XXXI CONFERENZA ITALIANA DI SCIENZE REGIONALI

A MULTI-SCALAR ANALYSIS OF EUROPEAN CITIES

Enrico GIOVANNETTI[1], Francesco PAGLIACCI[2]

ABSTRACT

European medium-sized cities are facing serious problems in terms of exploitation of local resources (land, water, air). In this article, we observe existing links between sustainable development and economic and structural features of cities. We adopt a multi-scalar perspective, as the theme of sustainable development involves both urban areas and wider regions surrounding them. First, we identify clusters of urban areas that are homogenous on structural terms; then we compare these results at different territorial scales. Observing the sustainable development of clusters, a clear 'geography of exploitation of resources' emerges and it is consistent both with urban economic and with environmental indicators. Then, as a possible response to these problems, we suggest a typical tool which is adopted by planners: that is, polycentrism. Far from considering it a simple morphological feature of European urban system, we look at it as a possible form of governing networks of medium-sized cities. Anyway, in last section of the paper, we analyse the economic and structural drivers that explain potential for polycentric integration.

[1] Department of 'Economia Politica', Università degli Studi di Modena e Reggio Emilia, viale Berengario 51, 41121 Modena (MO). E-mail: enrico.giovannetti@unimore.it.
[2] Ph.D Course in 'Economia e Statistica Agroalimentare', Università degli Studi di Bologna, Via Belle Arti 41, 40126, Bologna (BO). E-mail: francesco.pagliacci2@unibo.it.

1 Introduction

In recent years, European cities have been facing many challenges: economic crisis of manufacturing sectors, globalization, changes in local labour market, fast and deep social changes due to international migrations, congestion of local transportation system, heavy use of natural resources (i.e., land, air…). In particular, the exploitation of environmental resources seems to undermine the sustainable development of our cities. Since the first definitions of sustainable development (World Commission on Environment and Development, 1987)[3], this concept has been applied to different thematic areas: from environment, to society and economy. Now it is clear that in cities many environmental problems both originate and are experienced at their most intense. Also European institutions are well-aware of the problem: in 2007, the "Leipzig Charter on Sustainable European Cities" was approved (European Union, 2007). Even if the Charter is quite generic, it shows a first focus on sustainability of medium-sized cities.

But when speaking about sustainability of European cities, a more 'economic' definition must be adopted. Cities are complex organisms, where both space, time, and institutional activity matter. If in mainstream economic theory cities are generally considered as dimensionless markets (whose main role is the facilitation in exchanges between producers and consumers[4]), in this paper, we consider them as processes. Cities are cycles of production and reproduction of both human activities and resources. We can define a city as sustainable if and only if it can either reproduce all the resources it uses or internalize the costs of their reproduction. In that sense, they are quite similar to 'enterprises'.

Even without approaching the theme of reproduction of resources in complex organisms, economic geography has already tried to strengthen the relevance of space location (and land use) in economic phenomena (Fujita *et al.*, 1999). From the seminal works of von Thunen (1826) and Christaller (1933), location theory is one of the pillars of regional science (Thisse, 2010) and it can be divided into three subfields: i) spatial competition theory (Hotelling, 1929); ii) urban economics (Alonso, 1964); iii) economic geography (Krugman, 1991a). In particular, the concept of New Economic Geography (or NEG) explains the geographic location of firms in central regions through the existence of both increasing returns to scale (IRS) and transportation costs (Krugman, 1991a; Krugman, 1991b). In doing so, NEG overcomes the theory of comparative advantage (by Ricardo), that explains location and specialization of firms only on the basis of exchanges. In Krugman (1991a, 1991b), agglomeration economies (i.e., the existence of "sharing, matching and learning mechanisms", to use the words of Duranton *et al.*, 2004; and Marshall, 1890) are balanced by

[3] In *Our Common Future* (1987), we can read: *"Sustainable development is a process in which the exploitation of resources, the direction of investments […] are all in harmony and enhance both current and future potential to meet human needs and aspirations"*.

[4] In Weber (1979), a city is mainly a fortification and a market. Then, it is also an association of urban citizenry.

the existence of agglomeration diseconomies (that is, increase in land rent and price of houses; increase in transportation and commuting costs; rise of environmental and social costs in central areas). These two kinds of forces work towards divergence or convergence in location: the final output naturally depends on which of them dominates. Naturally, the application of NEG is quite wide: it can also be applied to urban economics (Krugman, 1993), as, in cities, main forces at work are fairly similar[5] (Thisse, 2010).

As already said, NEG introduces the importance of spatial dimension in economy and also in urban trends. At the same time, it seems not to highlight all the consequences existing at the institutional and social level. If the core-periphery model is path dependent and largely self-reinforcing (see Krugman, 1991a), then also temporal dimension matters and then it is possible to look at cities as processes that should be coordinated. In particular, institutional activity assumes a strong importance in shaping the regional landscape: institutions (whose role, from the "invisible man" of Adam Smith, has always been neglected) can create and relax new constrains, both in short and long run. So, both resources and increasing returns to scale – far to be naturally given – are sharply modeled by policies of national and local authorities. But, if this is true, then institutions matter: they have an explicit role in managing public goods (such as the land); in fostering sharing rules; and in promoting local identity of territories. They also contribute in defining divisions of labour and, as a consequence, in determining competitiveness and cohesion of a region. In a few words, local institutions may foster or hinder the right reproduction of exploited resources.

Anyway, in recognizing the importance of institutional activity in strengthening the sustainability of cities, we do not know which policies can represent best practices. As markets, also institutions may fail. Also among European researchers and urban planners the debate is still wide and open. Anyway, over the past decades, interest on polycentrism as a possible form of governance of medium-sized cities has been increasing (Anas *et al.*, 1998; Bailey *et al.*, 2001; Romein, 2004; Meijers, 2005; Cowell, 2010). The concept is quite "vague" (Riguelle *et al.*, 2007, p.195), so we count many different interpretations. They depend on the viewpoint of the researchers, first in terms of scale of analysis (Romein, 2004; Riguelle *et al.*, 2007): polycentrism can either refer to intra-urban or to inter-urban patterns (Forstall *et al.*, 1997; Kloosterman *et al.*, 2001). In the paper, we refer to inter-urban polycentrism (within sub-national regions) and we talk about it as a possible form of integration between medium-sized cities. Analogies to the network theory are clear[6] (Meijers, 2005). In polycentric regions, cities are: located in close proximity; historically distinct; lacking a clear leading city and, as a consequence, constituting independent political entities

[5] Both IRS in production and IRS in exchange are relevant to explain the existence of urban agglomerations (o' Sullivan, 2007). When speaking about transportation costs, we also count commuting costs (o' Sullivan, 2007; Cavailhès et al., 2007). In other words, "in urban economics, workers compete for land and then travel to a city's central business districts" (Thisse, 2010, p. 281).

[6] In this paper, we cannot test network theory's main hypothesis, due to the lack of detailed and comparable data about European urban areas.

(Kloosterman *et al.*, 2001). They are also well-connected (Meijers, 2008) and interrelated through co-operation flows (Cowell, 2010).

Historically, the concept of PUR (Polycentric Urban Region) comes from the direct observation of some regions in Northwestern Europe (Bailey *et al.*, 2001): the Randstad, the Flemish Diamond and the Rhein-Rhur area are classic examples. Examples of polycentric regions outside Northwestern Europe exist as well: the Basque Country; the Padua-Treviso-Venice Area and Emilia-Romagna in Northern Italy (Romein, 2004; Cowell, 2010). From a simple descriptive tool, the concept of PUR has often been advocated by policy-makers in the Netherlands[7], Belgium and Germany, and it has rapidly developed in a spatial planning tool (Bailey *et al.*, 2001). The concept of PUR has been employed in various national and European planning frameworks (Federal Ministry for Regional Planning, Building and Urban Development, 1993; Albrechts, 1998; Priemus, 1998; European Council of EU Ministers responsible for Spatial Planning[8], 1999; ESPON, 2005).

In other words, polycentrism is now considered a best practice rather than a simple morphological feature of European regions (Governa *et al.*, 2005). It offers a sound basis for strategies that promote the "advantages of stronger interaction between neighbouring cities to develop specialized and complementary assets, while avoiding large-scale urban sprawl and destructive territorial competition" (Bailey *et al.*, 2001, p. 698). The fact that there is a "strong 'anti-sprawl' agenda built into the PUR idea" (Bailey *et al.*, 2001, p. 698) really confirms that PURs and sprawl come from opposite policies, based on different perspectives[9].

Moving from these achievements, the purpose of this paper is to study the European urban system in a comparative and interdisciplinary way: we will detect conditions for a more sustainable development, by adopting both multiscalarity as main methodology and polycentrism as hypothesis to be tested. The structure of the paper is as follows. Section 2 briefly shows which data can be used to perform a multi-scalar analysis of European cities. In section 3, a cluster analysis is performed. Different typologies of cities are detected, on the basis of structural indicators. Obtained results are tested both at different territorial scales, to verify multiscalarity, and in terms of exploitation of natural resources. In section 4, we define a potential of polycentric integration for European cities and, through a regression analysis, we link it to cities' main structural features. In section 5, we show some concluding remarks, highlighting some possible future developments.

[7] Principles associated with polycentrism are part of planning documents in the Netherlands since 1958 (Cowell, 2010).

[8] In particular, ESDP argues for the need for balanced and polycentric patterns of urban development within Europe: polycentrism should imply both a more balanced system of metropolitan regions, city clusters and city networks and an integrated spatial development strategy (European Council of EU Ministers responsible for Spatial Planning, 1999).

[9] For example, critics of suburban development argue that in U.S.A. the diffusion of sprawl is the result of a special mix of policies, i.e., the treatment of mortgage interest and property taxes in the federal income tax code, the extensive highway subsides, low gasoline taxes and rigid suburban zoning codes (Richardson *et al.*, 1999).

2 How to describe a continent of cities: the sample of cities and the adopted data

Europe has always been a continent of cities (Weber, 1979; Le Galès *et al.*, 2001; Le Galès, 2006) and in cities we can now observe the most intense problems of exploitation of resources (i.e., land, water and air). A very simple (or naïve) analysis can confirm this hypothesis. Figure 1 shows NO_2 concentrations in Europe. This pollutant is formed in many combustion processes (i.e., industrial activities, road traffic…), so it is a good proxy of anthropic activities. The geography of these activities across European cities is clear: monocentric megalopolises (that is, Paris, London, Madrid…) sharply differ from polycentric urban systems of medium-sized cities (that is, the Randstad, Northern Italy…) and from rural areas.

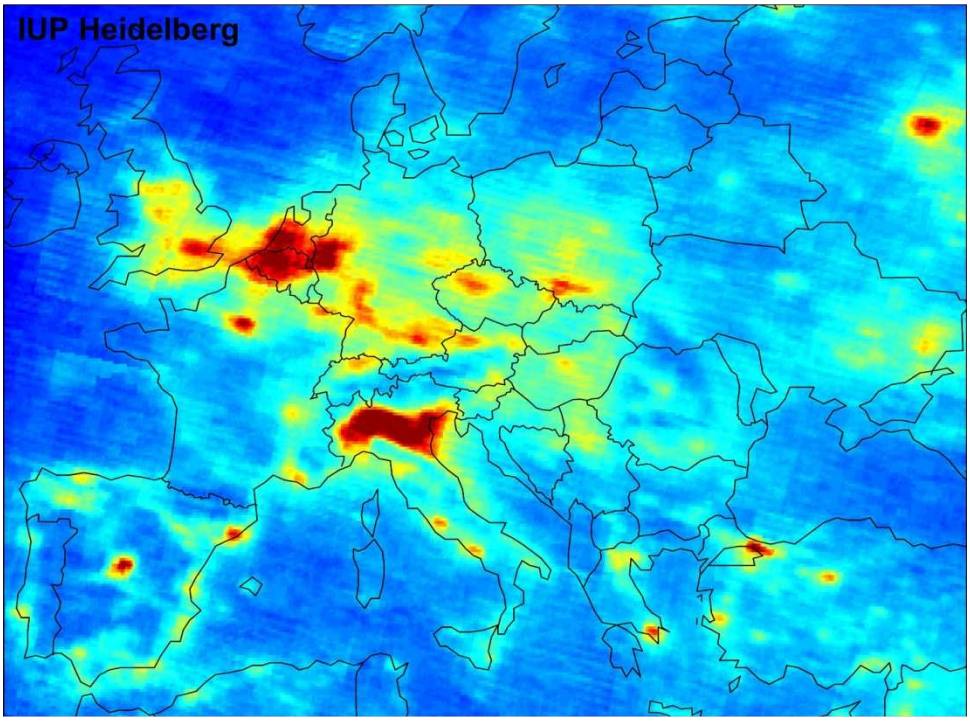

Figure 1: Mean tropospheric nitrogen dioxide (NO_2) vertical column density (VCD). Data are collected between Jan 2003 and Jun 2004 and the scale is in 10^{15} molecules/cm^{-2}. Image produced by S. Beirle, U. Platt and T. Wagner of the University of Heidelberg (Source: ESA - http://www.esa.int/esaCP/SEMN9VZ990E_Italy_1.html).

Even if the comparative analysis of the exploitation of resources in European cities is one of the aim of the present paper, we will not identify typologies of cities on the basis of their degree of sustainability. We will analyse rather their economic and structural features at different territorial scales, in order to compare the obtained results. For this reason, we merge urban structural data from different databases: the Urban Audit (Eurostat); the database REGIO-Eurostat; and data collected by ESPON Project 1.1.1 (2005).

The analysis moves from the Urban Audit Database, which collects data for European core cities (LAU-2 level). Due to a rather poor coverage of data, our analysis is limited to 181

cities in Western European Countries (i.e. EU-15 Member States). Referring to indicators, we collect the following structural variables: *resident population*; *per capita GDP* (in Euro); *unemployment rate*; *proportion of employment in industrial sectors*; *proportion of graduated population*. To enrich the analysis, two other indicators are added: *multimodal accessibility index*[10] and *total agricultural area (in ha.) per inhabitant*. They do not strictly refer to urban areas, as defined before. They highlight geographic features of the NUTS-3 regions (e.g. Italian *Province*, French *Departments*, German *Kreis*...) which surround the 181 cities in the sample (For a more detailed explanation of both cities and adopted indicators, see "Appendix – Cities and Indicators"). Although last Urban Audit collection round dates back to 2006/2007, we use 2001 data in order to limit the presence of missing values. Remaining missing values have been replaced by data at NUTS-3 level or at NUTS-2 level (data source is REGIO-Eurostat). We are well-aware of distortions deriving from using different geographical units. Anyway, in doing so, we can use only data from Eurostat, without mixing data from different national statistical sources.

Second involved database is the database REGIO-Eurostat. In order to adopt a multi-scalar perspective, we collect information also for the NUTS-3 regions that contain the 181 cities in our sample[11]. The same variables (i.e., *resident population*, *per capita GDP*, *unemployment rate*...) are collected[12]. Reference year is still 2001, to guarantee comparable data.

Finally, we use also data from ESPON Project 1.1.1 (2005), which studies polycentrism in Europe on the basis of morphological proximity of cities. Building blocks of polycentrism are the *Functional Urban Areas* (FUAs), that are composed by an urban core and surrounding and economically integrated areas (e.g., local labour markets). Then, for each FUA, ESPON (2005) estimates the area that can be reached within 45 minutes by car from the FUA centre and then approximates it to municipal boundaries: this area is labelled as *Potential Urban Strategic Horizon* (PUSH). In the last step, *Potential Polycentric Integration Areas* (PIAs) are identified on the hypothesis that neighbouring cities with overlapping PUSH areas can be functionally integrated to each others, forming polycentric areas.

In our analysis, we associate each Urban Audit city to a single PIA. By construction, some cities may share the same PIA. For each city, we then compute: i) the *demographic mass gained through polycentric integration*, that is the population change comparing the population of core cities and that of the entire PIA (the more the increase in this mass, the

[10] The index is based on the assumption that the attraction of a destination increases with size (in terms of population or in terms of local market) but declines with distance, travel time or cost. The higher the index is, the more a city is connected to other cities, also in different countries. Even if data for multimodal accessibility index are reported in the Urban Audit Database (Eurostat), the source is © ESPON Database, 2006.

[11] The Urban Audit Database also provides data on Larger Urban Zones (LUZs), which are defined on the basis of commuter flows. They describe cities as so-called Functional Urban Regions (including both the core city and its commuter belt). We do not use LUZs as territorial units, as LUZ data are of a substantially poor quality. We adopt NUTS-3 region as proxy for LUZ, although we know that the former is an administrative unit, so it cannot exactly capture a functional area around a city centre.

[12] By construction, *multimodal accessibility index* and *total agricultural area per inhabitant* are indifferently used for both the spatial units of the analysis.

more a city may take advantages from polycentric integration). For cities not belonging to any PIA, we compare population of core city and that of its PUSH area; ii) the *number of FUAs belonging to each PIA*; iii) the *status of the city with regards to PIAs*, that is, if a city is a PIA main node; a PIA secondary node; or a node not belonging to any PIA (see "Appendix – Cities and Indicators").

3 A multi-scalar cluster analysis of European cities

As exploratory analysis, in order to detect different typologies of European cities, we perform a cluster analysis. This analysis, which is a general approach to multivariate problems (Kaufman *et al.*, 1990), is applied to the 181 cities in our sample and it is based upon the seven variables collected at LAU-2 level[13]. To graphically show the results, we adopt a dendrogram, i.e. a tree-like plot where each step of hierarchical clustering is represented as a fusion of two branches of the tree into a single one (figure 2).

After having analysed the structure of the dendrogram, we cut it at the height of 11, so obtaining eight different clusters[14]. Moving from the left side of the dendrogram, we first come across clusters of Northern and central cities: "powerhouses", "regional poles", "industrial cities" and "capital cities". Cities belonging to these four clusters are wealthy (especially powerhouses) and they show an accessibility index above the average (see table 1). With the only exception of the cluster of capitals, all these cities are generally medium-sized towns. Other three clusters ("rural cities", "peripheral cities" and "cities in economic delay") cover both Southern cities and cities located in remote European regions (that is, Greece, the Atlantic coast, Scandinavian countries...). They share poor economic indicators and an accessibility index which is below the average (see table 1). At the right end of the dendrogram, the cluster of "global cities" is composed by London and Paris, that sharply differ from all other European cities in terms of demographic dimension, per capita income and proportion of graduated persons.

[13] Methodologically, cluster analysis is performed adopting a hierarchical algorithm, following an agglomerative method. Dissimilarity matrix is obtained from the computations of Euclidean distances between objects; whereas distances between groups are computed adopting the Ward's method (Ward, 1963). To avoid distortions deriving from variables with different measurement units, they are previously standardized, so obtaining z-scores (Kaufman et al., 1990).

[14] In order to highlight similarities between observations, it is important to choose the right height at which cutting the dendrogram. By increasing this height, bigger but less homogeneous clusters are obtained; by converse, by decreasing the height of cutting, clusters are composed by more similar observations, but they have less explanatory power. In our case, we can demonstrate that the choice of eight clusters is particularly efficient: by choosing seven clusters, we would obtain much less homogenous clusters (i.e., we observe a rapid jump in the height of merging); on the opposite side, by choosing nine clusters, we would not be able to increase the explanatory power of our analysis.

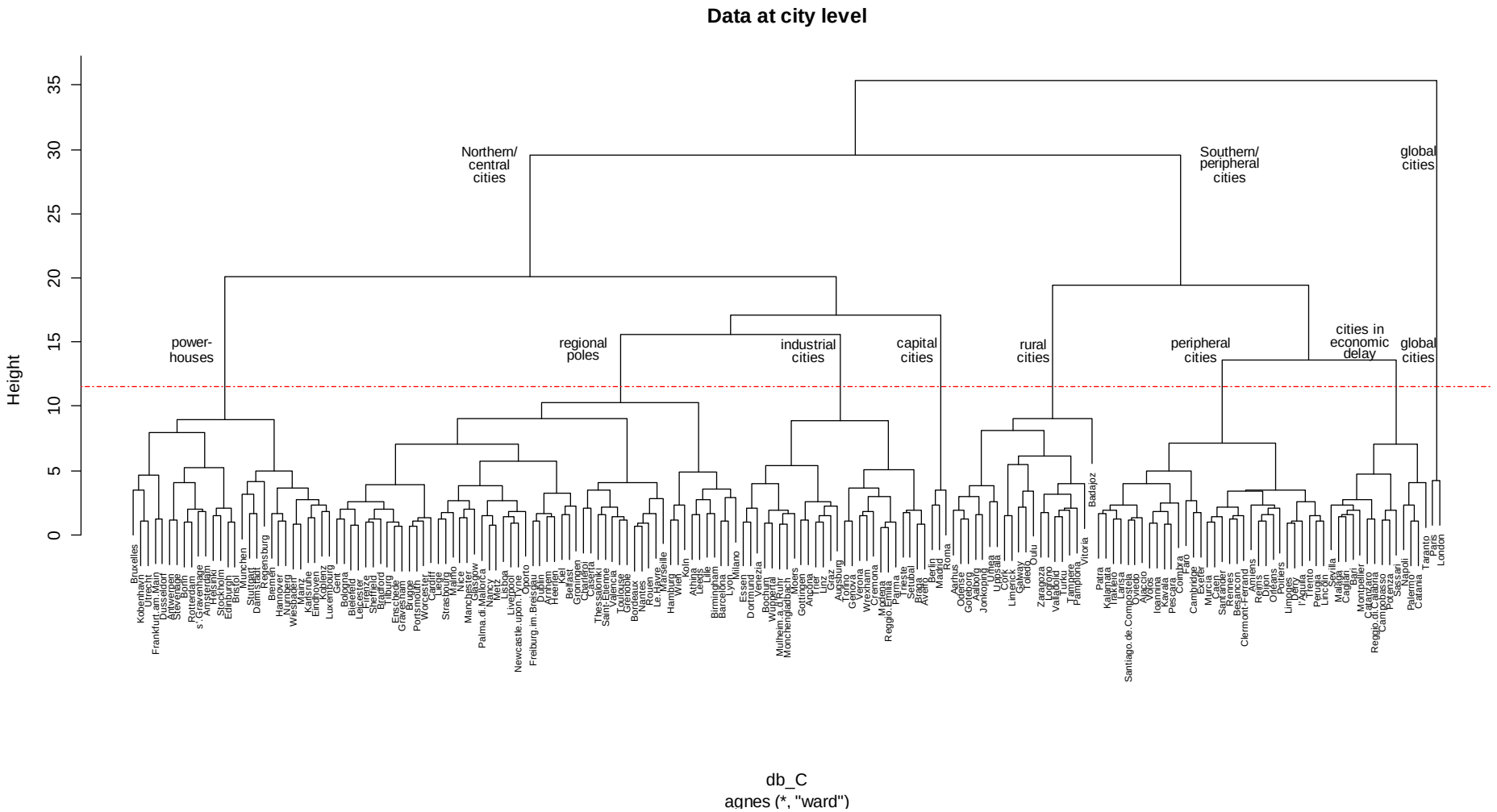

Figure 2 – Classification of European core cities (Source: Personal elaboration on Urban Audit-Eurostat data, 2001 and © ESPON Database, 2006).

Table 1 – The profile of the eight clusters which are composed by core cities (Source: Personal elaboration on Urban Audit-Eurostat, 2001 and © ESPON Database, 2006).

		Population	Per capita GDP	Unemploymen t rate	Employment in Industrial sectors (%)	Proportion of graduated persons (%)	Accessibility Index	Agricultural area (ha) per inhabitant
Powerhouses (28)	Mean	444,463	44,519	5.5	13.5	26.0	145.8	11.5
	Sd	*273,827*	*10,442*	*2.2*	*5.9*	*5.1*	*27.6*	*11.8*
Regional poles (56)	Mean	490,826	25,466	9.4	14.8	21.5	115.2	14.0
	Sd	*387,872*	*7,183*	*4.1*	*4.5*	*2.7*	*19.1*	*13.5*
Industrial Cities (26)	Mean	258,205	23,841	6.6	23.4	14.1	118.6	19.5
	Sd	*199,435*	*7,229*	*1.7*	*5.9*	*2.2*	*32.0*	*13.8*
Capital cities (3)	Mean	2,957,987	23,371	12.8	12.8	23.7	133.0	5.4
	Sd	*421,146*	*2,945*	*1.8*	*3.0*	*5.6*	*24.6*	*4.7*
Cities in rural areas (20)	Mean	194,859	25,067	9.2	19.9	25.8	72.2	141.4
	Sd	*138,523*	*5,337*	*4.6*	*5.3*	*6.0*	*15.1*	*62.2*
Peripheral Cities (32)	Mean	153,282	17,980	10.6	13.7	18.5	73.5	63.7
	Sd	*81,817*	*5,195*	*3.6*	*4.1*	*2.5*	*15.8*	*25.5*
Cities in econ. delay (14)	Mean	344,660	13,380	22.3	12.8	14.3	82.1	45.3
	Sd	*285,724*	*2,660*	*5.1*	*4.1*	*3.2*	*16.8*	*33.6*
Global Cities (2)	Mean	6,668,255	57,088	9.1	8.3	33.3	167.0	0.0
	Sd	*712,532*	*18,084*	*3.7*	*0.2*	*0.1*	*12.7*	*0.0*

As expected, the classification highlights important differences in European urban typologies. Unfortunately, such a classification is not free from critics. Having adopted a reduced set of structural indicators, we may have ignored some other important discriminating variables. Some distortions are plain: for example, looking at the cluster formed by "industrial cities", we hardly find similarities between the small city of Aveiro (PT) and Modena or Torino (IT).

Anyway, these single aspects does not undermine the general framework of our analysis. Rather, focusing on structural features and minimizing the amount of needed information, the chosen algorithm allows us to identify typologies of cities that may differ also in terms of local sustainability. But before drawing any conclusions in this sense, a multi-scalar validation is necessary. As noted in the introduction, sustainability and exploitation of resources are themes that involve not only administrative cities (i.e., LAU-2 level) but also the functional areas surrounding them. In order to develop this multi-scalar approach, a cluster analysis based on data at NUTS-3 level is performed[15].

We do not show the dendrogram for the cluster analysis based upon NUTS-3 level data. Anyway, we can say that results are largely confirmed. The general structure of the dendrogram is quite similar to the previous case: it is possible to identify a group of densely-populated NUTS-3 regions (powerhouses, capital and global NUTS-3) in opposition to less populated NUTS-3 regions (rural and peripheral NUTS-3, NUTS-3 in economic delay,

[15] Moreover, by performing two similar cluster analysis at different territorial scales, it is possible to overcome a methodological drawback of cluster analysis: that is, the lack of tests for the statistical significance of results. As a matter of fact, by duplicating the analysis, we can compare the obtained results and validate or reject them.

regional poles and industrial NUTS-3)[16]. It is also possible to note that differences between global NUTS-3 and the other clusters become less narrow when shifting to wider spatial units (that is, when shifting form LAU-2 to NUTS-3 level[17]). Table 2 shows the profiles of the eight clusters based on NUTS-3 level data.

Table 2 – The profile of the eight clusters which are composed by NUTS-3 regions (Source: personal elaboration on REGIO-Eurostat, 2001 and © ESPON Database, 2006).

		Population	Per capita GDP	Unemploymen t rate	Employment in Industrial sectors (%)	Proportion of graduated persons (%)	Accessibility Index	Agricultural area (ha) per inhabitant
Powerhouses (33)	Mean	877,393	41,604	4.7	13.6	25.0	143.9	10.5
	Sd	*539,419*	*10,351*	*2.2*	*4.4*	*5.0*	*27.2*	*11.1*
Regional poles (61)	Mean	654,228	26,444	6.7	19.0	21.2	115.5	20.9
	Sd	*366,383*	*6,060*	*2.9*	*3.6*	*3.1*	*24.0*	*19.1*
Industrial NUTS-3 (12)	Mean	723,467	24,633	3.5	29.0	9.6	104.5	27.0
	Sd	*507,061*	*6,924*	*1.3*	*5.3*	*1.3*	*23.4*	*10.8*
Capital NUTS-3 (8)	Mean	3,699,800	22,838	10.1	17.7	21.4	125.4	8.4
	Sd	*1,041,141*	*6,142*	*3.3*	*7.2*	*8.2*	*24.4*	*7.9*
Rural NUTS-3 (15)	Mean	452,860	21,753	7.6	23.9	25.1	65.7	162.4
	Sd	*164,469*	*6,109*	*4.2*	*6.6*	*6.0*	*10.7*	*56.4*
Peripheral NUTS-3 (27)	Mean	673,364	20,211	6.6	17.2	15.3	82.0	58.9
	Sd	*409,831*	*5,043*	*2.3*	*4.3*	*5.4*	*16.5*	*38.1*
NUTS-3 in econ. delay (23)	Mean	657,839	14,278	17.3	12.0	12.2	74.3	47.2
	Sd	*678,912*	*3,416*	*6.1*	*4.5*	*4.1*	*18.2*	*29.8*
Global NUTS-3 (2)	Mean	9,225,750	41,200	7.0	10.2	33.3	167.0	0.0
	Sd	2,704,754	4,384	0.6	2.5	0.1	12.7	0.0

These results seem to validate our classifications: both typologies of clusters and their composition are largely confirmed when changing territorial scale. Table 3 shows the numeric cross-composition of clusters: 123 cities (i.e., 68% of the sample) are distributed along the main diagonal of the matrix (that is, they are classified in the same group in both analysis).

Table 3 – Cross composition of clusters based upon core city data and NUTS-3 data.

		NUTS-3 REGIONS							
		Global Nuts-3	Capital Nuts-3	Power-houses	Regional poles	Industrial Nuts-3	Nuts-3 in econ. delay	Peripheral Nuts-3	Rural Nuts-3
CORE CITIES	Global cities	2							
	Capital cities		3						
	Powerhouses			25	3				
	Regional poles		5	8	37	2	1	3	
	Industrial cities				13	10		3	
	Cities in econ. delay						13	1	
	Peripheral cities				5		9	18	
	Rural cities				3			2	15

[16] To obtain comparable results, the partition in eight clusters is keep fixed. Anyway, it can be shown that a partition in 9 or 13 clusters would be more appropriated in this second analysis.

[17] Although we use respectively a NUTS-2 region and a NUTS-1 region to describe the functional urban areas surrounding Paris and London (see "Appendix –Cities and Indicators").

Therefore, we are allowed to conclude that both data from the Urban Audit and data from the REGIO-Eurostat database validate a similar pattern of urban typologies across Europe. In other words, using both strictly urban data (i.e., data at LAU-2 level) and regional data (NUTS-3 level data), a similar classification is returned.

Another validation of our findings comes from the direct observation of geographic distribution of cities and NUTS-3 regions belonging to different clusters (figures 3 and 4): the stability in composition of clusters, when shifting the scale of analysis, is clear.

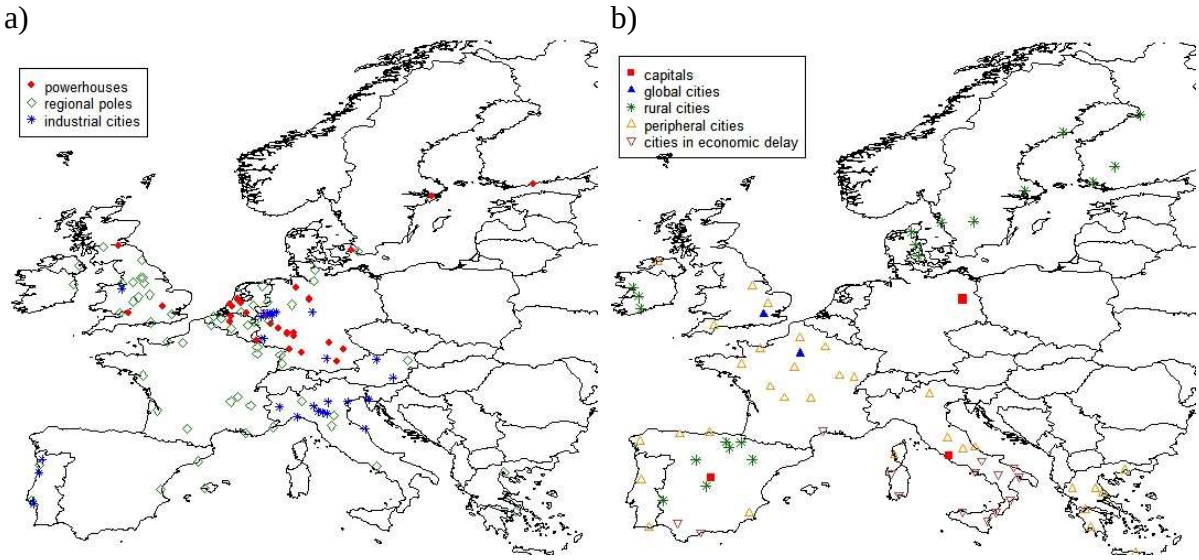

Figure 3 – Powerhouses, regional poles and industrial cities (a) and capital, global, rural, peripheral cities and cities in economic delay (b) in Europe (Source: Personal elaboration on Urban Audit-Eurostat, 2001 and © ESPON Database, 2006).

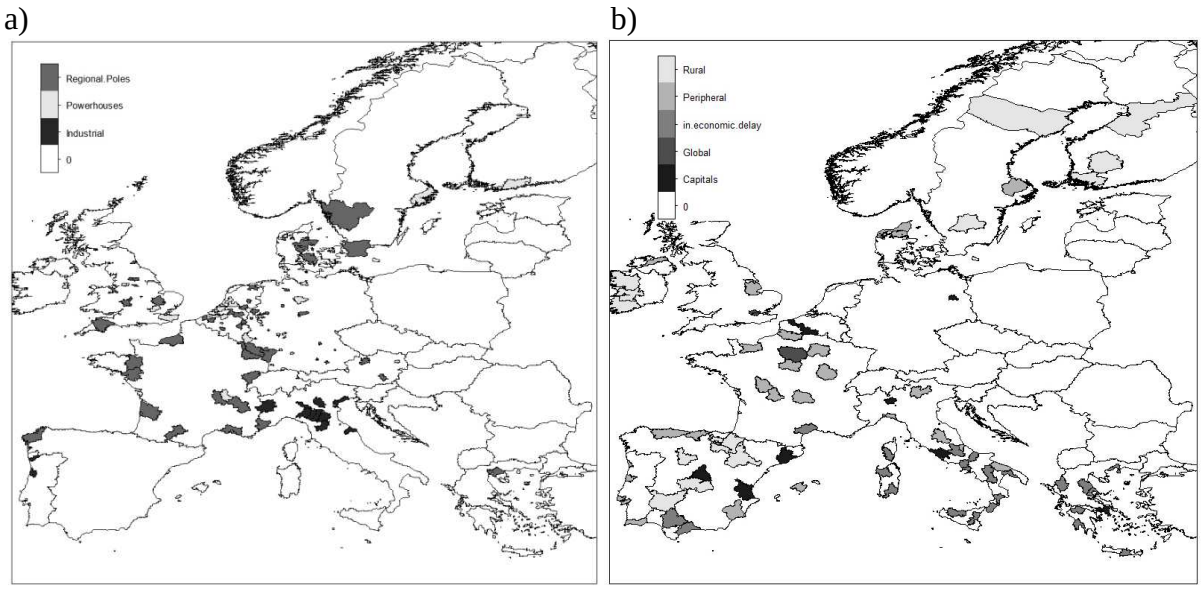

Figure 4 – Powerhouses, regional poles and industrial NUTS-3 (a) and capital, global, rural, peripheral NUTS-3 and NUTS-3 in economic delay (b) in Europe (Source: personal elaboration on REGIO-Eurostat, 2001 and © ESPON Database, 2006).

By observing the geographic distribution of clusters, other interesting considerations emerge. First, we note that any analysis based upon NUTS-3 level data may be biased by the existence of differences in national administrative structures. In Germany, the Netherlands and Belgium, NUTS-3 regions are generally very small (in Germany, NUTS-3 level and LAU-2 level coincide in many cases); whereas in peripheral countries, their extension is much wider.
Second, figures 3 and 4 show that it is possible to distinguish two main groups of clusters also on the basis of their location. All cities and NUTS-3 regions that belong to the clusters of powerhouses, regional poles and industrial urban areas are concentrated in the central regions of the continent. So, we can suppose that these three cluster share also other features, especially in terms of sustainability. If we recall figure 1 (which shows NO_2 concentrations across Europe), we can easily note that cities belonging to these three clusters are located in the same regions that are also characterized by the greatest anthropic pressure and exploitation of resources.
This hypothesis can be partly tested by analysing some features of the cities belonging to these three clusters. LAU-2 and NUTS-3 variables which have been used in cluster analysis can also measure the degree of exploitation of local resources in European cities. In this analysis, we leave out cities that are not stable in two classifications[18] and we focus our attention on so-called stable cities. Among them, the groups composed by stable powerhouses, stable regional poles and stable industrial cities share important features.
First, these groups are generally composed by medium-sized cities, whose importance in cohesion and competitiveness of European urban system is recognized by European Union (see European Union, 2007; ESPON, 2006). Second, they seem to share dynamic labour markets: they may differ in terms of manufacturing employment or in terms of proportion of graduated people, but all these cities are affected by the lowest unemployment rates across European cities. Specifically referring to urban environment, these cities show an heavy use of natural resources. Agricultural area is very limited (generally, under 50 ha. per inhabitant) and, by converse, these cities show a multimodal accessibility index which is generally above the average. These are good hints about the 'infrastructuration' of these areas. In a few words, all these cities show an heavy anthropical pressure on local resources, which is undermining their future growth. Figure 5 shows these findings, throughout box plot graphs. Only stable cities are considered in each cluster; the horizontal line shows the average value for the 123 considered cities. In colour, we highlight the clusters of powerhouses, regional poles and industrial cities. This analysis confirms that the highlighted cities are exploiting natural and human resources (both at core city level and at NUTS-3 level) in a not sustainable way. Also geographical location of these 72 cities strongly confirms this hypothesis (figure 6): by comparing these results with pollution levels which have already been reported in figure 1, we can conclude that a clear 'geography of exploitation of resources' is returned.

[18] That is, about a third of the total sample, as previously noted.

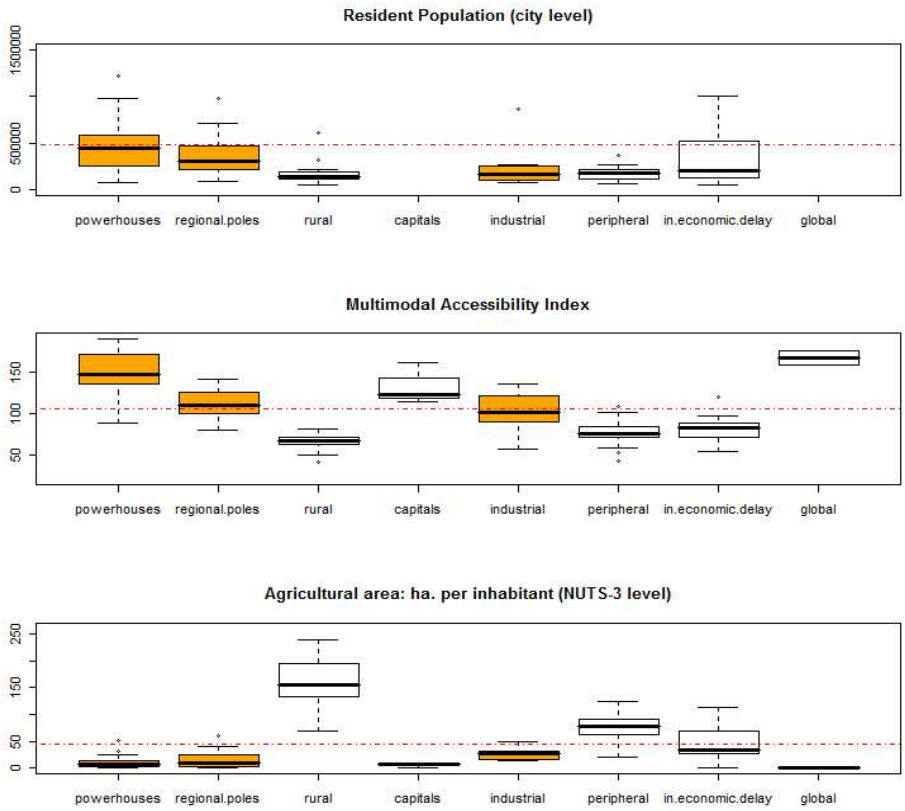

Figure 5 – Anthropic pression on local resources among the 8 groups of stable cities (Source: personal elaboration on Urban Audit-Eurostat, 2001; REGIO-Eurostat, 2001 and © ESPON Database, 2006).

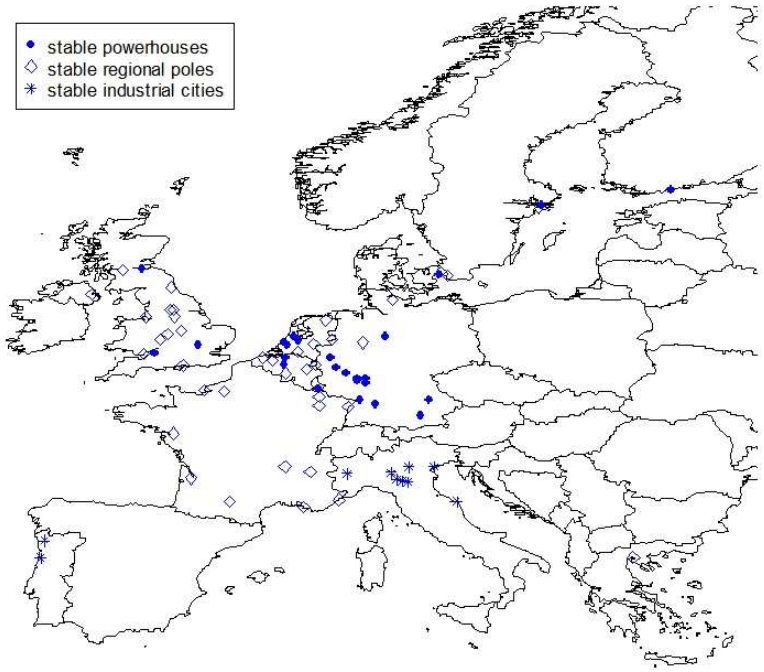

Figure 6 – Cities that are exploiting local resources in a not sustainable ways: stable powerhouses, stable regional poles and stable industrial cities (Source: personal elaboration on Urban Audit-Eurostat, 2001; REGIO-Eurostat, 2001 and © ESPON Database, 2006).

4 Structural and economic drivers of potential for polycentric integration

The challenges these medium-sized cities are facing in terms of sustainability appear clear. Unfortunately, solutions are less easy to find. Anyway, if we recognize a 'market failure' in the way these cities and regions are growing, then we can conclude that institutions (at both national and local level) matter. But, like markets, also institutions can fail. So it is not easy to identify which are those policies that can best foster sustainability in medium-sized cities and in their surrounding regions. Anyway, by observing geographic distribution of these cities (recall figure 6), some suggestions emerge.

In recent years, many authors have looked at polycentrism as a possible form of governing networks of medium-sized cities. Although, it cannot be univocally defined, polycentrism can foster urban sustainability, through a more closely integrated governance of wider regions. In other words, polycentrism is a way to officially acknowledge the intrinsic multiscalarity of European urban phenomena. In that sense, a potential for polycentric integration exists in the whole European continent (ESPON, 2005). In particular, policies reinforcing polycentrism are supposed to promote synergies between cities (Meijers, 2005), both limiting the exploitation of land and the urban sprawl and leading to a more rational allocation of population and industrial activities across a region.

But, as already said, the idea of polycentrism really comes from the direct observation of some morphological aspects of those urban areas that we have already highlighted in figure 6: that is the Randstad, the Flemish Diamond, the Rhein-Rhur region (Bailey *et al.*, 2001; Meijers 2005; Romein, 2004; Cowell, 2010). So we can adopt polycentrism as a working hypothesis which is functional to the theme of the exploitation of resources in a multi-scalar perspective. By analysing morphological features of European urban system, we can check if those cities that share an heavy exploitation of resources also share an higher potential for a polycentric integration. In particular, we do not study the implications of polycentric policies on sustainability[19]; by converse, we try to detect which are the main drivers of polycentrism in terms of economic and structural features of cities.

Such an analysis is not simple. Generally, polycentrism is analysed through single case studies (Bailey *et al.*, 2001; Meijers *et al*., 2003; Meijers, 2005; Meijers, 2008; Cowell, 2010). A focus on a single area gives the possibility to use a large amount of information about the geographical structure of employments and settlements (see Riguelle *et al.*, 2007) and the adopted policies. When a comparative approach is followed (see, for example, ESPON, 2005), some difficulties emerge both in terms of choice of indicators and in terms of the right scale of analysis[20]. In this section, we adopt an approach to polycentricism which is basically based on two related concepts that are developed by ESPON (2005): the concepts of FUA and

[19] That is, if they really can abate the degree of exploitation of natural resources or the levels of pollution.

[20] ESPON (2005) shows how, adopting different measurements of polycentrism across European regions, different results are obtained. Moreover, the analysis of polycentrism at national level leads to distorted results.

PUSH. The approach leads to the identification of PIAs (potential polycentric integration areas), by considering cities with overlapping PUSH areas as nodes of inter-urban networks (see section 2). So, this analysis can be directly linked with our previous approach based on core city data. At the same time, the introduction of the concept of PIA reinforces our multi-scalar approach: PIAs generally cover many NUTS-3 regions, so they introduce a sort of regional scale of analysis.

In order to study the drivers of polycentrism, we need to compute a degree of potential polycentric integration for each city in the sample. Different measurements can be used. In our analysis, after having linked each city to the PIA it belongs to (either as "PIA main node" or as "PIA secondary node"), we then compute the *demographic mass gaining*, that is the increase in population that each city experiences as a consequence of being part of a polycentric integrated area[21]. For cities that do not belong to any PIA, we consider the increase in population due to the existence of the PUSH area (i.e., the 45 minutes isochrones around each FUA). This demographic mass gaining can be considered a good proxy of the potential of polycentric integration of each city.

Other important control variables are: the number of FUAs that compose each PIA[22] (for cities not belonging to any PIA, this indicators equals to one); and a qualitative variable, showing the status of the city with regards to PIAs (that is, main or secondary node).

In the following regression analysis (table 4), we use demographic mass gaining as dependant variable. In model 1, only urban structural features (that is, calculated at LAU-2 level) are adopted to analyse demographic mass gaining. By controlling for the logarithm of population, model 1 shows that all variables but proportion of graduated people significantly contribute to the demographic mass gaining. Potential for polycentrism is positively related with accessibility: as already observed, in Europe, the most polycentric areas are the central regions of the continent. Moreover, the presence of a strong network of infrastructures in a region (not only a road network, but also the presence of railroad systems and air connections) has a positive impact on its degree of potential polycentric integration. The interpretation of the negative sign of per capita income is not so clear. Probably, this sign can be interpreted as the fact that wealthiest cities tend to be more isolated. The positive and significant relation between demographic mass gaining and proportion of manufacturing employment is interesting, although relation is no longer significant if we do not control for the logarithm of city population. If industrial cities are characterized by an higher demographic mass gaining, we can suppose that largest PIAs cover the most industrialised areas and cities in Europe. By

[21] From a methodological point of view, we take the logarithm of the ratio between PIA population and core city population. Taking the logarithm, we correct for the skewness of the density distribution of the ratio. ESPON (2005) suggests two different perspectives to assess this change in demographic mass: i) looking at the percentage change, comparing the population of each PUSH area and that of the entire PIA; ii) looking at how this change affects a city's position in the European urban hierarchy.

[22] A PIA formed by 27 *FUAs* (i.e., the *PIA* of Milano) is considered much more polycentric than a *PIA* formed by only 3 *FUAs* (i.e., the PIA of Paris), even if their total population are almost the same (in this case, respectively, 12.86 millions and 11.36 million inhabitants).

converse, major cities, where proportion of employment in manufacturing is generally lower on total employment, are typically monocentric. Finally, as expected, we observe a significant and negative relation between potential for polycentrism and agricultural area per inhabitant: rural cities are generally isolated or not included in polycentric networks.

Table 4 – Multiple regression analysis of the demographic mass gaining (logarithm of populations ratio)

	Model 1		**Model 2**		**Model 3**	
Intercept	1.125e+01	***	9.732e+00	***	9.499e+00	***
	8.468e-01		6.598e-01		6.656e-01	
Logarithm of Population	-9.251e-01	***	-7.351e-01	***	-7.156e-01	***
	7.694e-02		5.963e-02		6.001e-02	
Per capita GDP	-2.852e-05	***	-1.067e-05	*	-1.246e-05	*
	6.807e-06		4.917e-06)		4.966e-06	
Unemployment Rate	-3.103e-02	*	-1.900e-02	*	-1.843e-02	*
	1.249e-02		8.804e-03		8.739e-03	
Employment in industrial	2.937e-02	**	2.060e-02	**	2.015e-02	**
sectors	9.343e-03		6.583e-03		6.535e-03	
Graduated people	1.020e-02		-1.103e-03		-3.916e-03	
	1.156e-02		8.119e-03		8.186e-03	
Accessibility	2.977e-02	***	1.444e-02	***	1.450e-02	***
	2.544e-03		2.170e-03		2.153e-03	
Agricultural Area per	-6.056e-03	***	-2.746e-03	*	-2.107e-03	.
inhabitant	1.453e-03		1.068e-03		1.111e-03	
TypeNode: No PIA			-6.104e-01	***	-5.921e-01	***
			1.098e-01		1.093e-01	
TypeNode: secondary			4.227e-01	***	4.171e-01	***
			1.081e-01		1.072e-01	
High Pressure cities: Yes					1.682e-01	.
					8.723e-02	
Number of FUAs			5.522e-02	***	5.475e-02	***
			7.488e-03		7.433e-03	
Adjusted R^2	0.7033		0.8563		0.8586	
F-Statistics	61.95 on 7 and 173 DF p-value: <2.2e-16		108.3 on 10 and 170 DF p-value: <2.2e-16		100.3 on 11 and 169 DF p-value: <2.2e-16	
N	181		181		181	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Notes:
All variables refer to core city level (i.e., LAU-2 level). Accessibility (that is, multimodal accessibility index) and Agricultural area per inhabitant refer to NUTS-3 regions.
“High Pressure cities: yes” is a dummy that shows if a city belongs to stable “powerhouses”, stable “regional poles” or stable “industrial cities”.
“Type Node: No PIA” and “Type of Node: secondary” are indicators showing which kind of node a city is in the PIA it belongs to. Omitted indicator is “PIA main node”.

In model 2, we control for number of FUAs in each PIA and for the status of the city with regard to PIAs. We do not observe significant changes in signs and coefficients of the independent variables. As expected, relation between demographic mass gaining and the number of FUAs is significant and positive (the former increases by 5.5% for each additional

FUA in the same PIA). Then, compared to PIA's main node, cities that are secondary nodes, *ceteris paribus*, show a significantly higher demographic mass gaining. On the other side, the demographic mass gaining deriving from the existence of the PUSH (for cities not belonging to any PIA) is significantly smaller.

In model 3, we also control for a dummy that shows if a city belongs to the clusters with high exploitation of local resources. Relation is positive, but only at 0.10 level of significance. This is an important result. It means that previous classification (recall section 3) identifies cities that are characterized not only by an higher degree of exploitation of local resources, but also by an higher degree of potential polycentric integration[23]. So, geographically speaking, these two phenomena seem to be well related: potential for polycentrism really lies where it is necessary, that is in those medium-sized cities that are also characterized by heavy exploitation of environmental and human resources.

As we cannot collect detailed data at infra-communal level for a large amount of European cities, we can say nothing more about relation between polycentrism, urban sprawl and exploitation of resources. Anyway, our findings are quite interesting, especially as exploratory analysis. The hypothesis of polycentrism as form of multi-scalar governance appears quite valid, although we only analyse it in a potential perspective[24]. At the same time, further steps of the research should exactly be oriented to a deeper analysis of a small number of polycentric regions. Only through a direct exchange between researchers, urban planners and local policy-makers, it is possible to study and compare those policies that have been adopted to strengthen the idea of polycentrism in a given area.

5 Conclusions

In considering the environmental problems of urban areas, the theme of the exploitation and reproduction of resources plays a key role. In analysing it, cities have to be considered as processes of production and reproduction of both human activities and resources: so, it is clear that a problem of scale of analysis emerges. In particular, core cities (that is administrative cities) appear too small to capture these economic and environmental phenomena.

Anyway, we just move from administrative cities in order to identify different typologies of urban areas, on the basis of economic and structural data. From cities we then pass to NUTS-3 regions, that is regions generally wider than core cities. Such a multi-scalar approach confirms the main obtained results: similar clusters are returned using either urban data or regional data (that is, using, respectively, LAU-2 level or NUTS-3 level data). So, we can

[23] Splitting this dummy into four different indicators (i.e. stable powerhouses, stable regional poles, stable industrial cities and other cities), differences in the demographic mass gaining become no longer significant.

[24] We only look at those cities' morphological features that can lead to a polycentric integration. We do not study why policies have been adopted to create PURs.

draw a first conclusion: in Europe, urban dynamics generally involve also suburban and rural areas surrounding cities. But at the same time, if cities are not isolated, then urban planning must involve wider areas which generally cross administrative boundaries. Moreover, this is true also for medium-sized cities, although they generally do not enforce strategic multi-scalar urban plans.

In the second part of the paper, moving from the results of cluster analysis, we turn to analyse sustainable development across cities and NUTS-3 regions. Even if we have performed a cluster analysis using structural data about cities, we can observe that clusters also differ in terms of the degree of exploitation of local resources. In particular, industrial cities, powerhouses and regional poles share a common feature, that is a no longer sustainable way of exploitation of natural resources (see the excess in urbanization, the absence of rural areas, the strong presence of infrastructures).

At the same time, the most surprising finding is the fact that these cities have another important feature in common: that is, a strong potential for polycentric integration. Although polycentrism has to be considered the output of the institutional activity (i.e., a form of governance of networks of neighbouring cities), we have tested its main economic and structural drivers (and this is the reason why we talk about potential for polycentric integration). Accessibility, absence of rural areas and presence of manufacturing activities are the main features that characterize cities with the highest potential for polycentric integration. So a strong link between problems (i.e., heavy exploitation of resources) and possible solutions, as suggested in the recent debate (i.e., polycentrism), seems to emerge.

Anyway, before drawing so optimistic conclusions, further aspects should be analysed. First, we recall that the existence of a potential for polycentric integration does not assure the effective development of polycentric networks of cities. The choices made by policy-makers (both at local and national level) are important to obtain specific results. At the same time, we also know that institutional activity may fail. So, in future developments, it will be interesting to find, in a few case studies, best polycentric policies across Europe, in order to study their effects on environmental issues and on the reproduction of resources in urban regions. Second, future analysis should also include the disruptive effects of the current economic crisis on European cities. In particular, it will be interesting to test if polycentric urban regions can obtain better results than monocentric ones in managing the rising of unemployment, possible social uprisings and the lack of funds for public policies.

Appendix – Cities and indicators

The Urban Audit Database contains information about more than 300 variables (referring to nine domains, from demography and economy to culture and recreation) for 321 cities in the EU-27 Member States; 26 Turkish cities; 6 Norwegian cities and 4 Swiss cities (Europea Union, 2004). All data refer to core cities, according to political and administrative boundaries. Local Administrative Unit level 2 (LAU-2) is generally used. In France, the concepts of *Communauté d'agglomération* or *Communauté urbaine* are used; in Portugal, UK and Ireland, LAU level 1 units are used (European Union, 2004; European Union, 2010).
As the coverage of data is rather poor, our analysis is limited to cities belonging to Western European Countries (i.e. EU-15 Member States). In coherence with this choice, cities belonging to Germany's Eastern Länders are excluded from the sample. Also cities belonging to French Overseas Departments, to the Canary Islands (ES) and to the Azores Island and Madeira (PT) are excluded from our sample. On the opposite side, in order to strengthen our attention to Northern Italy, information for Parma, Reggio Emilia and Modena (IT) have been reconstructed. Our final sample includes 181 cities.

Also information for NUTS-3 regions surrounding these cities have been collected. Note that:

- The cities of Le Havre (FR012C) and Rouen (FR015C) belongs to the same NUTS-3 region, that is the French *department* of Seine-Maritime (FR232);
- Referring to Paris and London, NUTS-3 regions are too small to contain a functional area surrounding them. So we turn to consider a NUTS-2 region for Paris (Île de France - FR10) and a NUTS-1 region for London (London – UKI).
- In Germany, many NUTS-3 regions correspond to *stadtkreis* (or to *Kreisfreie Stadt*), that is the same administrative units that are adopted to define core cities in the Urban Audit. From a methodological point of view, even if core cities and NUTS-3 regions correspond, we use data from different database: the Urban Audit data for core cities and REGIO-Eurostat data for NUTS-3 regions.

Referring to adopted variable, table A.1 shows the seven variables that are used in cluster analysis. Five indicators are available both at core city level (LAU-2) and at NUTS-3 level. For core city level, statistical source is the Urban Audit Database; for NUTS-3 level, statistical source is the Database REGIO-Eurostat. On the opposite side, *multimodal accessibility index* (source: © ESPON Database, 2006) and *total agricultural area per inhabitant* (source: REGIO-Eurostat) are only available at NUTS-3 level. All data refers to 2001.
Table A.1 also shows the variables that are adopted to describe polycentric features of European cities. For these indicators, source is ESPON Project 1.1.1 (2005).

Table A.1 – Description of indicators

Name of the indicators	Description	Code core cities	Code Nuts-3 regions
Total Resident Population	All persons recorded as resident in households in an area even if they were present elsewhere on Census night, plus residents in communal establishments who were present in the establishment on Census night. This will include all persons, national or foreign, who are permanently settled (i.e. resident one year or more) in the (urban) area. In some countries (e.g. Ireland), the Census counts the *de facto* population, i.e. the population present on Census night that is not necessarily registered (*de jure*).	Popul_C	Popul_N
GDP per head of resident population	$\frac{Total\ GDP}{Total\ population\ (all\ ages, working\ or\ not)}$ Total Gross Domestic Product is the sum of the gross value-added at basic prices of all resident producers, plus all taxes less subsidies on products. The source is Eurostat, CODED, SNA95. For sub-national levels, the income approach is used.	GDPp.c_C	GDPp.c_N
Unemployment Rate	$\frac{Unemployed\ person}{Total\ economically\ active\ population}$ In accordance with ILO and the Community Labour Force Survey definition, unemployed persons comprise all resident persons above 15 and under 75 who, during the reference period, are: i) without work, i.e. neither have a job nor are not at work (for one hour or more) in paid employment or self employment; ii) available for work; iii) actively seeking work.	Unem_C	Unem_N
Proportion of employment in industries C-E, NACE Rev.1	$\frac{Employment\ in: mining\ and\ quarrying + manufacturing + electricity, gas\ and\ water\ supply}{Total\ employment}$ NACE Rev. 1 is a Statistical Classification of Economic Activities from Eurostat. Industries C-E refer to typical manufacturing employment (mining and quarrying; manufacturing; electricity, gas and water supply). Employment in construction industry is not comprised in the indicator.	Employm C.E_C	Employm C.E_N
Proportion of population qualified at ISCED levels 5 and 6:	$\frac{Population\ qualified\ at\ ISCED\ level\ 5-6}{Total\ resident\ population}$ There are 6 different levels of education in the International Standard Classification for Education (ISCED). Level 5 corresponds to the first stage of tertiary education (not leading directly to an advanced research qualification), including programmes that lead to the award of a first or second university. Level 6 is the second stage of tertiary education (e.g. PhD's, etc).	Isced5.6_C	Isced5.6_N
Multimodal accessibility index	The index corresponds to the Potential Accessibility Indicators proposed by the Study Programme on European Spatial Planning (Eskelinnen et al., 2002). Potential accessibility is based on the assumption that the attraction of a destination increases with size, and declines with distance, travel time or cost. So, accessibility is a construct of two functions, one representing the activities or opportunities to be reached and one representing the effort, time, distance or cost needed to reach them: $A_i = \Sigma\ g(W_j)\ f(c_{ij})$, Where, *Ai* is the accessibility of area i, W_j is the activity W to be reached in area j, c_{ij} is the generalized cost of reaching area j from area i. Functions $g(W_{ij})$ and $f(c_{ij})$ are respectively called *activity functions* and *impedance functions* and they are weights to each other. The indicator is standardized to the average accessibility of the ESPON space (that is EU-15 + 12 Candidate Countries). More in detail, multimodal accessibility index is computed from road accessibility, rail accessibility and air accessibility. Data source for this variable is © ESPON Database, 2006.	Access_C = Access_N	

Total Agricultural Area per inhabitant	$\frac{Total\ agricultural\ area\ (ha.)}{Total\ resident\ population}$ The total agricultural area includes arable land (D), permanent pasture (E), meadows (F), permanent crops (G) and woodlands (H). It is measured in ha. For German regions, total agricultural area is only available for NUTS-2 regions (so it is divided by total population in NUTS-2 regions).		TotalAgr.ab_C = TotalAgr.ab_N
Demographic mass gaining	*Cities belonging to PIAs*	$Ln\left(\frac{PIA\ population}{core\ city\ population}\right)$	
	Cities not belonging to PIAs	$\text{Ln}\left(\frac{PUSH\ population}{core\ city\ population}\right)$	
No. of FUAs in PIA	*Number of FUA belonging to the same PIA* For cities not belonging to any PIAs = 1.		Number of FUAs
Status of the city with regard to PIAs	Three possible status: *i) PIA Main Node;* *ii) PIA Secondary Node;* *iii) Node not belonging to any PIAs*		Omitted TypeNode: secondary TypeNode: No PIA

Acknowledgements

The present work has also been made possible through the support of Fondazione Mario Del Monte (Modena, Italy). We wish also to thank EU-POLIS, DITer (Dipartimento Interateneo Territorio, Politecnico e Università di Torino).

Bibliography

Albrechts L. (1998), The Flemish Diamond: Precious Gem and Virgin Area, *European Planning Studies*, 6, pp. 411-424.

Alonso W. (1964), *Location and Land Use*, Cambridge: Harvard University Press.

Anas A., Arnott R., Small K. (1998), Urban Spatial Structure, *Journal of Economic Literature*, 46, pp. 1426-1464.

Bailey N., Turok I. (2001), Central Scotland as Polycentric Urban Region: Useful Planning Concept or Chimera?, *Urban Studies*, 38, pp. 697-715.

Cavailhes J., Gaigné C., Tabuchi T., Thisse J.F. (2007), Trade and the Structure of Cities, *Journal of Urban Economics*, 62, pp. 383-404.

Christaller W. (1933), *Central Paces in Southern Germany*. Jena: Fischer. English translation by Carlisle W. Baskin (1966), Prentice-Hall, London.

Cowell M. (2010), Polycentric Regions: Comparing Complementarity and Institutional Governance in the San Francisco Bay Area, the Randstad and Emilia-Romagna, *Urban Studies*, 47, pp. 1-21.

Duranton G., Puga D. (2004), Micro-foundations of Urban Agglomeration Economies. In: Henderson J.V., Thisse J.-F. (eds.), *Handbook of Regional and Urban Economics*, Elsevier, Amsterdam, pag. 2063-117.

Eskelinnen H., Fürst F., Schürmann C., Spiekermann K., Wegener M. (2002*), Indicators of Geographical Position – Final Report of the Working Group "Geographical Position" of the Study Programme on European Spatial Planning*. Dortmund: IRPUD.

ESPON (2005), *Project 1.1.1 The role, specific situation and potentials of urban areas as nodes in a polycentric development. Final Report*. http://www.espon.eu

ESPON (2006), *Project 1.4.1: The Role of small and medium-sized towns. Final Report*. http://www.espon.eu

ESPON Database (2006). http://www.espon.eu

European Communities (2004), *Urban Audit. Methodological Handbook*, Office for Official Publications of the European Communities, Luxembourg.

European Council of EU Ministers responsible for spatial planning (1999), *European Spatial Development Perspective (ESDP)*, DG Regio, Brussels.

European Space Agency (2010), *Verso le previsioni dela qualità dell'aria*. http://www.esa.int/esaCP/Italy.html

European Union (2007), *Leipzig Charter on sustainable European cities*. http://www.eu2007.de.

European Union (2010), *European Regional and Urban Statistics. Reference Guide*, Publications Office of the European Union, Luxembourg.

Federal Ministry for Regional Planning, Building and Urban Development (1993), *Guidelines for Regional Planning: General Principles for Spatial Development in the Federal Republic of Germany*, Federal Ministry for Regional Planning, Building and Urban Development, Bonn.

Forstall R.L., Greene R.P. (1997), Defining Job Concentrations: the Los Angeles Case, *Urban Geography*, 18, pp. 705–739.

Fujita M., Krugman P., Venables A.J. (1999), *The Spatial Economy*. Cambridge: MIT Press.

Governa F., Salone C. (2005), Italy and European Spatial Policies: Polycentrism, Urban Networks and Local Innovation Practices, *European Planning Studies*, 13, pp.265-283.

Hotelling H. (1929), Stability in Competition, *Economic Journal*, 39, pp. 41-57.

Kaufman L., Rousseeuw P. J. (1990), *Finding Groups in Data. An Introduction to Cluster Analysis*. New York: Wiley & Sons.

Kloosterman R.C., Musterd S. (2001), The Polycentric Urban Region: toward a Research Agenda, *Urban Studies*, 38, pp. 623-633.

Krugman P. (1991a), Increasing Returns and Economic Geography, *Journal of Political Economy*, 99, pp. 483-499.

Krugman P. (1991b), *Geography and Trade*. Cambridge: MIT Press.

Krugman P. (1993), On the Number and Location of Cities, *European Economic Review*, 37, pp. 293-298.

Le Galès P., Bagnasco A. (eds.) (2001), *Le città nell'Europa contemporanea*. Napoli: Liguori Editore.

Le Galès P. (2006). *Le città europee. Società urbane, globalizzazione, governo locale*. Bologna: Il Mulino.

Marshall A. (1890), *Principles of economics*. London: Macmillan.

Meijers E., Romein A., Hoppenbrouwer E. (2003), *Planning Polycentric Urban regions in North West Europe. Value, feasibility and design*. OTB.

Meijers E. (2005), Polycentric Urban Regions and the Quest for Synergy: Is a Network of Cities more than the Sum of the Parts?, *Urban Studies*, 42, pp. 765-781.

Meijers E. (2008), Summing Small Cities Does Not Make a Large City: Polycentric Urban Regions and the Provision of Cultural, Leisure and Sport Amenities, *Urban Studies*, 45, pp. 2323-2342.

O' Sullivan A. (2007), *Urban Economics (6. ed)*. Boston: McGraw Hill.

Priemus H. (1998), The Randstadt and the Central Netherlands Urban Ring: Planners Waver between Two Concepts, *European Planning Studies*, 6, pp. 443-466.

Richardson H., Gordon P. (1999), Is sprawl inevitable? Lessons from abroad. Paper presented at the *41st Association of Collegiate Schools of Planning Conference*. Held in Chicago, USA: November.

Riguelle F., Thomas I., Verhetsel A. (2007), Measuring Urban Polycentrism: a European Case Study and its Implications, *Journal of Economic Geography*, 7, pp. 193-215.

Romein, A. (2004). Spatial Planning in Competitive Polycentric Urban Regions: Some Practical Lessons from Northwest Europe. Paper submitted to *City Futures Conference*. Held in Chicago, USA: July.

Thisse J.F. (2010), Toward a Unified Theory of Economic Geography and Urban Economics, *Journal of Regional Science*, 50, pp. 281-296.

von Thunen J.H. (1826), *The Isolated State*. Hamburg: Perthes. English translation (1966). Oxford: Pergamon.

Ward J. H. (1963), Hierarchical Grouping to Optimize an Objective Function, *Journal of American Statistical Association*, 58, pp. 236-244.

Weber M. (1979), *La città*. Milano: Bompiani.

World Commission on Environment and Development (1987), *Our Common Future*. Oxford: Oxford University Press.

SOMMARIO

Negli ultimi anni, le città europee stanno sperimentando un eccessivo sfruttamento delle risorse locali (aria, acqua, territorio). In questo articolo, vogliamo affrontare le relazioni esistenti tra il tema dello sviluppo sostenibile e le caratteristiche economico-strutturali delle città europee. In tale analisi, è necessario adottare una prospettiva multi-scalare, poiché il tema dello sviluppo sostenibile tende ad interessare più scale territoriali. In prima battuta, sono stati individuati alcuni cluster composti da aree urbane strutturalmente omogenee tra loro. Successivamente, i risultati ottenuti sono stati comparati a differenti scale territoriali. Analizzando poi il grado di sviluppo sostenibile di tali cluster, emerge una ben precisa 'geografia dello sfruttamento delle risorse naturali'. Tale geografia, in particolare, appare consistente con buona parte degli indicatori economici utilizzati. In risposta a tali problemi, si propone un tipico strumento utilizzato dai geografi economici e dai pianificatori: il policentrismo. Benché spesso considerato quale semplice elemento morfologico del sistema urbano Europeo, il policentrismo rappresenta in realtà una possibile forma di *governance* per reti di città di medie dimensioni. Nell'ultima parte del paper, si discutono proprio i principali driver economici e strutturali che possono spiegare il potenziale di integrazione policentrica delle città europee.