with the example above, the mayor of the city would again been asked to choose the weights for all the dimensions of quality of life, but keeping in mind that those weights must put the MPS on the frontier. As this requirement is made for all the DMUs in the sample, the optimal sets of shadow prices of all the linear programs must be appropriate for the MPS.

Therefore, the MPS forces a high degree of consistency in the sets of shadow prices across DMUs. An immediate effect of the VEA constraint is that DMUs that obtained a DEA score of 1 just because they had an extreme value in one input or output will only obtain a VEA score equal to 1 if they can resist the additional comparison with the MPS. The BCC VEA program with an output orientation can be expressed as follows:

$$
\begin{aligned}
& \min \sum_{m=1}^{M} v_m x_{im} + e_i \\
& s.a: \\
& \sum_{s=1}^{S} u_s y_{is} = 1 \\
& \sum_{s=1}^{S} u_s y_{js} - \sum_{m=1}^{M} v_m x_{jm} - e_i \leq 0 \quad , \quad \forall j \\
& \sum_{m=1}^{M} v_m x_{om} + e_i - \sum_{s=1}^{S} u_s y_{os} = 0 \\
& u_s, v_m \geq 0 \quad , \quad \forall s, m
\end{aligned}
\tag{4}
$$

Program (4) is identical to program (3) but the MPS constraint has been added. Thus, the MPS (*o*) must obtain a value of 1 with the shadow prices of DMU (*i*). Indirectly, this requirement restricts the range of shadow prices allowed to the range that makes the MPS (*o*) be part of the best practice frontier in all the linear programs[6].

A controversial issue in VEA is how to select the MPS (Korhonen et al. 1998). Our empirical setting is designed to measure quality of life by comparing the drawbacks and advantages associated with living in the different municipalities of the sample. In this context, it would be difficult to find an expert that would provide the MPS. We will rely on previous studies that evaluate the quality of life in the biggest Spanish cities using alternative methodologies in order to select a reasonable MPS for our sample.

4. Data

We are interested in measuring quality of life conditions in all the Spanish municipalities with population over 10000. While there is plenty of data at the regional level of analysis, comparable municipal information is still scant in Spain. The only database that contains comparable information for all the Spanish municipalities is the Census of Population and Housing which provides a very rich information to approach the drawbacks and advantages of living in different cities. The most recent available data refers to 2001. Our final sample includes a total of 643 municipalities and is sufficiently large and representative to solve the DEA model proposed. We followed existing literature to choose the variables that could reasonably approach the relevant dimensions of quality of life in municipalities (Table 1).

Table 1. Variables used to approach quality of life in municipalities

Drawbacks (inputs)	Advantages (outputs)
Unemployment (UNEMP)	Socioeconomic condition (ASC)
Pollution (POLLUT)	Commercial market share (SHARE)
Lack of Parks (GREEN)	Cultural and sports facilities (CULT)
Lack of cleanliness (DIRT)	Health facilities (HEALTH)
Acoustic pollution (NOISE)	Education facilities (EDUC)
Delinquency/vandalism (CRIME)	Social care facilities (SOCIAL)
Bad communications (COM)	Average education level (AEL)
Time spent in journeys (TIME)	Post compulsory education (POST)
	University studies (UNIV)
	Avg. Net usable area (AREA)
	Living conditions (LIVCOND)

To approach the advantages of living in a municipality we use variables in 6 of the 10 categories listed in Section 2: Consumption, Social services, Housing, Education, Health, Culture and Leisure. Economic advantages of municipalities are measured with two variables. The Average Socio-economic Condition (ASC) is an index variable elaborated by INE that reflects the socio-economic status of the population, on the basis of the jobs declared by citizens[7]. The second variable is the Commercial Market Share (SHARE) of the municipality. This variable, taken from the Anuario Económico de España (La Caixa, 2001), is an index that measures the consumption capacity of a municipality in relation with the total consumption capacity of Spain[8]. It approaches purchasing power.

Municipal facilities are approached with four variables[9]. Cultural and sports facilities (CULT) include theatres, cinemas, museums, art galleries, sports centres, etc. Health facilities (HEALTH) include hospitals and primary care centres. Education facilities (EDUC) include primary and secondary schools, colleges and nursery schools. Social care facilities (SOCIAL) encompass senior centres, social services, pensioner clubs, etc. Education is approached with three variables. First, the Average Education Level (AEL) is an index variable computed by INE that indicates the average attainment of the population of the municipality[10]. To this variable we add the percentage of people that completed post-compulsory education (POST) and the percentage of the population with university studies (UNIV). Finally, housing advantages are accounted for with two variables, the Average Net Usable Area per capita (AREA) and an Index of Living Conditions (LIVCOND)[11].

With respect to the drawbacks of living in a municipality we use variables that approach the other 4 categories listed in Section 2: Labour Market, Environment, Security and Transport. Labour market drawbacks are approached by the Unemployment Rate (UNEMP). Environmental drawbacks are measured in four dimensions. First, POLLUT indicates the percentage of houses that notify problems of pollution and/or bad smells. Second, GREEN indicates the percentage of houses that notify scant green zones (gardens, parks) around. Third, DIRT measures the percentage of houses that report a poor cleanliness in surrounding streets. Fourth, NOISE measures the percentage of houses that complain from acoustic pollution.

The security of the municipality is approached by the percentage of houses that report problems of delinquency or vandalism (CRIME). Finally, transport problems are approached by two variables: the number of houses that report having bad communications (COM) and the average time employed in journeys to the school or job (TIME)[12].

Table 2 shows some descriptive statistics of the variables used to approach the quality of life in Spanih municipalities. The table shows enormous differences between minimum and maximum values in almost all the variables considered. For instance, Las Rozas (Madrid) has 13.8 times more population with a university degree than Cabezas de San Juan (Sevilla). Or crime and vandalism problems in Olivenza (Badajoz) are 94 times lower than in Sevilla. However, being best or worst in one or other dimension does not necessarily imply a very high or low quality of life. In many cases, a municipality excels in some dimensions and shows a poor performance in other. Table 2 evidence one of these cases. First, Boadilla del Monte (Madrid) for instance excels in socio-economic condition but suffers from severe problems with communications which, in turn, imply time consuming journeys to job or school (4 times longer than living in Pilar de la Horadada (Alicante)). Other good example is El Ejido (Almería). This municipality seems to be a nice place to find a job, as reflected by a very low unemployment rate (5.43), although not the lowest. However, it shows very poor education attainments. This is why we need a technique capable of finding appropriate weights for the different dimensions that determine the overall quality of life. The VEA methodology explained in Section 3 allows setting reasonable weights for each dimension and constructing a meaningful aggregate indicator.

Table 2. Descriptive statistics of drawbacks and advantages

	Mean	SD	Min		Max	
Drawbacks						
UNEMP	13.55	5.86	4.57	Oñati	50.08	Illora
POLLUT	18.32	9.34	1.50	Olivenza	72.80	Rivas Vaciam.
GREEN	39.39	14.82	1.15	Santa Comba	82.40	Archena
DIRT	31.75	11.17	5.78	Muros	70.00	Cartagena
NOISE	29.45	9.55	3.47	Muros	61.34	Mejorada Cam.
CRIME	17.74	10.27	0.61	Olivenza	57.42	Sevilla
COM	14.42	9.85	0.87	Brenes	75.40	Boadilla Monte
TIME	21.15	5.45	10.05	Pilar Horadada	39.59	Boadilla Monte
Advantages						
ASC	0.96	0.12	0.63	Barbate	1.27	Boadilla Monte
SHARE	24.23	2.93	17.56	Bormujos.	48.83	Torrelodones
CULT	7.31	4.77	0.00	Bétera	36.14	Ejea Caballeros
HEALTH	10.86	12.44	0.00	Vilanova Camí	245.24	Laredo
EDUC	10.36	6.76	0.64	Mutxamel	98.34	Zafra
SOCIAL	6.97	4.52	0.00	Mogán	45.35	Aranjuez
AEL	2.74	0.22	2.19	Jódar	3.48	Tres Cantos
POST	37.22	9.38	14.45	Pájara	68.35	Tres Cantos
UNIV	11.26	6.09	3.32	Cabezas S. Juan	45.84	Las Rozas
AREA	35.52	4.27	20.45	Ceuta	64.79	Banyoles
LIVCOND	62.79	4.27	40.80	Mos	82.04	Barañain

5. Results

The DEA model was run to obtain an initial best practice frontier. This is a necessary step to know which municipalities are located on the frontier and, thus, can be considered as appropriate candidates to be the MPS for the VEA analysis. Table 3 summarizes the DEA results for the 643 municipalities grouped by autonomous regions.

The North and Central regions of Spain obtain scores of quality of life larger than the Southern regions. Navarra, Aragón, and País Vasco have a large share of the DEA frontier, with 32 out of 59 municipalities from these regions in the sample. La Rioja also shows an average that is very close to 1, although it doesn't have any municipality on the frontier. On the opposite case, Andalucía, Canarias, Comunidad Valenciana, and Murcia with only 28 out of 277 municipalities on the frontier show the poorest results with averages around 0.9. The other regions show mediocre results. Madrid and Galicia achieve mediocre averages with large standard deviations. In other words, some of the best and worst places to live in Spain may be found in Madrid and Galicia.

Table 3. Summary of DEA results grouped by autonomous regions

	n	Average	Min	Max	SD	Frontier (%)
Andalucía	134	0.882	0.761	1	0.064	12 (8.9)
Aragón	12	0.982	0.904	1	0.033	8 (66.7)
Asturias	21	0.943	0.836	1	0.055	5 (23.8)
Baleares	17	0.945	0.867	1	0.046	6 (35.3)
Canarias	36	0.890	0.769	1	0.069	6 (16.7)
Cantabria	10	0.940	0.909	1	0.034	2 (20.0)
Castilla y León	23	0.959	0.879	1	0.034	6 (26.1)
Castilla-La Mancha	28	0.949	0.866	1	0.049	10 (35.7)
Cataluña	96	0.945	0.822	1	0.043	18 (18.7)
Com. Valenciana	81	0.913	0.811	1	0.046	8 (9.9)
Extremadura	13	0.948	0.894	1	0.035	2 (15.4)
Galicia	56	0.918	0.814	1	0.058	10 (17.9)
Madrid	38	0.924	0.798	1	0.059	10 (26.3)
Murcia	26	0.899	0.810	1	0.049	2 (7.7)
Navarra	7	0.990	0.960	1	0.018	5 (71.4)
País Vasco	40	0.963	0.873	1	0.046	19 (47.5)
La Rioja	3	0.968	0.929	0.993	0.034	0 (0)
Ceuta/Melilla	2	0.809	0.806	0.812	0.005	0 (0)
Total	643	0.922	0.761	1	0.060	129 (20.1)

Overall, the minimum score (0.761) is obtained by San Lucar de Barrameda, a municipality in Cádiz (Andalucía). Among the main drawbacks of living in this municipality we find one of the largest unemployment rates in the sample (31.65%) and an important lack of green zones (61.7%)[13]. It also has one of the lowest average socio-economic condition in the sample (0.68) and a very poor education attainment (AEL=2.31). To resist the comparison with the frontier this municipality should improve (at least) a 24%.

A total of 129 municipalities in the sample obtain a DEA score equal to 1, which means they cannot make any (relative) improvement, given the data observed and the structure of the DEA program. Some of them belong to the frontier because they are excellent places to live in many or all the dimensions considered (e.g., Tres Cantos). In turn, other frontier municipalities do not excel in any dimension but have a good balance between drawbacks and advantages (e.g., Pamplona, Oviedo, Vitoria, San Sebastián). Still, some other municipalities reach the DEA frontier just because they excel in some dimension although they have mediocre results in other and therefore can be questioned as appropriate referents (e.g., El Ejido, Carballo, Boadilla del Monte)[14].

There are two views about these last set of DEA-frontier municipalities. First, there can be certain specialization in the offers of municipalities as good or reasonable places to live and questioned frontier municipalities are simply the best possible referents to those that specialize in offering the same lures. The second view is that DEA is very flexible in evaluating municipalities with extreme data. These municipalities are allowed to assign unreasonable weights to drawbacks and/or advantages in the DEA program to reach the DEA frontier.

In our view, some of the results of the DEA analysis evidence the strong limitations of this technique in assigning reasonable weights. Some municipalities with very poor results are taken to the frontier simply because there is no other municipality that does better in some dimension of the quality of life setting. In other words, the flexibility of the weights allows some municipalities to put a very low value in those dimensions in which they perform poorly and a high value in those dimensions in which they perform better. El Ejido (Almería) is a perfect example of this. It achieves a DEA score equal to 1 giving a very high value (cost) to unemployment, since it shows one of the lowest unemployment rates in the sample. It would no matter if this country reduced its yet poor education attainment figures to half. It would still be on the DEA frontier just because it cannot be compared with any other high performing municipality in terms of unemployment. Therefore, in this particular case, just one simple indicator completely determines the results of the DEA program. A close scrutiny of the data reveals that El Ejido is good in just one variable (unemployment), infamous in other variables (education, living conditions) and mediocre in the rest. Therefore it may not be considered as a good place to live and even less so a referent.

To increase the discriminating power of DEA and achieve a higher degree of congruence in the shadow prices assigned by the different municipalities in the DEA linear programs, we solved the VEA analyses using as MPS the city of Pamplona. We selected this city as the MPS on the basis of previous studies that approach the quality of life of Spanish municipalities using very different methodologies. OCU (2007)[15] carried a survey to know the degree of satisfaction of citizens regarding the city where they lived. They only surveyed people in 17 of the largest Spanish cities, asking about 11 variables related with the quality of life (housing, culture, sports and amusement facilities, education, transport and communications, security, urban landscape, labour market, commercial activity, public administration and health attention). They also asked the citizens to weight the variables[16]. Pamplona obtained the best evaluation from its own citizens. Another study that highlights the virtues of Pamplona as a good referent and therefore candidate to be our MPS is Mercociudad elaborated by MERCO (2008). The methodology is based on a survey to 9000 citizens of the 78 cities with population over 100.000 in Spain but is complemented with the use of secondary sources of information and the criteria of experts. Their goal is not measuring the quality of life but rather the overall reputation of cities as attractors of tourists, businessman, cultural activity, etc. However, one of the rankings they elaborate refers to the 10 best cities to live in. Barcelona, Madrid, Valencia and Pamplona are the first four. Of these four only Pamplona is in our DEA frontier[17].

Therefore, Pamplona is a nice place to live as reported by independent studies that rely on very different methodologies and also have a very good balance with respect to the drawbacks and advantages included in our quality of life framework. In all our 19 variables Pamplona stands much better than average, except for the variables that measure the number of facilities in which Pamplona is around the average. Pamplona excels in education attainment, communications and time to job or school, pollution and living conditions[18].

The results of the VEA (Table 4) show a dramatic reduction in the number of municipalities that are ascribed to the quality of life frontier and a more moderate reduction in the average score of quality of life. Remember that now the linear programs search the weights that maximize the score of the municipality but those weights must keep Pamplona on the frontier (i.e., the weights must be reasonable according to our reasonable MPS, Pamplona).

Table 4. Summary of VEA results grouped by autonomous regions (MPS=Pamplona)

	n	Average	Min	Max	SD	Frontier (%)
Andalucía	134	0.854	0.755	0.972	0.051	0 (0)
Aragón	12	0.965	0.877	1	0.038	3 (25.0)
Asturias	21	0.884	0.809	0.984	0.041	0 (0)
Baleares	17	0.915	0.863	1	0.039	1 (5.9)
Canarias	36	0.856	0.762	0.976	0.059	0 (0)
Cantabria	10	0.934	0.901	1	0.033	1 (10.0)
Castilla y León	23	0.938	0.877	1	0.032	1 (4.3)
Castilla-La Mancha	28	0.902	0.839	0.970	0.038	0 (0)
Cataluña	96	0.923	0.814	1	0.044	6 (6.2)
Com. Valenciana	81	0.892	0.806	0.975	0.036	0 (0)
Extremadura	13	0.920	0.877	1	0.032	1 (7.7)
Galicia	56	0.875	0.779	0.997	0.054	0 (0)
Madrid	38	0.882	0.766	1	0.062	2 (5.2)
Murcia	26	0.868	0.805	0.937	0.033	0 (0)
Navarra	7	0.988	0.960	1	0.017	4 (57.1)
País Vasco	40	0.945	0.866	1	0.045	5 (33.3)
La Rioja	3	0.951	0.916	0.980	0.032	7 (17.5)
Ceuta/Melilla	2	0.808	0.805	0.811	0.004	0 (0)
Total	643	0.893	0.755	1	0.057	26 (4.0)

The number of frontier municipalities reduces from 129 (DEA) to 26 (VEA), an 80% reduction. This means that only 26 municipalities in the sample can fully justify their quality of life dimensions when using weights that are reasonable for Pamplona. To see how unreasonable some DEA results can be, the VEA score for El Ejido

(Almería) is just 0.81, while it belonged to the DEA frontier. Carballo (Coruña) also falls from 1 to 0.82 and Boadilla del Monte (Madrid) abandons the frontier falling to 0.95, penalized by its bad communications[19]. Analyzing the averages in the autonomous regions all of them experiment notable reductions except Cantabria, Navarra and Ceuta/Melilla. It is specially significant the reduction in Asturias, Castilla-La Mancha, Galicia and Madrid. Eight regions have no municipalities on the VEA frontier, while only two did not have representatives on the DEA frontier. The least VEA score is again obtained by San Lucar de Barrameda (Cádiz). The Central and Northern regions of Spain also obtain the largest indexes of VEA quality of life, although the scores in Castilla-La Mancha and Asturias suffered important reductions. Andalucía, Canarias, Murcia, and Ceuta/Melilla obtain the poorest scores and are closely followed by Madrid, Asturias, and Galicia. The standard deviation is very high in these regions while it remains moderate in the rest of Spain.

Figures 1 to 3 depict the geographical distribution of quality of life conditions in Spain[20]. While our sample covers more than 76% of the Spanish population, it only represents an 18.3% of the territory as evidenced by Figure 1. The maps show how the highest indexes of quality of life are obtained by municipalities in the central north part of Spain. The southern regions, Canary Islands, Madrid and some parts of Galicia and Asturias account for the majority of low quality of life municipalities. However, we can see that in all these low quality of life zones there are municipalities with excellent living conditions like Tres Cantos (Madrid), Oviedo (Asturias), Santiago de Compostela (Galicia), Estepa (Andalucía) or San Bartolomé de Tirajana (Canary Islands).

<<<<<<<<<<<<FIGURES 1 to 3 ABOUT HERE>>>>>>>>>>>>>>>>

The previous tables and figures evidence that the distribution of quality of life is far from been uniform across the territory. In statistical language this means that some of the variance in the QOL indicators of the municipalities is shared within territorial areas that comprise several municipalities. But a simple look at the map is not enough to get an accurate idea about how much of that variance is shared within regions or provinces and how much is specific of each municipality. In order to provide an answer to this critical question, we performed a variance decomposition using a random effects model with three nested sources of variation. The municipality, the province and the region. The nested structure comes from the fact that regions are composed of provinces which, in turn, are composed of municipalities. Although there are several possible estimators for our variance decomposition, here we report the results of the Restricted Maximum Likelihood estimator (REML)[21]. According to our results, the regional level would explain a 37.8% of the variance in QOL, while the province would just explain a 9.6%. It is noticeable that almost 40% of the QOL of the citizens depends not on the municipality where they live but on the region. However, the municipal level explains 52.6% of the variance and, therefore, can be considered as the most relevant level of analysis for QOL assessment.

These findings have two obvious policy implications. First, once the regional system of competencies and financing is almost closed, a further boost in assuring a correct financing for municipalities is definitely called for. Municipal authorities complain that they have many competencies attributed but they don't have a stable source of financing. Municipal budgets are too dependent on tributes that are tied to the construction sector and in the actual context (sudden stop of production in this sector in almost all the Spanish municipalities) this would no longer be sustainable. Given that the largest part of QOL can be attributed to the municipal level, assuring stable financing to municipal services is a need. The second implication is a statistical one. Official statistics are dominated by the regional level and contain very scant information at the municipal level. This trend needs a profound revision. If the objective is to improve the QOL of the people, measuring the variables that relate to this concept at a municipal level is necessary.

6. Concluding remarks

There are two main empirical problems in the measurement of quality of life in municipalities. The first one has to do with the data. Choosing a representative set of variables that approaches the drawbacks and advantages associated with living in each municipality is essential to obtain meaningful results. Unfortunately the selection of variables is strongly constrained by the availability of comparable data. There is very scant comparable information about living conditions in Spanish municipalities. The only sources of comparable information that can be used are the INE surveys on population and housing and La Caixa's *anuario económico*[22]. The INE surveys are very rich in variables that can approach the quality of life conditions of municipalities. We have selected 19 variables (8 drawbacks and 11 advantages) that approach the most relevant dimensions of quality of life: Consumption, Social services, Housing, Transport, Environment, Labour market, Health, Education, Culture and leisure and Security.

The second empirical problem is how to synthesize the information contained in the raw variables collected to construct an aggregate index of quality of life that can be useful for citizens and decision makers. We contend that the DEA methodology provides an excellent procedure to aggregate information in a sensible manner. DEA constructs a quality of life frontier and weights the drawbacks and advantages in the manner that is most advantageous to the municipality under analysis. However, the empirical application of DEA also has some important problems that we have tried to overcome in this paper. Value Efficiency Analysis (VEA) was developed to easily incorporate a piece of qualitative information within the DEA specification. Our results show that VEA significantly increased the discriminating power of DEA and achieved more congruence in the weights of the variables used in the analysis.

The paper applied both DEA and VEA methodologies to quality of life data on a sample of 643 Spanish municipalities during the year 2001. The sample includes all the municipalities over 10000 inhabitants for which we were able to compile complete data[23]. Our sample represents 76.3% of the Spanish population. The DEA scores show moderately high average levels of quality of life, with an average of 0.92. However, after the weights are forced to have some degree of consistency in the VEA analysis, the average decreases to 0.89. From 129 DEA frontier municipalities only 26 are also on the VEA frontier. In reality what is happening is that VEA allows a simple identification of the municipalities which DEA (high) score is based on unrealistic values for the shadow prices of the variables used in the analysis. These municipalities (El Ejido or Boadilla del Monte, for instance) benefit from the extreme flexibility of DEA but do not resist a further analysis on their activity data.

We also checked what level of analysis explains a larger share of the variance in the QOL of the population. We find that the municipal level of analysis explains a 52.6% and the regional level explains a 37.8%. The province only explains a 9.6%. Therefore, the municipal level can be considered as the most relevant level of analysis for QOL assessment. This result contrast with the importance that the regions have had in obtaining a sustainable model of financing and also a rich statistical coverage. Municipalities suffer from both problems. First, the finance of their competencies is not assured, since the taxes that have assigned are strongly tied to the construction sector.

Second, there is very little statistical information related to quality of life at the municipal level. Both problems seriously compromise the objective of improving the quality of life of the population. Governors can do little if they can't obtain accurate measures of their objective functions and also they don't have a sustainable financial structure to organize the services that contribute to those objectives. Therefore, according to our results, the challenge for the near future would be to develop an appropriate financial model for the municipalities and developing a stable source of statistical information about QOL at the municipal level of analysis.

References

Ali, A.I. (1994). Computational aspects of Data Envelopment Analysis. (In A. Charnes, W.W. Cooper, A.Y. Lewin, & L.M. Seiford (Eds.), *DEA: Theory, methodology and applications* (pp. 63-88). Boston: Kluwer Academic Publishers.)

Allen, R., Athanassopoulos, R., Dyson, G., & Thanassoulis, E.. (1997). Weights restrictions and value judgements in Data Envelopment Analysis: Evolution, development and future directions. *Annals of Operations Research*, 73, 13-34.

Banker, R.D., Charnes, A., & Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies. *Management Science*, 39, 1261-1264.

Charnes, A., Cooper, W.W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2, 429-44.

Despotis, D.K. (2005a). A reassessment of the Human Development Index via Data Envelopment Analysis. *The Journal of the Operational Research Society*, 56, 969-980.

———. (2005b). Measuring Human Development via Data Envelopment Analysis: the case of Asia and the Pacific. *OMEGA*, 33(5), 385-390.

Dyson, R.G., & Thanassoulis, E. (1988). Reducing weight flexibility in Data Envelopment Analysis. *Journal of Operational Research Society*, 6, 563-576.

Halme, M., Joro, T., Korhonen, P., Salo, S., & Wallenius, J. (1999). A Value Efficiency approach to incorporating preference information in Data Envelopment Analysis. *Management Science*, 45(1), 103-115.

Hashimoto, A., & Ishikawa, H. (1993). Using DEA to evaluate the state of society as measured by multiple social indicators. *Socio-Economic Planning Sciences*, 27, 257-268.

Hashimoto, A., & Kodama, M. (1997). Has livability of Japan gotten better for 1956-1990? A DEA approach. *Social Indicators Research*, 40, 359-373.

Hollingsworth, B., & Smith, P. (2003). Use of ratios in Data Envelopment Analysis. *Applied Economics Letters*, 10, 733-735.

Korhonen, P., Siljamäki, A., & Soismaa, M. (1998). Practical aspects of Value Efficiency Analysis. Interim Report IR-98-42. International Institute for Applied Systems Analysis.

La Caixa. (2001). Anuario Económico de España.

Marshall, E., & Shortle, J. (2005). Using DEA and VEA to evaluate quality of life in the Mid-Atlantic states. *Agricultural and Resource Economics Review*, 34/2, 185-203.

MERCO-Mercociudad. (2008). Monitor Empresarial de Reputación Corporativa. Retrieved February 18, 2009, from http://www.mercoinfo/ver/mercociudad/ranking-sectorial.

Murias, P., Martínez, F., & Miguel, C. (2006). An economic well-being index for the Spanish provinces. A Data Envelopment Analysis approach. *Social Indicators Research,* 77(3), 395-417.

OCU-Organización de Consumidores y Usuarios. (2007). Encuesta sobre calidad de vida en las ciudades. *Compra Maestra,* 317.

OECD. (2008). *Handbook on Constructing Composite Indicators*. (Paris: OECD Publishing.)

Pedraja, F., Salinas, J., & Smith, P. (1997). On the role of weight restrictions in Data Envelopment Analysis. *Journal of Productivity Analysis*, 8, 215-230.

Pena, J.B. (1977). *Problemas de la medición del bienestar y conceptos afines (Una aplicación al caso español)*. (Madrid: Instituto Nacional de Estadística (INE)).

Roback, J. (1982). Wages, rents, and the quality of life. *Journal of Political Economy,* 90(6), 1257-1278.

Roll, Y., Cook, W.D., & Golany, B. (1991). Controlling factor weights in Data Envelopment Analysis. *IIE Transactions,* 23, 2-9.

Rosen, S. (1979). Wage-based indexes of urban quality of life. (In P. Mieszkowski & M. Straszheim (Eds.), *Current Issues in Urban Economics,* Baltimore: Johns Hopkins University Press.)

Sánchez, M.A., & Rodríguez, N. (2003). El bienestar social en los municipios andaluces en 1999. *Revista Asturiana de Economía,* 27, 99-119.

Sarrico, C.S., & Dyson, R.G. (2004). Restricting virtual weights in Data Envelopment Analysis. *European Journal of Operational Research,* 159, 17-34.

Searle, S.R. (1971). *Linear Models.* (New York: John Wiley and Sons.)

Searle, S.R., Casella, G., & McCulloch, C.E. (1992). *Variance Components.* (New York: Wiley.)

Somarriba, N., & Pena, B. (2009). Synthetic indicators of quality of life in Europe. *Social Indicators Research,* 94(1), 115-133.

Thompson, R.G., Singleton, F., Thrall, R., & Smith, B. (1986). Comparative site evaluations for locating a high energy physics lab in Texas. *Interfaces,* 16, 35-49.

Wong, Y-HB., & Beasley, J.E. (1990). Restricting weight flexibility in Data Envelopment Analysis. *Journal of Operational Research Society,* 41, 829-835.

Zarzosa, P. (2005). *La calidad de vida en los municipios de Valladolid*. (Valladolid: Diputación Provincial de Valladolid.)

End Notes

[1] The use of the DEA methodology to estimate a composite index of quality of life traces back to the early work of Hashimoto and Ishikawa (1993) who assessed the quality of life in Japan's prefectures.

[2] There are also other methods not included in the Handbook as the multidimensional distance (DP_2) proposed by Pena (1977) and the hedonic price methods proposed by Rosen (1979) and Roback (1982), although the last one falls outside the social indicators approach. The papers that have dealt with the measurement of QoL in regional samples of Spanish municipalities have relied on the DP2 distance measure (Sánchez and Rodríguez, 2003; Zarzosa, 2005).

[3] Some authors also point to factor analysis as a valid aggregating methodology (Somarriba and Pena, 2009).

[4] The DEA approach tries to reduce inputs to the minimum possible because they imply a cost in production. It also tries to increase outputs to the maximum because they have a positive value for the productive firm. In our setting city drawbacks imply a cost of living in the municipality and should be reduced to a minimum, while advantages imply a benefit for citizens and should be increased to the frontier maximum. Thus, the parallelism is clear and the applicability of DEA to our research setting is granted. Throughout the paper we will refer indistinctly to inputs-drawbacks and outputs-advantages.

[5] We describe the dual DEA programs instead of the more usual primal specifications because we will use the weights of inputs and outputs in these dual programs to perform the VEA analysis. Anyway, the primal specification would, of course, reach exactly the same solutions and provide the same performance indicators.

[6] We used the software LINGO to solve the DEA and VEA programs of this research. While many packages are pre-programmed to solve DEA, we are not aware of anyone that can solve VEA. However, any mathematical programming software can be used to solve (4).

[7] In the computation of this index, INE uses class marks that go from 0 (unemployed) to 3 (entrepreneur).

[8] To compute this index, La Caixa takes into account the population, number of phones, automobiles, trucks and vans, banking offices and retail activities. In order to make this index comparable across municipalities we divided it by the population and multiplied by 10000.

[9] To make the numbers comparable we divided the total number of facilities by the population and multiply by 10000.

[10] For the computation of the index, INE uses class marks that go from 1 (illiterate) to 10 (PhD).

[11] This index, elaborated by INE, ranges from 0 to 100 and takes into account factors of the buildings as the age of construction, tumbledown status, hygienic conditions, running water, accessibility, heating, etc.

[12] The raw data distinguishes between these two destinations. Our variable is the arithmetic average of both. We also must indicate that INE does not compute an index associated with these variables. Instead the report includes the percentage of people on seven intervals that go from "less than 10 min" to "more than 90 min". We took mark classes in the mean of the intervals (90 for the last interval) and weighted each class mark by the percentage of population within the interval. The weighted sum can be interpreted as the average time employed to get to the school or job and is the variable used in this paper.

[13] In the other dimensions is about the mean although far from the best performers.

[14] Boadilla del Monte is a municipality in Madrid that excels in many dimensions (education, socio-economic condition, housing, pollution). In change its citizens must incur costly hours driving to the schools or jobs and the level of facilities (health, cultural, etc) is relatively low.

[15] OCU stands for Organización de Consumidores y Usuarios and is the largest consumers association in Spain.

[16] Security was the main variable to account by citizens with an average weight of 18%, then labour market (15%), housing (13%) and health services (12%).

[17] Therefore is the only one that can be used as MPS. Barcelona, Madrid and Valencia could not be considered as the MPS because the VEA program would not have a feasible solution because the city is not on the DEA frontier.

[18] Other good candidates to be the MPS were Vitoria, Getxo and San Sebastian. However, we were not able to find the independent support of other studies as we did with Pamplona. We repeated the VEA analysis with these municipalities as MPS and found no important differences.

[19] In the DEA program Boadilla del Monte assigned a weight 0 to communications and time to the job or school. Although it still is a good place to live it is no longer a referent (frontier) under the VEA formulation.

[20] Figures 2 and 3 show the weighted average of QOL in the municipalities included in the sample for each province and region, respectively. The weights are the ratio of the population of a municipality to the sum of the population of all the municipalities of that province or region included in the sample.

[21] In an unbalanced design (as it is our case) many different estimators of the variance components can be used (Searle, 1971: Ch.10). All of them would collapse to the Analysis of Variance estimator in a balanced design. Searle et al. (2002) manifest a strong preference for the REML estimator in unbalanced designs. We checked the results obtained with other estimators (ANOVA type 1 and 3, Minimum Variance Quadratic Unbiased Estimator types 0 and 1, and Maximum Likelihood estimator) and the results are nearly identical.

[22] Caja España also provides on its webpage a municipal database, but most of the information is taken from the INE statistics.

[23] Only one municipality with population over 25000 was excluded because data on journey times and universitary studies were not reported in the INE database. This municipality is La Vall d'Uixo (Castellón).