Quality of life and urban size. Testing the relationship using simultaneous equation models.

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Very preliminary version

Abstract

In this work we look at changes in the intra-metropolitan distribution of population. Particularly we use the classical determinants of urban growth to test which ones are more important within a metropolitan area. These determinants are: amenities and disamenities, which are considered as constituents of the more global concept of quality of life; the supply-oriented dynamic approach; and the city network paradigm. In particular we focus our paper on the role of quality of life variables in urban growth. In this sense, as we expect a potential endogeneity between quality of life and urban size (growth), we use a simultaneous equation model. We test our model empirically in a local dynamic framework, the city of Barcelona (Spain), in the period 1991-2004.

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1. Introduction

In the last recent centuries cities have been growing and spreading out. Advances in transport and communication technologies have shaped the spatial structure of modern cities. In Europe, the old centres that were formerly medieval towns are still city centres, and the spread of the metropolis is dependent of the spatial structure of the previously existing villages surrounding the old town. Our case of study, Barcelona, is a clear example of that. Thus, in Muñiz et al (2003) the Barcelona area has been defined as a Mediterranean polycentric city, where polycentricity comes from the large urban centre expanded its commuting area, incorporating medium sized cities that had previously been self-sufficient. The shape of this area is, thus, a consequence of history. But we can also think that its recent evolution will be the consequence of economic and social forces.

In this paper our main objective is focused on finding the key factors that have played a major role on determining the current shape of the metropolitan area. In particular we will focus on: the supply-oriented dynamic approach; and the city network paradigm; and specially amenities and disamenities, which are considered as constituents of the more global concept of quality of life. Two additional aspects arise as objectives of our work: the territorial unit of analysis, and the potentially endogenous relationship between certain variables.

Choosing the basic unit of our analysis is not an easy task. For instance it is not easy to determine if we speak of one city or of a family of linked cities or urban systems and subsystems (we could even speak of a hierarchy of cities within the metropolitan area). Besides, usually the researcher faces the problem of having to work with administrative units, usually not homogeneous, to which the data is related.

Finally, an endogenous relationship can exist between urban size and its determinants. For instance, if a city is experiencing an important increase in the provision of services, the social quality of life will improve. Several consequences can arise: an increase in housing prices, reflecting this new situation, and also a migration process of population attracted by the new circumstances of that place. In these both cases a potential loss of wellbeing can arise. Thus, an increase in quality of life results in an increase of population, but subsequently, an increase of population can result in a decrease of quality of life.

In the following sections we revisit several theoretical determinants in the city size (section two); we display the theoretical model (section three); we devote a particular attention to the concept of quality of life (section four); and we finally try to see the empirical relationship between urban size and quality of life in a local framework, the province of Barcelona, Spain (section five). Finally, section six concludes and summarises the main findings of our work.

2. Determinants of the size of cities.

Urban size is the result of individual decisions made by households and firms, which decide to stay in a city or to move to another place by trying to maximise their utility levels or profits. If cities exist it is because they are the more efficient way of spatially distribute personal, social and economic relationships between individuals. The basis for explaining this higher economic efficiency is found in the scale economies: more efficient processes can only be developed when a minimum scale is achieved. Even if that only happens in one sector, other sectors with productive links will have more benefits for locate in that place, workers will save transportation costs for residing there, and public services will be provided there. Thus, in economic terms large urban areas exist because of positive externalities related to the higher productivity that agents could achieve by being near other producers or market agents.[2]

Of course, several limits arise, related with congestion costs or negative externalities: increasing transportation costs, higher salaries and house rents, higher traffic intensity, worst environmental quality or increasing criminality. Thus, agglomeration economies can, after a critical point, degenerate into agglomeration diseconomies.

One could think on an optimal city size of a city, as a result of the maximum difference between a location cost curve and the aggregate agglomeration advantage curve. Of course costs and benefits are differently expressed in terms of utility and profits for residents and firms, and also are affected through a wide and diverse set of conflicting amenities and disamenities.[3] Every individual balances between them, and if the difference is positive or higher than in alternative locations, people will have powerful reasons for living in that place, while if the balance is negative or lower than in other places, people will have incentives to move. This is the mechanism that drives cities to grow or decrease in size.

Theoretical models always try to simplify reality in order to focus key aspects to consider. In these basic models, as all cities are basically equal, in equilibrium all of they should have the same size. Of course, reality is much more complex and, as Henderson (1985) points out, cities are not all the same, and they produce different goods according to their size, what can be summarised as having different production functions. These usually depend on the position of the city in the urban hierarchy, being the bigger the one with more and more complex functions.[4] In this framework, if every city has its own production function, any urban size can be the result of equilibrium, and urban settlements could be equally ranked by size or by the complexity of the functions that the city develops.

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[2] These increasing returns to scale at the aggregate level can arise from constant returns to scale at the micro level. See, for instance, Duranton and Puga (2004).

[3] We will consider *average* amenities and disamenities, rather than *marginal* ones. The latter case would drive us to consider the social optimum size of cities (marginal costs equal to marginal benefits), while the former case drive us to consider the maximum size (average costs equal to the average benefits). Neither of them is the optimal city size per capita (maximum differences between average costs and average benefits).

[4] One of the consequences of the hierarchy of urban centres is the well known rank size rule, which is quite persistent.

Nevertheless, sometimes we see medium size cities with superior functions. The network city paradigm (Camagni, 1993; Camagni and de Blasio, 1993) helps to explain why small and / or medium-sized cities may have higher-order functions.

The form of urban systems has been analysed in the literature. Thus, we have seen in recent decades how the spreading out of cities has taken a more polycentric form, with a number of concentrated employments centres (or subcentres), which are subsidiary to the still important Central Business District. The trend toward urban sprawl is one of the key features of urban growth. Glaeser and Shapiro (2003) quote it as much more important than the increase in density. Additionally, low-density cities grew faster in the USA in recent decades than high-density cities. As Mills (2004) points out, both the increase in real income and the decrease in the cost per mile of commuting have pushed to the decentralisation and suburbanisation of cities. It has happened together with suburbanisation of production and employment.

A metropolitan area of this kind is usually a coherent urban system and forms an interdependent system with a size distribution analogous to the system of cities in a larger economy. Anas et al (1998) explore several assumptions that can help to explain this dynamics: spatial inhomogeneities, internal and external scale economies, imperfect competition and the stability/instability of subcentres.

Consequently, within a stable hierarchy of urban centres and/or subcentres, the increasing or decreasing size of cities depends on the strength of a list of forces: having superior functions in the urban system; enjoying network economies; changes in real income; changes in the cost of commuting; and the amount of amenities and disamenities. The latter aspect will focus our attention in the next section.

3. The Model

The basic model is the one developed in Glaeser et al (1992) and extended in Glaeser et al (1995). There, cities are treated as separate economies that share common pools of labour and capital, which are assumed to be mobile. Consequently, cities differ only in the level of productivity and the quality of life. Total output is given by:

$$A_{i,t} f(L_{i,t}) = A_{i,t} L_{i,t}^{\sigma},$$

where $A_{i,t}$ is the level of a broad definition of productivity in city *i* at time *t*, $L_{i,t}$ denotes population of city *i* at time *t*, *f(.)* is a common across cities Cobb-Douglas production function, and σ is a nation-wide production parameter. The labour income of a potential migrant will be:

$$W_{i,t} = \sigma A_{i,t} L_{i,t}^{\sigma-1}.$$

This potential migrant would face a total utility that equals wages multiplied by a quality of life index ($QoL_{i,t}$), that is assumed to be declining in the size of the city. Glaeser et al (95) uses the following definition of quality of life:

$$QoL_{i,t} = Q_{i,t} L_{i,t}^{-\delta}, \quad \text{(X)}$$

where $QoL_{i,t}$ captures a wide range of factors related with crime, housing prices, and traffic congestion. In our view, the separation of the quality of life index in $Q_{i,t}$ and $L_{i,t}^{-\delta}$ is assuming that $Q_{i,t}$ does not depend on urban size. This assumption is in contrast with the findings of Capello and Camagni (2000) and Royuela and Suriñach (2005), where a relationship between amenities or disamenities and urban size is found. Consequently, here we assume that we cannot separate the quality of life variables and urban size, as is done in equation (X). Consequently, here we assume a generic function of quality of life:

$$QoL_{i,t} = f(Q_{i,t}, L_{i,t}),$$

where: $Q_{i,t} = f(L_{i,t})$, and $\frac{dQoL_{i,t}}{dL_{i,t}} < 0$.

The main difference between the Glaeser et al (1995) approach and ours is that we think that many quality of life variables depend on the size of the city. Consequently, it is not an easy task to separate the quality of life function between constituents of quality of life not correlated with urban size ($Q_{i,t}$) and urban size ($L_{i,t}$).

Total utility of individuals equals wage multiplied by a function of the quality of life index:

$$Utility = \sigma A_{i,t} L_{i,t}^{\sigma-1} QoL_{i,t}^{\delta},$$

where δ>0. Free migration across cities is assumed. Consequently, there is a constant utility across space at a point of time, $U_{i,t} = \underline{U}_t$.

Thus, for each city:

$$\log\left(\frac{\underline{U}_{t+1}}{\underline{U}_t}\right) = \log\left(\frac{A_{i,t+1}}{A_{i,t}}\right) + \delta \log\left(\frac{QoL_{i,t+1}}{QoL_{i,t}}\right) + (\sigma - 1)\log\left(\frac{L_{i,t+1}}{L_{i,t}}\right).$$

Changes in productivity and quality of life are assumed to be a function of two vectors of city characteristics at time t, $X1_{i,t}$ and $X2_{i,t}$ respectively:

$$\log\left(\frac{A_{i,t+1}}{A_{i,t}}\right) = X1_{i,t}^{'}\beta + \varepsilon_{i,t},$$

$$\log\left(\frac{QoL_{i,t+1}}{QoL_{i,t}}\right) = X2_{i,t}^{'}\theta + \gamma \log\left(\frac{L_{i,t+1}}{L_{i,t}}\right) + \zeta_{i,t},$$

where we expect γ<0. Combining these equations, we obtain the following system of equations:

$$\begin{cases} \log\left(\frac{L_{i,t+1}}{L_{i,t}}\right) = \frac{1}{1-\sigma} X1'_{i,t}\beta + \frac{\delta}{1-\sigma}\log\left(\frac{QoL_{i,t+1}}{QoL_{i,t}}\right) + \omega_{i,t} , \\ \log\left(\frac{QoL_{i,t+1}}{QoL_{i,t}}\right) = X2'_{i,t}\theta + \gamma\log\left(\frac{L_{i,t+1}}{L_{i,t}}\right) + \zeta_{i,t} \end{cases}$$

where the error terms are uncorrelated with the error characteristics. In this model cities will *increase* their population if they experience an increase in quality of life. And, simultaneously, quality of life will *decrease* as population increase. The results of the model can be interpreted as showing how the city level variables ($X1$ and $X2$) determine the growth of city productivity, city population and quality of life.

4. Defining quality of life

In the model defined in section three, a key point arises: how can we define and even measure quality of life? In this section we develop a definition of quality of life to be used in the model.

As a starting point we assume that the academic literature usually employs a simplification of what is generically labelled as amenities (benefits) and disamenities (costs). Here we refer to these aspects in a global framework: quality of life. In our view, all inhabitants of a city have a general problem: maximization of their utility. In many studies (Giannias et al, 1999; Clark, et al, 1988), the concept of quality of life is included explicitly in the utility function. In this paper the theoretical framework to examine quality of life is based on Maslow's theory of human needs. This leads us to reformulate the way amenities and disamenities are considered and to propose a composite measurement of quality of life.

Though economic factors have important territorial consequences, non-economic ones also do. Many economically advanced industrial societies have increased dramatically the level of material well-being. This has led to post-materialist values, which have seen economic factors as a relative question that is part of a much more complex understanding of how people take decisions (Inglehart, 1990)[5]. Thus, economic factors, such as the distance to the central business district, may be just one factor among several when a household is deciding its place of residence. At this point, to understand the definition of quality of life, the concept of human need needs to be introduced. Thus, human nature looks for continuous improvement, which means that a need already satisfied becomes the starting point for new needs. Then, new social needs have to be interpreted as a new way of satisfying our needs in a new environment. But then, are needs really everything that we express as needs?

Maslow (1975) sees five different kinds of needs, from objective to subjective: physiological needs, health and security, ownership and love, need to being loved, and self-fulfilment.

[5] The social materialist vision of reality that predominates is the instrumental character of economic activities that allows people earning resources that are used in other activities giving satisfaction. The post-materialist vision, however, argues that in societies characterised by abundance resources are not infinite, but they are sufficient, such that choices are made in terms of opportunity costs. Thus, even a job can be valued highly, apart from the earnings it produces.

Following Maslow, once we have covered the more basic and objective needs, we are ready to try to cover more spiritual needs. Nevertheless, several authors have denied linearity in the needs classification of Maslow (Doyal and Gough, 1994); others have classified them in a Marxist dialectic (Heller, 1978); and others have developed their own classifications. Thus there is no consensus on the definition and nature of human needs. Our point here is that we can only evaluate overall needs when we intend to optimise these needs. Then, we can supersede the basic *objective* idea of welfare and move on to the more complex idea of quality of life.

Here we understand quality of life in the social sense, as defined in Liu (1978, p. 249): "The optimal level of quality of life is produced only by combining both the physical and psychological inputs (...). Therefore, the quality of life that each individual perceives is assumed to be directly dependent on his capability constraints to exchange and to acquire, while the major concern for a society is how to improve an individual's capability by shifting the constraint curve outward to the right". For our purposes, we will understand quality of life as the satisfaction that receives a household from his physic and human environments, with an emphasis in external components, in contrast to subjective well-being (Diener, 2005). We interpret then quality of life as social or human wellbeing, and we will assume it to influence and restrict human opportunities (Smith, 1977 and Mulligan et al, 2004). This definition influences the analysis scope that has to be local-urban, territorially speaking.

Quality of life is a multidimensional concept. According to Wish (1986), there may be many vectors to consider. We need to study all of them if we are to reach a full definition of quality of life. Here we see two basic alternatives. The first one assumes that benefits and costs cannot be considered separately, but jointly in a composite quality of life measure, because benefits and costs considered apart are difficult to interpret in human need terms. On the contrary, the second alternative, summarised by von Böventer (1974, p. 6), assumes that, at the same time "economists cannot shy away from the problems of big agglomerations and the difficulties that all kinds of agglomeration economies and diseconomies present (…) one should continue looking for indicators of the positive and negative effects that are generated by large agglomerations, measure them and try to arrive at conclusions, however partial or incomplete they may be".

Another aspect to consider is: can we measure quality of life? Myers (1988) lists four approaches to quality of life analysis:

- the personal well-being approach which measures life-satisfaction of individuals;
- the community trend approach which focuses on quality of life components and trends within the community;
- the liveability comparisons approach which focuses on comparing different urban areas according to a number of objective indicators assumed to reflect quality of life; and
- the market/resident approach in which housing price and/or wage differentials are theorised to compensate for quality of life differences between urban areas.

The last two attempt to compare quality of life in urban areas directly through construction of quality of life indices and subsequent ranking of urban areas. Here we will assume the objective indicators based approach, and we will use two different alternatives to reach both composite and disaggregate measurement of quality of life. In discussing applied techniques to city-rankings, Gyourko *et al* (1999) and Becker *et al* (1987) point out that city-ranking studies appear to be plagued by a length list of methodological problems, and recommend that future research should target intracity scale where more detailed can be achieved.

In Royuela, et al (2003), the quality of life of a group of municipalities of Barcelona province was analysed, using a wide list of dimensions. Nevertheless, here we will focus only on quality of life coming from his physic and human environments, and particularly emphasizing the external components, in contrast to subjective well-being or with the personal characteristics of the individuals. Thus, our final definition of quality of life is listed in Table 1, and the composite index can be labelled as the External Community Conditions of Life (ECCL).

As Morris (1979) and Gwartney et al. (1996) say, there is no weighting system above criticism. Following Babbie (1995) we finally decided to attribute the same weight to the components, but with two exceptions: because of their inherent importance, the educational and health facilities indices were over-weighted compared to the rest of dimensions. Several criticisms of this ad hoc selection have been made (Todaro, 1989; Elkan, 1995). However, in our view, methodological doubts have restricted the application of quality of life studies to social problems and planning. We agree that the structure, the indices and the weights are inherently subjective, and of course, we assume all critiques for our study but, as recommended von Böventer, “we do not shy away” from the problems and we think that it can not be an excuse for conducting quality of life research (Rogerson, 1995).

Table 1. Quality of Life Components and their variables

External Community Conditions of Life = ECCL = 0.10 HC + 0.10 PTI + 0.15 EFI + + 0.15 HFI + 0.10 SOASI + 0.10 EI + 0.10 CI + 0.10 CFI + 0.10 MMI

HC= Housing Characteristics

- \+ Index of housing conditions
- \+ Houses size per inhabitant
- \+ Rate of one-family houses
- \+ Housing services index (water, phone, etc.)

PTI= Public Transport Index

- \- 1-Rate of public transport users among workers
- \- 1-Rate of public transport users among students
- \+ Train services
- \+ Number of urban buses per potential users

EFI= Educational Facilities Index

- \+ Educational services index
  - \+ Basic school units
  - \+ Primary school units
  - \+ High school units
  - \+ Special education units
- \+ Students per school unit index
  - \- Basic school
  - \- Primary school
  - \- High school
- \+ University Index
  - \+ University courses per 10,000 inhabitants between 19 and 24
  - \+ University's diversity of supply

HFI= Health Facilities Index
- \+ Pharmacies per 1,000 inhabitants
- \+ Hospitals per 1,000 inhabitants
- \+ Hospital beds per 1,000 inhabitants
- \+ Outpatients' health centres
- \+ Number of workers in the health sector per 1,000 inhabitants

SOASI= Social and Old Age Services Index
- \+ Number of old age residences over 1,000 old age inhabitants
- \+ Number of old age cultural houses over 1,000 old age inhabitants
- \+ Number of old age open-day residences over 1,000 old age inhabitants

EI= Environment Index
- \+ Air quality index in Catalonia
- \+ Proportion of residuals that is selectively collected

CI= Climate index
- \- Yearly temperature range (max-min)
- \+ Average temperature

CFI= Cultural Facilities
- \+ Theatres and theatre diversity
- \+ Museums and museum diversity
- \+ Bookshops and bookshop diversity
- \+ Municipal archives and municipal archive diversity
- \+ Cinemas and cinema diversity
- \+ Art galleries
- \+ Sport centres and sport centre diversity

MMI = Municipal Media index
- \+ Written media
- \+ TV and radio
- \+ Municipal bulletins

Source: Royuela, et al (2003)

5. City size and quality of life in Barcelona's metropolitan area

5.1. The local environment

The analysis focuses on the province of Barcelona, one of the four provinces of the region of Catalonia. Catalonia (NUTS II in the European administrative classification) is one of Spain's most developed regions, located in the north-east of the country. The region is divided into four administrative provinces (NUTS III in the European administrative classification). Barcelona is the most populated one, with 76% of the region's inhabitants: 4,628,277 in 1996. Together with Madrid, it is Spain's most populated and urbanised province. It has 314 municipalities, organised in 11 administrative groups, called *comarques.* These municipalities are the basic unit of measurement in our study. Describing territorial groups is a very important part of the work; elsewhere, we used different territorial groups, defined as urban systems and urban subsystems (Artís et al., 1999). These aggregations were developed following commuting and services areas criteria, and are referred to 1991.

Thus, the local framework of our study has four territorial dimensions: the 11 *comarques*, 24 urban systems, 48 urban subsystems and 314 municipalities. The 24 urban systems and their subsystems (if the former can be partitioned), together with their size, are shown in Table 2. A substantial part of the total population is concentrated in a small number of municipalities: the city of Barcelona had 33% of the total population of the province in 1996. There are also differences in terms of urban development. Some systems and subsystems are best described as urban areas or simply cities (near Barcelona), while others are rural areas, further away from Barcelona. The province is similar to other areas in Europe, in which a large city has a relatively wide area of influence: its suburbs, its surrounding towns, industrial clusters, and so on.

Table 2. List of urban systems and subsystems within Barcelona province

Urban Systems (and their subsystems if they can be divided)	**Size (1996 inhabitants)**	**Number of municipalities**
System of l'Alt Penedès	**73,196**	**27**
Subsystem of Sant Sadurní	14,093	4
Subsystem of Vilafranca	59,103	23
System of l'Anoia	**86,964**	**33**
System of Bages	**152,586**	**35**
Subsystem of Manresa	122,895	27
Subsystem of Bages Nord	29,691	8
System of Baix Llobregat Nord	**123,778**	**12**
Subsystem of Esparraguera-Olesa	31,864	3
Subsystem of Martorell	73,582	8
Subsystem of Sant Andreu de la Barca	18,332	1
System of Baix Montseny	**22,792**	**9**
System of Barcelona	**1,508,805**	**1**
System of Berguedà	**38,606**	**31**
System of Besòs	**413,106**	**8**
Subsystem of Badalona	231,514	4
Subsystem of Sant Adrià del Besòs	33,361	1
Subsystem of Masnou	25,056	2
Subsystem of Santa Coloma de Gramenet	123,175	1
System of Cerdanyola, Montcada and Ripollet	**106,474**	**3**
Subsystem of Cerdanyola	50,503	1
Subsystem of Montcada i Reixac	27,068	1
Subsystem of Ripollet	28,903	1
System of Cornellà	**82,490**	**1**
System of Delta del Llobregat	**135,310**	**5**
Subsystem of Gavà	41,090	2
Subsystem of Castelldefels	38,509	1
Subsystem of Viladecans	55,711	2
System of Garraf	**90,435**	**6**
System of Granollers	**173,168**	**23**
Subsystem of Pla de Granollers	159,659	19
Subsystem of Congost	13,509	4
System of Maresme Nord	**59,537**	**7**
Subsystem of la Riera de Calella	33,843	4
Subsystem of la Tordera	25,694	3
System of Maresme Sud	**213,771**	**18**
Subsystem of la Riera d'Arenys	28,799	5
Subsystem of Mataró	145,570	10
Subsystem of la Riera de Premià	39,402	3
System of Mollet-Parets	**70,331**	**10**
System of Osona	**122,923**	**51**
Subsystem of Osona Nord	19,422	9
Subsystem of Vic	78,299	36
Subsystem of Manlleu	25,202	6
System of El Prat de Llobregat	**63,255**	**1**
System of la Riera de Caldes	**29,193**	**7**

System of Rubí - Sant Cugat	**101,295**	**2**
Subsystem of Rubí	54,085	1
Subsystem of Sant Cugat	47,210	1
System of Sabadell	**283,954**	**10**
Subsystem of Barberà del Vallès	42,542	2
Subsystem of Sabadell	223,530	6
Subsystem of Castellar	17,822	2
System of Sant Boi	**84,477**	**3**
System of Terrassa	**177,824**	**6**
System of la Vall Baixa de Llobregat	**415,430**	**9**
Subsystem of Esplugues and Sant Just	60,116	2
Subsystem of Sant Feliu de Llobregat	35,797	1
Subsystem of l'Hospitalet	255,050	1
Subsystem of Molins	37,662	4
Subsystem of Sant Joan Despí	26,805	1

Despite the differences between systems or subsystems, they are much smaller than those between municipalities. In any case, the main characteristic of systems or subsystems is not their more homogeneous size, but that they clearly form separate areas on the basis of commuting and services criteria.[6]

5.2. The data

As stated section 4, a structural definition of quality of life is developed, based on a list of seven dimensions. The final index is constructed using a weighted (*a priori*) arithmetic average index of partial indicators that express the relative standardised position of every individual (municipality, subsystem or system) after combining the variability of all variables, with a Paasche-type temporal aggregation. A description of the methodology is displayed in annex 1, and is also explained in detail in Royuela et al (2003). All indices are defined in positive terms (the higher, the better). The database referred to all years in the 1991-2004 period.

Besides the key variables of the simultaneous equation model, we need a list of variables that determine the growth of productivity ($X1$) and quality of life ($X2$). The lists are displayed below:

$X1$: list of variables influencing the growth of productivity:

- characteristics of individuals:
  - age: proportion of people aged 25-35
  - birth rate: number of births over 1,000 inhabitants
  - wealth: personal income declared in the national income tax
  - education levels: average of years studied; proportion of adult people with education equal or higher than non compulsory secondary school
  - availability of cars for personal commuting
  - unemployment rate
- Efficiency of the housing market: housing prices, and affordability ratio. These variables only could be computed for groups of municipalities, and there are territorial groups where all municipalities within every group share the same value. It doesn't happen for subsystems.
- Position in the hierarchies: dummies for the head of systems and subsystems, considered cumulatively, in order to capture a threshold effect

[6] Each system or subsystem has basic health or educational services that are not shared with other systems or subsystems. So, general services such as universities and large hospitals are not considered as defining features of urban systems or subsystems.

- Network economies variables: more connected municipalities are supposed to have more chances to be adaptable. We used an indicator of the telephone cells installed in 1996, as in Capello and Camagni (2000). We understand that, though nowadays this variable might not be appropriate, for the considered period it can be seen as a good indicator of the network paradigm.

*X*2: list of variables influencing the growth of quality of life:

- characteristics of individuals:
    - age: proportion of people aged 0-15, and people aged +65
    - wealth: personal income declared in the national income tax
    - availability of cars for personal commuting
    - unemployment rate
- Congestion: amount of cars over km of roads; population density: both are proxies of congestion, this is, measurements of complications to create new services for immigrants
- Position in the hierarchies: dummies for the head of systems and subsystems, considered cumulatively, in order to capture a threshold effect
- Network economies variables: more connected municipalities are supposed to be more adaptable. We used an indicator of the telephone cells installed in 1996, as in Capello and Camagni (2000). We understand that, though nowadays this variable might not be appropriate, for the considered period it can be seen as a good indicator of the network paradigm.
- Financial position of the municipalities: a financial index is developed, using three indicators of the financial position of the city council, always linked with the administrative definition of municipalities

Finally, we also considered the possibility of having spatial interactions. Thus, we computed the time that one person lasts in arriving by car: to the capital of the province, Barcelona; to the nearer central city, and to the closer functional city (centres and subcentres).

Different alternatives arise to be considered as alternative datasets. Firstly, related with the territory: we consider two alternatives: the use of 314 municipalities or, alternatively, 48 subsystems. And secondly related with the time span: five datasets can be considered: as our data considers 1991-2004, one 14 years period of growth (1991-2004), one ten years period of growth (1991-2001), to avoid the influence of the more recent explosion of foreign immigration in the province; and finally, three alternative narrower years subperiods: 1991-1996, 1996-2001, and 2001-2004. Consequently, 10 different databases can be used to computes the proposed model.

In order to save space, we do not display here the descriptive statistics of the variables that, in any case, are available upon request.

5.3. The estimation results

In order to proceed to estimate our model, a functional form has to be chosen. We finally considered a linear form, and the dependent variables, rate of growth of population and quality of life, are computed in percentage terms.

Tables 1 and 2 display the results of the model with all the initially considered variables, and tables 3 and 4 presents the results with only the significant variables in a base period: the growth between 1991 and 2001. The results are computed for both the municipal dataset (314 municipalities) and for the subsystems dataset (48 subsystems). The estimation method was three-stage least-squares regression (3SLS),[7] and our strategy was starting from the more general model and driving to the more narrow one.

As expected, the results display different directions depending on the territorial scope of the analysis and also depending on the considered period. Basically the results confirm that the growth of the composite index of external conditions of quality of life depends negatively on the growth of population. But, and very interestingly and surprisingly, no significant result in found inversely: population growth doesn’t depend on growth of the composite index of external conditions of quality of life. This is true for almost all periods and for all territorial scopes.

Besides, a convergence process in the population variable is found at the municipal level, but not at the subsystems level. The composite index of external conditions of quality of life does experience a convergence process at both territorial datasets.

Now, several comments are made to the variables considered in the models of table 3 and 4.

- Birth rate: subsystems with higher birth rate experience a higher population growth. This result would explain part of the population growth as a result of the vegetative growth.
- Studied years: municipalities with more educational level of their population experience a higher population growth, but the opposite result is found for subsystems. Several comments on that: the literature highlights that more educated individuals are more mobile, what would explain the negative sign at the subsystems level, what would show more distant moves. Besides, places with high educational levels could reflect higher salaries, and the provision of superior goods and services, what would be an attractive factor.
- Unemployment: both municipalities and subsystems with higher unemployment rate experience a higher population growth, probably due to lower housing prices, for instance. *But* subsystems with higher unemployment rate have lower growth of the index of external conditions of quality of life, showing the difficulties to improve the level of provided services where worst social problems are present.
- Activity rate: influences positively population municipality growth and subsystem quality of life growth. This variable would be very related to the explanations given to studied years per person and unemployment rate.
- Housing prices: this variable is only found significant at the subsystem level and with the expected a negative sign. We understand that the problems in the definition of this key variable (only fully available at the subsystem level) drives to the found result related to the municipality level. And concerning the subsysmes result, it is interesting to see that in the 1991-96 period, in which no particular inflation was found in the housing market, this variable is not significant. On the contrary, the parameter in further subperiods is significant and higher.

[7] For our computations we used the command reg3 of Stata 9.0.

- Network economies: the ratio of telephones cells per 1,000 inhabitants has a positive influence in population growth, at both municipality and subsystems level. This variable is very related with productivity growth, and consequently with population growth.
- Funsis: municipalities or subsystems with a superior role of systems, experience a lower population growth but higher quality of life growth (at the subsystems level). In our view, it means a suburbanization pattern and also the gain of agglomeration economies: the considered services in the ECCL are more efficiently provided in a few number of municipalities.
- Distances: no clear pattern is found. The distance to Barcelona influences positively the growth of quality of life in the municipalities dataset, but negatively in the subsystem dataset. Besides, the distance to the head of the urban systems influences negatively the population growth at the municipality level, but influences positively quality of life growth at the subsystems level. This results, together with the ones concerning the variable ‘Funsis’ indicates that the suburbanization pattern has a limit depending on distance.
- Cars per capita: subsystems with higher ratio of cars per 1,000 inhabitants experience a higher population growth. This variable is very related with the distance variables and with the suburbanization process.

Table 1. Results of the model with all the considered variables. Municipalities dataset. Population growth equation

Equation	Obs	"R-sq"	Obs	"R-sq"	Obs	"R-sq"	Obs	"R-sq"	Obs	"R-sq"
pop_91_01	314	-7,1626	314	-0,8966	314	-0,3088	314	0,1472	314	0,4959
ECCL_91_01	314	0,7728	314	0,7646	314	0,3608	314	0,6856	314	0,2038
	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err
pop_91_01										
ECCL_91_01	**-17,9171**	6,424	**-11,43179**	2,753	-3,762493	2,465	**1,825872**	1,095	-17,9171	1,452
ECCL_91	**-0,3129916**	0,114	**-0,1955583**	0,049	-0,0169794	0,013	**0,0182341**	0,011	-0,3129916	0,003
pop_1991	**0,0000019**	0,000	4,39E-07	0,000	-6,5E-09	0,000	-1,18E-07	0,000	0,0000019	0,000
P_25_35_91	1,257972	2,103	-0,0965825	1,510	-0,1120165	0,441	**0,6707547**	0,344	**1,257972**	0,206
Birth_R_91	-0,0454694	0,047	-0,0078175	0,016	0,0000798	0,002	0,0072096	0,006	**-0,0454694**	0,002
Wealth_91	-0,137544	0,103	**-0,124881**	0,076	-0,0328298	0,034	-0,0113352	0,019	-0,137544	0,007
Stud_Y_91	0,0630676	0,095	0,1676862	0,105	0,0064612	0,023	0,02047	0,020	**0,0630676**	0,008
Cars_91	0,001005	0,001	-0,0002105	0,001	0,0000277	0,000	0,0001215	0,000	0,001005	0,000
Unempl_R_91	**-7,980607**	4,304	**-7,572582**	3,489	-0,6467609	1,956	**1,672771**	0,768	**-7,980607**	0,502
AcR_91	**2,293022**	0,928	1,173188	0,771	0,2548794	0,368	**0,4326889**	0,191	2,293022	0,293
H_price_91	0,0000117	0,000	0,0000104	0,000	0,00000283	0,000	-9,99E-07	0,000	0,0000117	0,000
H_Aff_R_91	-0,0047347	0,052	-0,030583	0,060	-0,0173058	0,067	-0,0172207	0,019	-0,0047347	0,008
FUNSub	-0,249908	0,251	**-0,3624671**	0,219	-0,0622842	0,078	-0,0174733	0,049	-0,249908	0,029
FUNsis	-0,4135672	0,333	**-0,5379529**	0,278	**-0,1687504**	0,102	-0,0575141	0,053	-0,4135672	0,028
Dist_BCN	**0,0203816**	0,011	0,0062761	0,005	**0,0055083**	0,003	0,0001674	0,001	**0,0203816**	0,000
Dist_Sis	-0,0233688	0,019	**-0,0353299**	0,015	**-0,009887**	0,005	-0,002823	0,003	-0,0233688	0,002
Dist_Sub	0,0259828	0,019	**0,0348634**	0,015	0,0059147	0,006	-0,0012654	0,003	0,0259828	0,002
Netw_xcap_96	-0,0006661	0,001	0,0007735	0,001	**0,0004736**	0,000	**0,0007057**	0,000	**-0,0006661**	0,000
_cons	**28,25542**	10,228	**17,72471**	4,456	1,976533	1,737	**-2,452204**	1,174	28,25542	0,142

Note: coefficients in red are significant at 10% and negative, coefficients in blue are significant at 10% and positive. The rest of coefficients are non significant at 10%.

Table 1 (continued). Municipalities dataset. Quality of life growth equation

ECCL_91_01										
pop_91_01	-0,0437428	0,0791	-0,010019	0,0617	**-0,2050964**	0,0988	-0,0877863	0,1025	-0,0437428	0,053
ECCL_91	**-0,0175234**	0,0009	**-0,017597**	0,0009	**-0,0046638**	0,0007	**-0,0095993**	0,0004	**-0,0175234**	0,0005
pop_1991	**0,00000013**	5E-08	**8,92E-08**	5E-08	1,57E-08	4E-08	**8,49E-08**	3E-08	0,00000013	2E-08
P_0_15_91	-0,0178965	0,2216	0,2171187	0,2369	0,0108901	0,1671	-0,0574482	0,1138	-0,0178965	0,0866
P_m65_91	0,0319165	0,3577	0,3793237	0,3917	0,0430123	0,2356	**-0,3157484**	0,114	0,0319165	0,0579
Wealth_91	-0,0038591	0,0055	-0,0044454	0,0055	-0,0054766	0,0047	-0,0016147	0,0036	**-0,0038591**	0,0022
Unempl_R_91	**-0,483522**	0,2702	**-0,8134176**	0,2655	-0,2807845	0,229	**-0,502311**	0,1637	-0,483522	0,1735
AcR_91	**0,1469396**	0,0839	0,1492178	0,0976	0,0447408	0,0675	**-0,1661382**	0,0788	**0,1469396**	0,0392
Cong_I_91	-0,0001052	0,0002	-0,0001842	0,0003	-0,0000684	0,0002	**0,0003723**	0,0002	-0,0001052	0,0001
Mun_Fin_91	-0,0000099	4E-05	0,0000579	8E-05	-0,0000117	4E-05	0,0000458	8E-05	-0,0000099	8E-05
FUNSub	-0,0222187	0,0223	-0,0230175	0,022	-0,0162378	0,0191	-0,0097916	0,0165	-0,0222187	0,011
FUNsis	-0,0174174	0,0264	-0,0256762	0,0259	**-0,0395458**	0,0224	0,0128392	0,0175	-0,0174174	0,0116
Dist_BCN	**0,0009498**	0,0003	0,0001282	0,0003	**0,0014136**	0,0003	-0,0001159	0,0002	**0,0009498**	0,0002
Dist_Sis	-0,0007	0,0014	-0,0013907	0,0015	**-0,002278**	0,0011	0,0004091	0,0009	-0,0007	0,0006
Dist_Sub	0,0011346	0,0014	0,0022293	0,0014	0,0013714	0,0012	0,0006584	0,0009	0,0011346	0,0006
Netw_xcap_96	-0,0000477	0,0001	-0,0001133	0,0002	0,0000903	7E-05	-0,0000227	7E-05	**-0,0000477**	2E-05
_cons	**1,637113**	0,1142	**1,605386**	0,113	**0,5651745**	0,0846	**1,128115**	0,0884	1,637113	0,0587

Note: coefficients in red are significant at 10% and negative, coefficients in blue are significant at 10% and positive. The rest of coefficients are non significant at 10%.

Table 2. Results of the model with all the considered variables. Subsystems dataset. Population growth equation

	1991-01		1991-2004		1991-1996		1996-2001		2001-2004	
Equation	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*
pop_91_01	48	0,7886	48	0,7749	48	0,6632	48	0,6923	48	0,8383
ECCL_91_01	48	0,8215	48	0,8358	48	0,2723	48	0,8235	48	0,3728
	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err
pop_91_01										
ECCL_91_01	-1,26736	1,113	-2,190569	1,005	-0,9326343	0,679	-1,528953	0,451	-1,26736	0,540
ECCL_91	-0,0179178	0,017	**-0,030425**	0,016	0,0008932	0,002	**-0,0156565**	0,004	-0,0179178	0,002
pop_1991	9,3E-08	0,000	4,76E-08	0,000	4,17E-08	0,000	1,87E-08	0,000	**9,3E-08**	0,000
P_25_35_91	-0,6999391	2,368	-0,3487895	1,857	-0,3470113	1,437	0,458327	0,585	-0,6999391	0,468
Birth_R_91	0,0388923	0,036	**0,0508163**	0,028	**0,0254869**	0,012	0,0080155	0,005	**0,0388923**	0,004
Wealth_91	0,0326427	0,046	0,0163045	0,068	0,0037959	0,042	-0,0108819	0,019	0,0326427	0,010
Stud_Y_91	-0,1275662	0,103	-0,1448159	0,118	-0,1077355	0,084	0,0298214	0,027	-0,1275662	0,016
Cars_91	**0,0009354**	0,000	**0,0013076**	0,001	**0,0014458**	0,000	0,0001868	0,000	**0,0009354**	0,000
Unempl_R_91	0,3692702	0,813	-0,3470602	1,189	**0,94045**	0,533	-0,2747371	0,390	**0,3692702**	0,497
AcR_91	**1,370665**	0,710	**1,700763**	0,906	**0,8694394**	0,479	-0,0076687	0,390	1,370665	0,372
H_price_91	-5,79E-06	0,000	**-6,12E-06**	0,000	**-5,83E-06**	0,000	9,94E-07	0,000	-5,79E-06	0,000
H_Aff_R_91	**0,0358162**	0,016	**0,0422277**	0,019	**0,04339**	0,011	-0,0084834	0,007	0,0358162	0,005
FUNsis	-0,0676245	0,151	**-0,188856**	0,100	-0,0822465	0,053	**0,0926901**	0,049	-0,0676245	0,023
Dist_BCN	-0,0021716	0,002	-0,0004236	0,002	-0,0008483	0,001	**-0,0016788**	0,001	-0,0021716	0,000
Dist_Sis	0,000343	0,014	-0,0097449	0,009	-0,0029867	0,005	**0,0095399**	0,005	0,000343	0,002
Dist_Sub	**0,0142204**	0,006	**0,0297193**	0,011	**0,0110056**	0,004	0,0035864	0,003	**0,0142204**	0,002
Netw_xcap_96	**0,0011222**	0,001	**0,0024594**	0,001	0,0005486	0,000	0,0002606	0,000	**0,0011222**	0,000
_cons	0,6123145	1,449	1,082372	1,244	**-0,6676777**	0,346	**1,069723**	0,517	0,6123145	0,166

Note: coefficients in red are significant at 10% and negative, coefficients in blue are significant at 10% and positive. The rest of coefficients are non significant at 10%.

Table 2 (continued). Subsystems dataset. Quality of life growth equation

ECCL_91_01										
pop_91_01	**-0,3266082**	0,0848	**-0,1932298**	0,0568	-0,1517597	0,1309	**-0,533112**	0,1946	**-0,3266082**	0,2134
ECCL_91	**-0,0131361**	0,0016	**-0,0128776**	0,0015	0,0008182	0,0018	**-0,0099599**	0,0009	**-0,0131361**	0,0013
pop_1991	2,74E-08	4E-08	-1,34E-09	4E-08	1,41E-08	4E-08	3,44E-08	3E-08	2,74E-08	2E-08
P_0_15_91	0,8209131	0,711	0,4465375	0,5309	**1,809703**	0,8607	0,0628146	0,5136	0,8209131	0,3955
P_m65_91	**0,9431362**	0,4571	**1,135351**	0,4606	**1,239176**	0,6099	0,1957772	0,341	0,9431362	0,2342
Wealth_91	0,0052226	0,0089	-0,0012846	0,0083	-0,0004128	0,0098	0,0057553	0,0061	0,0052226	0,0035
Unempl_R_91	0,1662562	0,37	0,073009	0,3447	0,4660598	0,4218	-0,2279979	0,2933	0,1662562	0,5348
AcR_91	**0,7031955**	0,3286	**1,006239**	0,3159	0,0148196	0,4348	0,3559661	0,2968	**0,7031955**	0,1868
Cong_I_91	-0,0000504	0,0002	-0,0000791	0,0002	-0,0000823	0,0003	-0,0000499	0,0002	-0,0000504	0,0002
Mun_Fin_91	0,0003734	0,0003	0,0004141	0,0003	0,0001465	0,0003	-0,0000495	0,0003	0,0003734	0,0003
FUNsis	**0,054854**	0,0331	-0,0057341	0,0311	0,043616	0,035	**0,0464203**	0,0234	**0,054854**	0,0162
Dist_BCN	**-0,0024505**	0,0009	**-0,0015989**	0,0009	-0,0006155	0,0009	**-0,0015235**	0,0008	-0,0024505	0,0005
Dist_Sis	**0,0071962**	0,0029	0,0010775	0,0027	0,0044891	0,0031	**0,0049694**	0,0021	**0,0071962**	0,0015
Dist_Sub	0,004677	0,003	**0,0082284**	0,0028	0,0010854	0,0033	**0,0040459**	0,0022	**0,004677**	0,0019
Netw_xcap_96	0,0000681	0,0003	0,0003308	0,0003	-0,0001232	0,0003	0,0000786	0,0003	0,0000681	0,0002
_cons	0,4666308	0,3639	0,2888603	0,3053	-0,4683431	0,4307	**0,6835395**	0,2058	0,4666308	0,1686

Note: coefficients in red are significant at 10% and negative, coefficients in blue are significant at 10% and positive. The rest of coefficients are non significant at 10%.

Table 3. Results of the model with only the base dataset significant variables. Municipalities dataset.

	1991-01		1991-2004		1991-1996		1996-2001		2001-2004	
Equation	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*
pop_91_01	314	0,4147	314	0,4187	314	0,3319	314	0,4715	314	-0,207
ECCL_91_01	314	0,7563	314	0,7335	314	0,5148	314	0,6532	314	0,052

	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err
pop_91_01										
ECCL_91_01	-0,1006656	0,183	-0,11411	0,270	-0,0319622	0,283	-0,0006982	0,102	**2,390815**	0,652
pop_1991	**-4,25E-07**	1,92E-07	**-5,63E-07**	2,8E-07	**-1,88E-07**	1,02E-07	**-1,49E-07**	7,46E-08	-7,11E-08	6,15E-08
Stud_Y_91	**0,0791586**	0,034879	0,0812141	0,05041	**0,0584964**	0,020073	0,0155793	0,010897	**0,0149687**	0,008894
Unempl_R_91	**2,043083**	0,82502	**2,730749**	1,16936	**1,24256**	0,39868	0,5129399	0,313682	-0,8927455	0,598155
AcR_91	**0,78479**	0,317715	**0,9190437**	0,46232	**0,64022**	0,182042	**0,4732611**	0,120098	-0,1505807	0,162203
FUNsis	**-0,2722337**	0,077806	**-0,3366976**	0,11255	**-0,1281959**	0,041827	**-0,0973913**	0,027907	-0,0198114	0,024431
Dist_Sis	**-0,0056134**	0,002198	**-0,0076184**	0,0031	-0,001617	0,001287	**-0,0028064**	0,000731	-0,0003586	0,000672
Netw_xcap_96	**0,0016352**	0,000153	**0,0025892**	0,00022	**0,0006176**	0,000083	**0,0006098**	5,52E-05	**0,0004047**	5,13E-05
_cons	**-1,481142**	0,277484	**-1,874187**	0,40101	**-0,9814985**	0,199933	**-0,5318328**	0,086843	0,0451759	0,15838
ECCL_91_01										
pop_91_01	**-0,0518371**	0,016742	**-0,0346868**	0,01131	**-0,0843026**	0,02639	**-0,0791722**	0,030667	-0,0282152	0,038618
ECCL_91	**-0,01768**	0,00073	**-0,0176696**	0,00073	**-0,0049649**	0,000516	**-0,0097396**	0,000434	**-0,0016387**	0,000462
Unempl_R_91	**-0,5642572**	0,198192	**-0,8310391**	0,19844	**-0,3777839**	0,142819	**-0,4872862**	0,155204	0,119632	0,178268
Dist_BCN	**0,0010344**	0,000195	**0,0006571**	0,00019	**0,0013549**	0,000137	0,0001729	0,000143	-0,0000535	8,29E-05
_cons	**1,664441**	0,072862	**1,670529**	0,07323	**0,5712355**	0,051389	**1,027558**	0,053127	**0,1252862**	0,050645

Note: coefficients in red are significant at 10% and negative, coefficients in blue are significant at 10% and positive. The rest of coefficients are non significant at 10%.

Table 4. Results of the model with only the base dataset significant variables. Municipalities dataset.

	1991-01		1991-2004		1991-1996		1996-2001		2001-2004	
Equation	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*	*Obs*	*"R-sq"*
pop_91_01	48	0,7643	48	0,7711	48	0,6406	48	0,7627	48	0,7018
ECCL_91_01	48	0,8092	48	0,8027	48	0,1891	48	0,8128	48	0,2917
	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err	Coef,	std err
pop_91_01										
ECCL_91_01	-0,1491962	0,1394	-0,259328	0,1992	-0,3951172	0,5943	0,025768	0,0869	**0,7481124**	0,2650
Birth_R_91	**0,0827118**	0,0112	**0,1108652**	0,0151	**0,0408556**	0,0104	**0,0234602**	0,0042	**0,0133773**	0,0020
Stud_Y_91	**-0,0879581**	0,0347	**-0,1074416**	0,0469	**-0,0796633**	0,0287	-0,0042193	0,0125	-0,0097654	0,0084
Cars_91	**0,0011724**	0,0004	**0,0013499**	0,0005	**0,0013803**	0,0003	-0,0000847	0,0002	-0,0000725	0,0001
Unempl_R_91	**1,06935**	0,5519	0,9274931	0,7503	**1,087237**	0,4238	**0,6566651**	0,2401	-0,6497406	0,4510
H_price_91	**-2,58E-06**	0,0000	**-4,63E-06**	0,0000	1,93E-07	0,0000	**-2,44E-06**	0,0000	**-8,49E-07**	0,0000
FUNsis	**-0,0606055**	0,0239	**-0,0685881**	0,0321	-0,0309262	0,0198	-0,0094373	0,0112	-0,0018612	0,0081
Netw_xcap_96	**0,0010864**	0,0004	**0,0020326**	0,0005	-0,0000674	0,0003	**0,0009453**	0,0002	**0,0007695**	0,0001
_cons	**-0,9010187**	0,1628	**-1,245059**	0,2145	**-0,398739**	0,1828	**-0,3767852**	0,0650	**-0,1130874**	0,0568
ECCL_91_01										
pop_91_01	**-0,2804335**	0,0518	**-0,1561638**	0,0353	-0,0931438	0,1080	**-0,3921721**	0,0901	-0,090537	0,1093
ECCL_91	**-0,0141615**	0,0013	**-0,0142344**	0,0013	-0,0016355	0,0014	**-0,0093737**	0,0008	**-0,0030137**	0,0010
P_m65_91	**0,8965259**	0,3384	**1,458727**	0,3370	-0,0218696	0,3757	**0,8431882**	0,2708	0,195339	0,1365
AcR_91	**0,613763**	0,3246	**0,9229514**	0,3146	-0,1186788	0,3925	**0,5225714**	0,2746	**0,3270377**	0,1459
FUNsis	**0,0868304**	0,0239	**0,0506943**	0,0235	0,0317675	0,0272	**0,0731569**	0,0171	0,0004151	0,0140
Dist_BCN	**-0,0024615**	0,0006	**-0,0017797**	0,0006	0,0003222	0,0007	**-0,002222**	0,0005	-0,0000639	0,0004
Dist_Sis	**0,009491**	0,0022	**0,0053106**	0,0021	0,0028189	0,0025	**0,0073335**	0,0016	-0,0001259	0,0012
_cons	**0,882407**	0,2037	**0,6258776**	0,2017	0,3297258	0,2351	**0,5041419**	0,1772	0,0137423	0,0980

Note: coefficients in red are significant at 10% and negative, coefficients in blue are significant at 10% and positive. The rest of coefficients are non significant at 10%.

6. Conclusions

The main purpose of our work is check the main determinants of the population growth within the metropolitan area of Barcelona (Spain) in the 1991-2004 period. Particular attention is devoted to the role of amenities and disamenities, as we understand that these concepts are dependent on population growth.

Consequently a simultaneous equation model is proposed, in which population growth and the growth of quality of life are considered as endogenous variables, and a list of determinants influence both variables. The estimates are developed at the municipal (314 municipalities) and the subsystems (48 subsystems) levels, and for five different periods of time.

The basic results display the importance of the population growth in the decrease in the growth of our quality of life index. It would mean that there exists a negative relationship between quality of life and population. On the contrary, the positive influence of quality of life on population growth is not found in our estimates. Other variables arise as more important factors of population growth. As expected, there is a suburbanization process and housing prices have a negative influence in the population growth. The position in the labour market is clearly determinant for population growth, and the network economies variable is positively related with population growth.

Finally, we see that there is a clear convergence process in the quality of life index. It means that municipalities with an initial quality of life index are the ones that experience a lower quality of life growth. Besides, a convergence process in the population variable is found at the municipal level, but not at the subsystems level.

The implications of our results are clear: the picture of the distribution of population in the metropolitan area of Barcelona does depend on economic forces, like housing prices, the position in the labour market, or accessibility to the centre(s) of the metropolis. On the contrary, amenities and disamenities related with the provision of the traditional facilities, are not important in the distribution of population in the territory.

For us, this is a striking result, and consequently we think that further research is needed in order to account for the influence in the computations of spatial interactions.

7. References

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ANNEX 1.

These criteria are the basis for our index, *I*, as a linear function of several, *K*¸ quality of life attributes (*X*). Each attribute measures quality of life, indicating the extent to which a municipality is above (below) the provincial average, which is equal to 100 in the base year. The structure of the ECCL reduces the dimensions at each level.

Every attribute, X_f, is originally measured in its own units (euros, inhabitants, hospitals, etc.), but needs to be redefined in terms of quality of life. We do so taking a relative measure, which converts the result into a percentage. If municipality *i* has a value in the *f* attribute equal to $X^i{}_f$, then we say that we can measure how far municipality *i* differs from the provincial average in terms of quality of life merely by computing:

$$Y_f^i = X^i{}_f \Big/ \overline{X}_f$$

Then, the final index, $I''^{\,i}$, is a linear function of the attributes' vector Y^i, $Y^i=(Y_1{}^i, ..., Y_K{}^i)$:

$$I''^{\,i}=Y^iW, \qquad \text{(A.1)}$$

where $W=(w_1, ..., w_K)$ are the weights given to every attribute. Differences between municipalities can be expressed in a dispersion measurement, for example the variance

$$VAR(I'') \quad \text{from } i=1 \text{ to N},$$

where N is the total number of municipalities. We understand that this variance is useful information about attribute Y_f. If we only had *one* quality of life attribute, then the measurement of quality of life would be defined by this particular variance. But as there is more than one attribute in each index, a general measurement for each aggregate index needs to be defined. Following (A.1), the total amount of information provided by the final index is:

$$VAR(I'')=VAR(YW)=W'\ VAR(Y)\ W. \qquad \text{(A.2)}$$

So, the index information is equal to the weighted variance and covariance matrix of the attributes. This is the measurement of quality of life that we will use in the final index *I''*, and it allows us to say that, considering all attributes, a municipality is above or below the provincial average – and also by how much, since it was measured in relative terms.

Nevertheless, if the final index is simply $I''=YW$, then the attributes with greater variance are overweighted. In order to avoid this, we should compute the index as:

$$I'=ZW,$$

where Z_f are the standardised variables: $Z_f = \left(X_f - \overline{X}_f\right) \Big/ SD\left(X_f\right)$. We can expect the variance of that index to be equal to one. But if there is information common to these attributes, we have:

$$VAR(I')=W'\ R\ W,$$

where *R* is the correlation matrix between the standardised attributes. This is the reason for computing the final standardised positions (number of standard deviations away from the trend) of the municipalities as:

$$I=ZW\ /\ (W'\ R\ W). \qquad \text{(A.3)}$$

As we built the final index measurement in (A.2), now we only have to add it to the standardised positions of all municipalities defined in (A.3). In order to make it more comprehensible we have included a level to the final measurement (100 in the base year). So, the *CQLI* is:

$$ECCLI=100\ (\ 1 + I\ *[\ W'\ VAR(Y)\ W\ ]\ ).$$