Questioning polycentric development and its effects: issues of definition and measurement for the Italian NUTS 2 Regions

Paolo Veneri and David Burgalassi

Polytechnic University of Marche, Department of Economics,
University of Pisa, Department of Economics

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Paolo Veneri[♣] and David Burgalassi[♦*]

Abstract

Polycentric development is a widely-used term both in academic research and in the normative agenda. However, its theoretical foundations and economic implications are still unknown and the concept of polycentricity still does not have a shared definition, or a shared measurement method. The aim of this paper is twofold. Firstly polycentricity is defined and measured at a NUTS 2 regional level, by comparing functional and morphological methods. Secondly, in the light of the role assigned to polycentric development in terms of policy, the paper investigates the relationships between the degree of regional polycentricity and the key economic variables of performance – namely competitiveness, social cohesion and environmental sustainability. The main finding was that functional and morphological methods led to similar results. In addition, a correlation was found between polycentricity and a more unequal income distribution and a higher level of productivity, especially when polycentricity was measured in functional terms. No stable correlations were found between polycentricity and measures of environmental sustainability, such as land consumption and greenhouse emissions.

[♣] Università Politecnica delle Marche, Dipartimento di Economia, Piazza Martelli 8, 60121 Ancona (Italy), p.veneri@univpm.it

[♦] Università Di Pisa, Dipartimento di Scienze Economiche, Via Ridolfi 10, 56124 Pisa (Italy), d.burgalassi@ec.unipi.it .

* Corresponding author.

"We would like to promote a polycentric territorial development of the EU, with a view to making better use of available resources in European regions. […] In this way we will contribute to a Europe which is culturally, socially, environmentally and economically sustainable."
(Ministers for spatial planning of EU members States and Commission of the European Union, Leipzig, May 25th 2007)

1 Introduction

Since 1999, when the "European Spatial Development Perspective"[1] (hereafter ESDP; CSD, 1999) was published, the concept of polycentricity has ceased to be only a theoretical interpretation of contemporary spatial organisation, especially regarding metropolitan regions. In fact with the ESDP, polycentricity has also begun to assume a normative relevance (Davoudi, 2003), with a set of normative tools that are supposed to be applied to achieve crucial European Union (EU) policy objectives . According to the guiding principles of ESDP, polycentric development is a pre-requisite for sustainable and balanced development and to enhance localisation advantages (CSD, 1999 – p. 21). The idea of polycentricity as a key policy goal was further developed by the National Ministers responsible for spatial planning of the EU - together with the European Commission - in the "Territorial Agenda of the European Union" agreed in 2007. More recently, also the report entitled "An Agenda for a Reformed Cohesion Policy" (better known as the "Barca Report"), which is a guiding document for EU new cohesion policies, highlighted the role of networked polycentric regions in order to promote balanced territorial development and to overcome the disadvantages arising from big urban agglomerations (Barca, 2009, p. 18).

On the basis of the documents cited above, polycentricity is considered as a key tool to promote social cohesion (Meijers and Sandberg, 2008), economic competitiveness (Hague and Kirk, 2003) and environmental sustainability (CSD, 1999). However, these propositions often lack a theoretical rationale and, even more importantly, they have not been sufficiently corroborated through appropriate empirical investigations (Meijers 2008).

[1] The ESDP is the first and the most important European guiding document on spatial planning. It established three main guiding principles for spatial development, namely i) polycentric development and stronger urban-rural partnerships, ii) parity of access to infrastructure and knowledge and iii) intelligent management of the natural and cultural heritage.

For this reason there is serious uncertainty among scholars as to the effectiveness of polycentric development as a policy tool for the above-mentioned goals. Such uncertainty is probably due to the *multi-scalar* and *multi-dimensional* nature of the concept of polycentricity. In fact, what is polycentric at a given spatial scale (e.g. intra-urban scale) may be at the same time monocentric at another spatial scale (e.g. inter-urban or national) and vice versa. In addition, polycentricity can be conceptualised from two different perspectives: the *morphological* and the *functional*. Some studies approach polycentricity from a morphological perspective (Lambooy, 1998; NordRegio, 2004; Parr, 2004; Meijers, 2008), while others adopt a functional perspective (Van der Laan, 1998; Hall and Pain, 2006; Limtanakool et al., 2007). As a consequence, different approaches lead to different measures, which in turn could differ in many respects (Burger and Meijers, 2010).

The aim of this work is twofold. Firstly, we compare the morphological and functional approaches used to analyse polycentricity, both theoretically and empirically. Hence, different measures of the degree of polycentric development are evaluated at the regional level. Secondly, we explore the link between the regional degree of polycentricity and the key-variables related to the main European spatial policy-aims: social cohesion, economic competitiveness (growth) and environmental sustainability.

The empirical analysis was performed on the Italian NUTS 2 regions. The decision to investigate polycentricity at a regional level was based on the fact that it is specifically referred to in the ESDP when talking about the spatial level at which polycentricity must be declined and pursued (CSD, 1999 – p. 19). Moreover, Italian NUTS 2 regions provide an interesting case study. Firstly, they are characterised by a strong diversity in their spatial structures, economic performance and internal social cohesion. In addition, they are one of the most important administrative levels in terms of political power and the consequent capacity to drive their spatial structures by means of spatial planning policy (Governa and Salone, 2005).

This work is organised as follows. Section 2 defines the concept of polycentricity from the various spatial scales and methodological approaches, by analysing how it became a normative tool in the ESDP and in the academic literature, since it is supposed to foster multiple goals. Section 3 reviews several measures of polycentric development – from morphological and functional perspectives. Section 4 describes how those measures have been applied to the Italian NUTS 2 regions: here a comparison between regional rankings in terms of morphological and functional polycentricity is proposed. Section 5 analyses the relationship between polycentricity and key socio-economic conditions in

Italian regions, namely social cohesion, economic competitiveness and environmental sustainability, on which much of the attention of the EU is focused. Section 6 concludes and gives insights for further research.

2 The concept of polycentricity

Polycentricity has been playing a central role in the planning and economic geography literature since the ESDP was released. The increasing research interest is highlighted by the amount of published papers on the topic, starting with the special issue of *European Planning Studies* "Polynucleated Metropolitan Regions in Northwest Europe", in 1998. Three years later a special issue was published on *Urban Studies* (April 2001). Subsequently, an issue of Regional Studies, entitled "Globalization, City-Regions and Polycentricity in North-West Europe" was published in 2008. A major contribution was made by the ESPON project "Urban areas as nodes in a polycentric development " (Nordregio, 2005), followed by the project "Study on Urban Functions" (IGEAT, 2007). Finally, it is worth mentioning the POLYNET project, led by Sir Peter Hall and Kathy Pain, within the North West European INTERREG IIIB Programme, which investigated polycentric spatial development in North-West European regions (Hall and Pain, 2006).

Despite the vast amount of literature on this topic, polycentricity is still considered as a vague and fuzzy concept (Meijers, 2008 – p. 1313). At the same time, the effects of polycentricity in terms of social cohesion, economic competitiveness and environmental sustainability are still ambiguous and not widely confirmed (Davoudi, 2003; Parr, 2004). For this reason, it is worth providing some underlying notions of polycentricity, by describing how it can refer to different spatial scales and, at the same time, how it can be described from different perspectives. The remainder of this section deals with these two issues. First, we describe the spatial levels to which polycentricity refers. Then, we introduce a possible taxonomy on the various analytical perspectives that can be used in order to describe polycentricity: the morphological and functional dimensions.

2.1 Different spatial scales

The lack of knowledge and empirical confirmation about the normative role of polycentric development can be due to the multi-scalar nature of polycentricity. In fact, polycentricity can be referred to in at least three spatial scales, namely the intra-urban, the inter-urban and the interregional scale

(Davoudi, 2003). The intra-urban scale is the spatial level to which scholars originally used the notion of polycentricity to conceptualise the distribution of economic activities over space. Already in the 1920's, Chicago School sociologists and land economists considered the possibility that new sub-centres could emerge near the central business district (CBD), forming a polycentric urban structure (Harris and Ullman, 1945). Lately, starting from the 70's, bid-rent theory models, based on a polycentric spatial structure, were developed (White, 1999; Glaeser and Kahn, 2003)[2]. Hence, the intra-urban scale is probably the spatial level at which polycentricity has been investigated the most, both in its drivers and in the different effects.

The concept of polycentricity has also been referred to as the inter-regional or inter-national scale. This includes both a national scale and an international one (Waterhout et al, 2005). Several metaphors in the scientific debate relate to polycentricity at this level, like the 'Megalopolis' or the 'Mega-city-region' (Gottmann, 1961), that of 'urban field' (Friedman and Miller, 1965) or the later version of 'poly-nucleated urban field' (Dieleman and Faludi, 1998 – p. 374). However, the notion of spatial interdependency among urban nodes is not defined, neither investigated with enough strictness (Van Houtum and Lagendijk, 2001 – p. 748). Other even more visionary metaphors have been introduced in the literature, such as the 'Blue Banana' (Brunet, 1989), the 'Golden Triangle' (Cheshire and Hay, 1989) and the 'Pentagon' (CSD, 1999). The latter concept is used by European Union in the ESPD to identify a rich transnational polycentric region that includes Paris, Milan, Hamburg, Munich and London metropolitan areas.

The third spatial scale to which polycentricity can be referred is the regional or inter-urban scale. This level concerns regions – administratively defined – or city-regions – if approaching functionally defined spaces –, which are organized around several cities or urban areas. Unlike the intra-urban scale, these cities must not be contiguous among themselves, but they should be separated between one another. More precisely, if a set of conditions are fully satisfied – about centres separation and distribution and about specialisation and interaction among centres – the region may be called Polycentric Urban Region (PUR) (Parr, 2004). Hence, the PUR is more a morphological concept, given the emphasis put on the physical separation and jobs distribution and the smaller role played by interaction among nodes. In this case, interaction is only a requisite to show that each centre is not isolated from the others.

[2] Glaeser and Kahn (2003), for instance, study the emergence of sub-centres in US urban areas, driven by income and private transportation use.

2.2 Morphological vs. functional perspective

As it has been argued above, a polycentric region is ideally characterised by the presence of different and physically separated cities. Taken together, these centres constitute a system characterised by a flat "hierarchy". However, this definition leads to a question: how to decline this "hierarchy"?

This question has been tackled from different approaches. Namely, polycentricity can be conceptualised from both a functional and morphological (or geographical) perspective. In both the cases, a polycentric region is supposed to be characterised by the coexistence of more than one urban centre (Riguelle et al., 2007 – p. 195). However, there are several points in which the two approaches substantially differ. Firstly, morphological polycentricity focuses mainly on the fact that centres must be clearly physically separated, with empty spaces between each other. At the same time, centres must not be too far each other, since there must be an interaction and a minimum proximity that allows the region to be considered as a single territorial entity.

Secondly, from a morphological perspective, centres must not be too dissimilar in terms of dimension, since there must not be any evidence of primacy at the top of distribution (Hall, 2009 – p. 261). Hence, the hierarchical ranking of cities is usually assessed looking at their population, mainly focusing on the size-distribution of cities (Beckmann, 1958). On the other hand, from a functional perspective, the focus is put mainly on the distribution of functions and, as a consequence, on the centralities emerging within the region from the interaction among urban centres. From the functional approach, the hierarchical ranking between cities is assessed with interaction measures, often based on flows of people, goods or information, by making use of tools borrowed from network analysis.

These distinctions allow highlighting of what is probably the most important difference between the functional and the morphological approaches to polycentricity. Such a difference should be referred to the concept of 'centre', which is at the origin of the notion of polycentricity. Morphologically, an urban centre could be simply defined as an agglomeration of jobs and population. In the literature aimed at sub-centres' identification, an agglomeration is considered to be a centre if it exceeds certain thresholds of absolute population (or jobs) and employment density[3] (Giuliano and Small, 1991). On the other hand, from a functional perspective, an urban centre is a place that wields power in the territory around it. Using Christaller's phrasing, a centre can be

[3] Other more complex approaches look at density peaks, hence focusing on those territorial units that show higher densities than areas in the surrounding territory. See, among others, Craig and Ng, (2001). For a recent survey on this topic, see Roca Cladera et al. (2009).

considered a place that supplies central functions to its surrounding territory. From this side the concept of centre is very similar to that of 'central place'. Hence, a region could be viewed as functionally polycentric if it is organised around two or more centres or focal points, places that supply central functions to the whole region or – at least – to a portion of it.

Notwithstanding the differences between the concepts of polycentricity from the two perspectives, it appears reasonable to think that functional and morphological indicators of polycentricity could be – at least to some extent – positively correlated. This is because, despite the different concept of 'centre' at the base of the two definitions, both perspectives are aimed at investigating the same phenomenon, that is to measure the degree to which a region is characterised by the coexistence of several centres, instead of being organised around a single core. The next session, after reviewing the main indicators of polycentricity, verifies to what extent different measures yield to similar results in the case of Italian NUTS 2 Regions.

3 Different perspectives, different indicators: a review of the measures of polycentricity

Instead of considering an area dichotomously as monocentric or polycentric, polycentricity should be measured by scoring an area with a value ranging from fully monocentric to fully polycentric (Meijers and Sandberg, 2008 – p. 78). Following the taxonomy that has been proposed in previous section, we first analyse the morphological dimension, then the functional dimension. Lastly, we see the relationships among those indicators, applying them in the analysis of the level of polycentricity in Italian regions.

3.1 Morphological indicators

The morphological dimension of regional polycentricity refers to the spatial distribution of economic activity across a region. Within a region, economic activity exploits in several ways. The most straightforward aspect to be considered is the distribution of population in cities belonging to the region. One may hypothetically distinguish between two extreme types of regions: the pure polycentric region and the pure monocentric region. The former would be characterised by an even distribution of economic activity across its cities. By considering population as proxy of economic activity, this basically would mean that every city holds the same amount of population or, in other words, the regional system lacks hierarchy.

There are several ways to measure the degree of morphological polycentricity. The first one is to consider the ratio of people living in the main city over total population in region, as shown in equation 1, where n=1 indicates the main city:

(1) $$weight = \frac{pop_{(1)}}{\sum_{n=1}^{N} pop_{(n)}}$$

This simple indicator can be applied to describe the role of the prime city in respect of the region: the higher the weight, the higher the monocentricity of the region. However, it poorly describes to what extent other centres of comparable hierarchic level characterise the region.

A more complete indicator is given by taking into account the size distribution of cities belonging to a region. Cities are ranked according to their population and then the equation (2) is estimated:

(2) $$\ln pop = \alpha + \beta \ln rank$$

The latter is the so-called rank-size equation in the Lotka form (Parr, 1985): if the estimated relation holds, the size distribution of cities follows a statistical log-linear distribution. The slope of equation (2), given by the estimated β, indicates the level of hierarchy, and thus the level of polycentricity within a region: the higher the value of estimated β, the higher the level of polycentricity. Rank-size estimations are widely used in the literature about spatial distribution of economic activity. In particular, they have been used to estimate the Zipf's Law, the well-known empirical evidence which holds if β equals -1: in this case, the size-distribution of cities follows a statistical power distribution (Gabaix and Ioannides, 2004).

As compared to the weight of the prime city, the rank-size coefficient appears to be a more complete and reliable measure of the degree of polycentricity within a region. In fact it synthesises the hierarchies in terms of population and, hence, economic activity across space. However, some problems arise from rank-size estimation. The first issue is the role of the threshold used (i.e. the number of cites taken into consideration to compute the slope of the rank-size regression), which is crucial for the value of the coefficient. There are several ways to consider a threshold (Meijers, 2008). The first one is to take into account cities over a certain amount of population, such as, for instance, 20.000 inhabitants. The second method consists in considering the *biggest n* cities of

the region, for instance the biggest 30 cities. Another method is to take into account the number of cities according to which population reaches a certain amount of total regional population, for instance by taking the median as a threshold. A second issue is related to the units of analysis. In fact, the cities might refer to several definitions, namely an institutional definition of city, which in Italy refers to municipalities, or a functional definition of city, intended as urban area – which in Italy has been declined into the concept of Local Labour System (LLS). Taking into account that municipalities have the advantage to allow for analysis over-time, they have been preferred and selected as the basic units of analysis for the estimation of rank-size coefficients. Moreover, when considering polycentricity referring to NUTS 2 regions, the number of LLS might be too small in some regions to allow a rank-size estimation for urban areas.

3.2 Functional indicators

In order to measure the degree of functional polycentric development, literature suggests various interaction indicators based on flow data that usually regard commuting. The starting point of these interaction methodologies consists in conceptualising the spatial aggregate under analysis – here the NUTS 2 region – as a system composed of nodes or territorial units (municipalities, cities, etc.) and relations among these nodes (Boix, 2002; Calafati, 2007). Polycentric regions should be characterised by highly interconnected urban nodes, following the idea that the more the interconnected the centres, the more the polycentric the system. However, a more important aspect is that connections should be balanced among nodes, without a full centralisation of flows towards a single node. This latter condition refers to the fact that polycentric regions are characterised by more than one centrality, so that there should exist several nodes that are in a similar hierarchic position.

One simple indicator based on commuting flows is the Entropy index proposed by Limtanakool et al. (2007). Such an indicator is aimed at measuring the structure of a given spatial system, where the 'structure' is one of the three S-dimensions – the other two being the Strength and the Symmetry – that authors consider to characterise regional spatial development. The entropy index is calculated as follows:

$$EI = -\sum_{i=1}^{L} \frac{(Z_i)\ln(Z_i)}{\ln(L)} \quad (3)$$

where L are the links in the network, Z_i is the proportion of journeys in link l in relation to the total number of journeys in the network. The *EI* indicator ranges from 0 to 1 and it measures how the total interaction is distributed among nodes. Values close to 0 means that almost all the trips are toward a single node; hence the region should be strongly monocentric. Conversely, values close to 1 indicate strong entropy of flows, hence a strong interaction among nodes, which is compatible with a polycentric regional structure. However, this very general indicator may not strictly describe the degree of *polycentricity*, but the dispersion of activities over the territory, which would even describe features of *urban sprawl* (see Section 5).

Another indicator to measure the degree of functional polycentricity is the Ordinary Polycentricity (*OP*) index recently proposed by Green (2007 – p. 2084). This index is built by using network analysis' tools in order to quantify the relations among urban nodes. In particular, using commuting flows, the *OP* index considers the in-degree as a measure of centrality of each node, looking at the distribution of these centralities within the region. More specifically, the index can be calculated as follows:

$$OP = 1 - s_F / s_{F\max} \quad (4)$$

where σ_F is the standard deviation of the nodal in-degree being measured; $\sigma_{F\max}$ is the standard deviation of a 2-node network where in-degree n_1=0 and in-degree n_2=in-degree of the node with the highest in-degree value in the network. This indicator also ranges from 0 to 1, where 1 indicates perfect polycentricity and 0 indicates perfect monocentricity. Compared with the entropy index, this indicator has been expressly constructed to measure regional polycentric development, hence it should do it more accurately than the former.

4 Indicators of polycentricity for Italian regions

Aiming to describe the spatial shape of Italian regions, both from the morphological and the functional approach, we selected the most relevant indicators. Then, a correlation analysis has shown their relationships.

4.1 The selection of indicators

Morphological dimension

The resident population in Italian municipalities at the date of last General Census (2001) was used as proxy for the economic activity in regions. First, the weight of the prime city for each region was computed, to get the first indicator. Then, for each region, cities were ranked and then rank-size coefficients were estimated. Italian regions are characterised by strong heterogeneity in their population and number of municipalities. Because of this heterogeneity, two issues arise. The first regards which definition of city has to be used, while the second refers to the number of cities to be taken into account or, in other words, the threshold to be used to select them. Regarding the former issue, we chose to use the administrative cities (municipalities) as units of analysis (see section 3.1).

Table 1: Rank size estimations for Italian region, year 2001, results

Region	Beta	t-statistics	Observations
Piedmont	-0.800***	-11.03	69
Aosta Valley	-0.772**	-3.32	14
Lombardy	-0.701***	-18.15	158
Trient – Sudtirol	-0.923***	-20.15	36
Venetio	-0.709***	-19.42	80
Friuli Venezia Giulia	-0.852***	-10.78	29
Liguria	-1.212***	-8.31	18
Emilia – Romagna	-0.942***	-15.19	30
Tuscany	-0.785***	-35.96	29
Umbria	-0.962***	-15.83	9
Marche	-0.683***	-12.58	22
Latium	-0.811**	-3.44	34
Abruzzo	-0.788***	-21.58	23
Molise	-0.937***	-23.42	17
Campania	-0.639***	-6.69	53
Apulia	-0.686***	-45.67	34
Basilicata	-0.773***	-11.66	22
Calabria	-0.824***	-54.77	46
Sicily	-0.794***	-13.06	38
Sardinia	-0.862***	-36.95	32

(***= 99% of significance, **= 95% of significance)

This choice allows to consider polycentricity also at a lower level than the regional, since, for instance, big urban systems are likely to be composed of several sub-centres: this aspect is described when considering municipalities, while it does not appear if one considers local labour systems as units of

analysis. So, according to our procedure, a system is to be considered as polycentric not only if several separated centres compose it with a flat hierarchy, but also if it is formed, for instance, by a big urban agglomeration, which is likely to be characterised by several sub-centres.

The second issue regards the threshold to be used to select municipalities or, in other words, the number of cities to be considered for each region in order to measure polycentricity. Rank-size coefficients were estimated considering, for each region, the biggest city and those municipalities that account for the median population, once excluded the biggest city. This method allows avoiding the bias given by the dimension of the capital city (which has already been considered as indicator of monocentricity). As shown in Table 1, the log-linear relationship holds for all the regions.

Functional dimension

Data about daily commuting for job purposes were used (accounted for the last General Census of population, year 2001), as proxy for the relational densities among cities. Again, the units of analysis were Italian municipalities. As the same for the morphological dimension, the problem of the number of units to be accounted for each region arose. As done for the rank-size coefficient, the same threshold was applied. Then, Ordinary Polycentricity and Entropy Index were computed. Table 2 provides some descriptive statistics of the selected indicators.

Table 2: Selected indicators of polycentricity, Descriptive statistics.

Variable	Mean	Median	Std. Dev.	Minimum	Maximum
Weight Prime city	0.163	0.127	0.111	0.060	0.498
Rank-size	- 0.823	- 0.797	0.130	- 0.639	- 1.212
Ordinary Polycentricity	0.619	0.624	0.103	0.384	0.841
Entropy	0.511	0.522	0.073	0.292	0.590

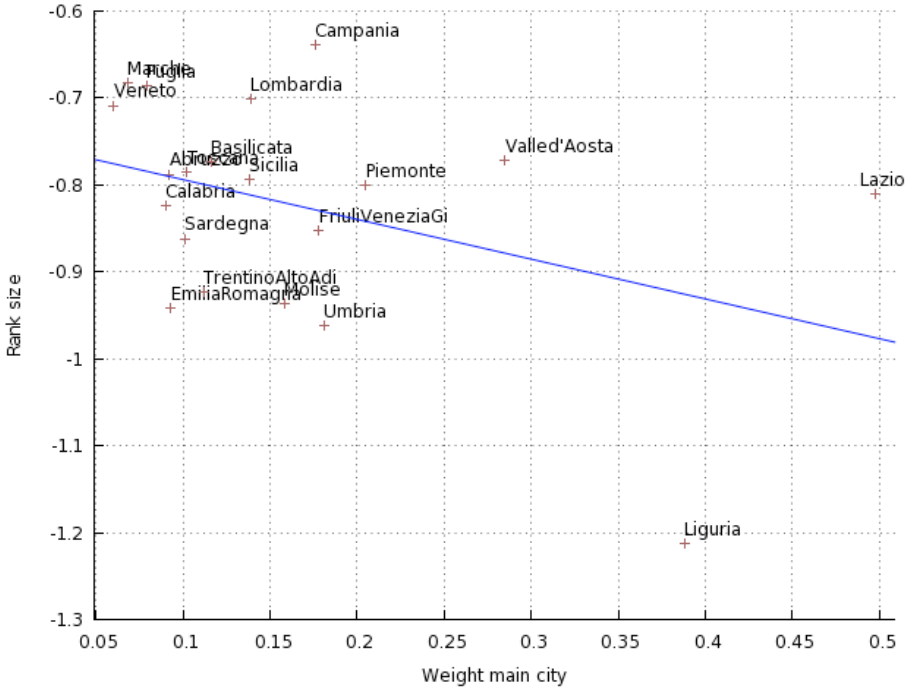
4.2 Relationships between morphological and functional indicators

In order to see the relationships among the indicators of polycentricity that we computed, a correlation analysis was carried out. R correlation coefficients among the selected indicators are shown in Table 3. With reference to the morphological dimension, rank-size estimations and the population share of the biggest city are consistently correlated (Fig. 1): since the higher the rank-size coefficient, the lower the level of polycentricity, we see that the higher the population living in the biggest city of the region – which is a measure of monocentricity – the lower the level of polycentricity.

Table 3: Correlation coefficients among indicators of polycentricity

	Rank Size	Weight Prime City	Ordinary Polycentricity	Entropy
Rank Size	1	-0.39	0,47	0,56
Weight Prime City		1	-0.12	-0.79
Ordinary Polycentricity			1	0.07
Entropy				1

Figure 1: Rank size results and weight of the main city



Then, referring to the functional dimension, we see that Ordinary Polycentricity and Entropy Index are uncorrelated: this reflects the fact that OP may account for polycentricity, while entropy indicates the *dispersion* of economic activity. Those two aspects seem not to be related to each other in the case of Italian regions.

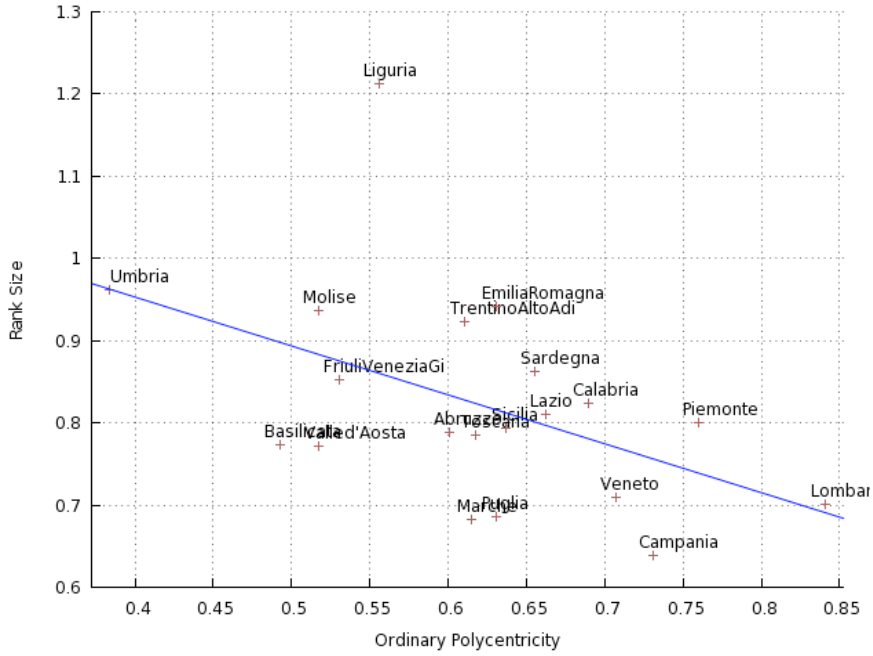
Regarding the relationship between functional and morphological measures, Table 3 shows that the rank size estimator is correlated with both functional indicators, while the latter are negatively correlated with the weight of main city. So, a higher level of morphological polycentricity is associated with a higher the level of functional polycentricity and with a higher the level of entropy. When the morphological polycentricity is measured by rank-size coefficients and the functional dimension by *OP*, results from the two approaches are consistent (r= 0,47). The same relationship holds for taking into

account the percentage of the biggest city instead of the rank size, but at a lower extent (r= -0,12). These results suggest, as it was expected, that even if polycentricity is tackled from the two different perspectives, results are fairly consistent.

A deeper look at the relationship between functional and morphological polycentricity allows us to propose a taxonomy of the Italian regions (Figures 2 and 3), identifying four groups[4], characterised by:

1. High degree of both morphological and functional polycentricity (7 regions);
2. High morphological and low functional polycentricity (5 regions);
3. Low morphological and high functional polycentricity (3 regions);
4. Low degree of both morphological and functional polycentricity (5 regions).

Figure 2: Rank size and Ordinary Polycentricity.



Unsurprisingly, the main regions in Northern Italy (Piedmont, Lombardy, Veneto) show high values of polycentricity both from the morphological and functional perspective. The latter has been investigated, for instance, by Camagni and Salone (1993), which highlighted, referring to Lombardy, the emergence of polycentric structure in the metropolitan area of Milan and in several sub-regional areas (1993, p. 1062). It is also worth remarking the fact

[4] The threshold applied to discriminate the high or low value of polycentricity is given by the mean values of rank-size estimators and *OP* results.

that the regions with highest values both of morphological and functional polycentricity are those with the highest population (Table 4). This finding is consistent with the idea that the number of centres grows with the regional population (Fujita and Ogawa, 1982).

Table 4: Levels of morphological and functional polycentricity in Italian regions.

Region	Population	Cluster of Polycentricity (Morphological-Functional)
Lombardy	9,032,554	High - High
Campania	5,630,280	High - High
Latium	5,140,371	High - High
Sicily	4,966,386	High - High
Venetio	4,380,797	High - High
Piedmont	4,302,565	High - High
Apulia	4,031,885	High - High
Emilia-Romagna	3,909,512	Low-High
Tuscany	3,529,946	High-Low
Calabria	2,070,203	Low-High
Sardinia	1,648,248	Low-High
Liguria	1,676,282	Low-Low
Marche	1,429,205	High-Low
Abruzzi	1,249,054	High-Low
Friuli-Venezia Giulia	1,197,666	Low-Low
Trient-Südtirol	890,360	Low-Low
Umbria	811,831	Low-Low
Basilicata	610,528	High-Low
Molise	330,900	Low-Low
Aosta Valley	115,938	High-Low

5 Polycentricity and economic performances in the Italian regions

This section investigates to what extent the degree of polycentricity of (Italian) regions is correlated with the major (spatial) normative goals that have been emphasised by the ESDP: social cohesion, economic performance and sustainable development. Economic theory can help finding some reasons why polycentricity should help reaching such policy aims. It has long been known that, despite the increase of ICT and the decrease of transport costs (which should lead to the dispersion of economic activity), cities continue to keep the

role of engines of economic development for regions and countries. From the "classical" perspective, the size and the density of the city foster several types of economic advantages, or *agglomeration economies*. These advantages incentivise the concentration of activity in one place, increasing the productivity level of the firms that cluster in space (static externalities). Moreover, cumulative causation processes taking place in urban environments – like cross-sectorial spillovers (see, e.g., De Groot et al., 2007) – might lead to higher innovation and growth, contributing in turn to concentration (dynamic externalities). Those assertions are confirmed by the fact that productivity levels and (per capita) income increase with urban size (Glaeser and Gottlieb, 2009). However, increases in size of cities can also determine negative externalities, such as traffic congestion, rising prices, pollution and other adverse effects on economy, society and environment, which may offset the benefits of agglomeration (Capello and Camagni, 2000, p. 1485). Polycentricity can be viewed as a particular manifestation of spatial agglomeration of activities. The morphological indicators proposed in the previous section – role of prime city and rank-size distribution – might account for such effects.

However, cities within a region can also be viewed as *nodes* that interact within a *network*. Hence, regional development can be fostered not only from agglomeration, but also from network externalities (Boix and Trullén, 2007), which arise from relationships among urban centres. More specifically, externalities can be generated by the networking between "major agglomerations and their hinterland" and by "dense networks of big or middle sized cities" (Barca, 2009, 18)[5]. The main idea at the base of the virtuous effects attributed to polycentricity is that networks externalities that take place within regions can substitute simple agglomeration externalities, by allowing the emergence of *regionalised* urbanisation economies (Meijers and Burger, 2010). These regional externalities would improve both competitiveness and cohesion, allowing for a more balanced economic development. Within this framework, functional indicators that have been proposed in this paper might take into account the structure of network relationships inside regions.

Regarding the link between polycentricity and environmental sustainability, some authors have conceptualised polycentric development as a model of spatial organisation midway between compact/monocentric areas and

[5] Barca Report emphasises the role of medium and small sized centres as drivers for development. In this light, polycentric regions characterised by high "network effects" are assumed to be the ideal ground for economies of scale and growth, which can be generated by the "networking between major agglomerations and their hinterland" and by "dense networks of big or middle sized cities" (Barca, 2009, 51).

dispersed ones (Camagni et al., 2002 – p. 52). This could present the advantage of allowing territories to expand spatially, without paying some of the costs of dispersed development that have already been highlighted in the literature (Muniz et al., 2006). Even in terms of traffic, polycentric development could facilitate shorter distances, the use of public transport and, as a consequence, more sustainable commuting patterns in terms of time spent travelling and polluting emissions (Veneri, 2010).

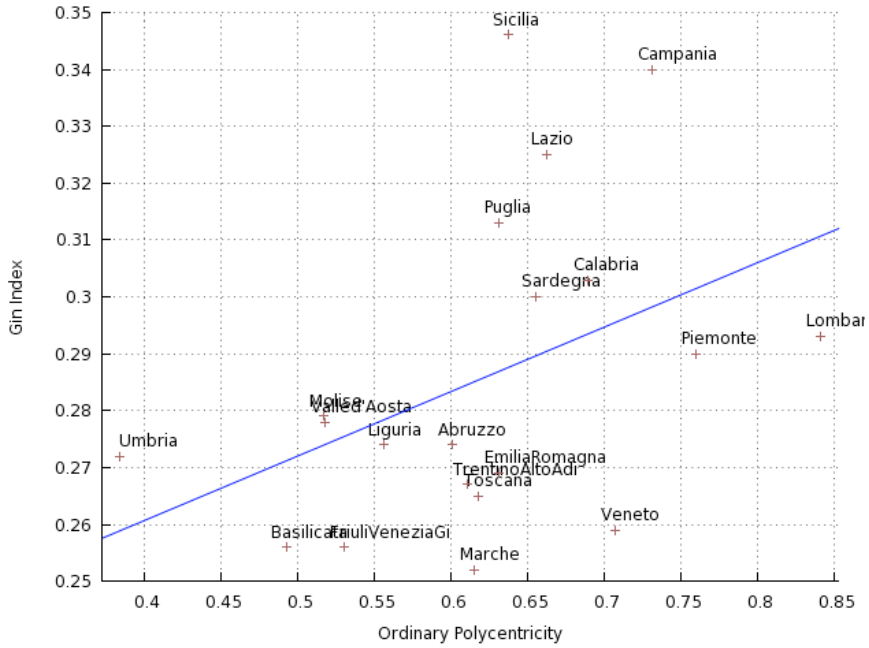
Table 5: Correlations between polycentricity, social cohesion and economic performances

Dimension		Rank Size	Weight Prime City	OP	Entropy
Social cohesion					
	Gini index a	0.255	0.259	0.421	- 0.308
	Gini index b	0.23	0.312	0.449	- 0.306
Economic performances					
	GDP	- 0.15	0.259	0.12	- 0.026
	GDP growth rate	0.057	0.186	-0.11	- 0.20
	Labour Productivity	- 0.124	0.450	0.40	- 0.348
	Productivity growth rate	- 0.1285	0.1916	-0.415	0.1479
Environment					
	Perc. residential land	0.2719	- 0.0762	0.6485	-0.0661
	Growth residential land	-0.2539	0.0185	- 0.3112	0.1835
	Perc. Discontinuous urban fabric	0.1262	0.1070	0.5661	-0.971
	Building licenses	0.117	- 0.538	0.128	0.392
	Final Energy Consumption	- 0.1551	0.0745	-0.1722	0.2109
	Energy for Transport	- 0.178	0.333	- 0.186	- 0.018
	Public transport use	- 0.0926	0.5792	0.301	-0.5991
	Greenhouse gas emissions	- 0.191	0.065	0.211	- 0.284

5.1 Polycentricity and social cohesion

Aiming at seeing how the degree of polycentricity relates to social cohesion, we focused mostly on the income distribution in regions, measured by Gini Index on the base of data provided by the Italian Statistical Office for the year 2003. Ranging from 0 to 1, 0 represents a perfectly equal distribution of income, while 1 is the opposite. So, the higher the index, the lower the social cohesion.[6] The results show that the more polycentric the regional shape is - measured with both morphological and functional indexes - the more unequal the income distribution (see Table 5) . Those results are different from the conclusions in the ESDP, but consistent with results by Meijers and Sandberg (2008), which found the same relationship in a European comparison at the country level. The same holds for the weight of the biggest city: the higher the population living in the prime city, the less equal the distribution. The negative correlation between polycentricity and income distribution is particularly noticeable by considering functional polycentricity (Fig. 3; r=0,4). Entropy is the only measure negatively correlated with income distribution. However, as it has been already remarked, entropy could indicate a dispersed pattern of development instead of an actual polycentric spatial organisation of the regions to which it is applied.

Figure 3: Ordinary Polycentricity and Income Distribution.



[6] Gini Index a includes the income generated by house rents, which are excluded in Gini Index b (see Table 5).

5.2 Polycentricity and economic competitiveness

Regarding the relationship between regions' competitiveness and their degree of polycentricity, four indicators were used in order to approximate economic competitiveness: labour productivity and regional Gross Domestic Product, both in levels (referred at 2001) and in growth rates between 2000 and 2007. Data were provided by Istat.

The degree of concentration of population in the prime cities is positively correlated with all the economic competitiveness indicators (Table 5), especially with those regarding "static" measures (GDP and Labour productivity in levels). This would suggest that urbanisation economies arising in big urban environments may be important drivers for economic performance of the region. In other words, in the biggest agglomeration, where agglomeration externalities may play an important role, there is on average a higher productivity level.

Regarding rank-size coefficients, it appears that polycentricity is poorly related to economic performances, while the OP index is quite highly correlated with GDP growth and, moreover, with the level of labour productivity (R=0.40). The latter, on the other hand, is negatively correlated with entropy. More in depth, regions that show a high degree of functional polycentricity – where there might be higher network externalities – are associated with a higher level of productivity and, to a lesser extent, with a higher GDP growth. On the other hand, regions characterised by a pattern of spatial organisation that may be called "polycentric dispersion", as accounted by the Entropy index, are associated with lower levels of productivity and lower rates of GDP growth.

5.3 Polycentricity and environmental sustainability

Regarding the environmental sustainability, two main issues that might be strictly linked with regional spatial structure have been considered in this work: land uses, energy uses and greenhouse gas emissions.

Polycentricity and land use

Theory suggests some insights to analyse the possible role of polycentric development in environmental terms. Firstly, a polycentric region might avoid the congestion arising in monocentric regions (Parr, 2004; Barca, 2009). This would lead to economic advantages, as seen in the previous section, but also to environmental advantages. Another insight may come from distinguishing polycentric regions from sprawled regions. Contemporary Italian cities are spatially growing, even in regions characterised by a steady population. As a result, the pressure of *artificial land* on *open space* (agricultural and natural

land) is more and more higher. This process is at the base of the well-known phenomenon of urban sprawl[7]. In fact, since the Fifties almost all the Italian regions have been involved in a huge process of urban expansion, sometimes following a scattered pattern. While in a first moment this was mainly seen as being caused by population movement towards cities, more recently it seems to be due also to other factors, among which it is worth mentioning the change of preferences towards housing in low-density and newly urbanised areas (Camagni et al., 2002) and technological progress, especially in the field of transport and communication technologies. The latter has enlarged individual circadian cycles and it has even re-shaped the functional boundaries of urban areas (Calafati and Veneri, 2010).

In this light, a balanced polycentric pattern, characterised by compact cities, would be able to optimise the land use. However, "there is little consensus on whether polycentric metropolitan form represents compactness or sprawl" (Tsai, 2005, 141). Urban sprawl is a multidimensional phenomenon, which is characterised by some aspects, such as the metropolitan size, the density, the degree of distribution and centrality of population (*ibid.*). The polycentricity indexes proposed here do not explicitly take into account all the dimensions of sprawl. However, the weight of the prime city gives insights on the *metropolitan size*. Then, rank-size estimations capture the degree of distribution of population, while network analysis and entropy indexes give an overview of the centrality and degree of clustering of centres.

In order to verify how polycentricity and environmental sustainability – in terms of land use patterns – are linked, a set of indicators were selected. Data was obtained from CORINE land cover statistics[8], referring to years 1990 and 2000. The ratio of urbanised area in respect to the total regional area has been computed as an indicator of urban sprawl[9]. Then, since low-density settlements are another characteristic of urban sprawl, the percentage of the discontinuous urban fabric over the total territory was computed[10].

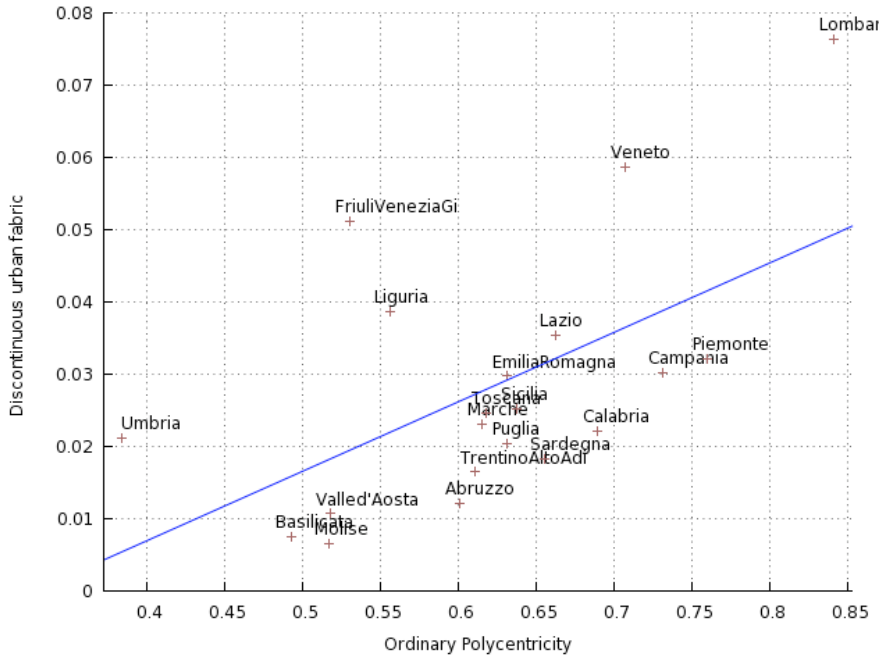
Results show that polycentricity and land use are positively correlated, both considering rank-size and ordinary polycentricity (Table 5). The more polycentric the structure, the more the land needed for artificial use. The correlation is particularly noticeable when accounting for ordinary polycentricity. The same results hold by considering only the discontinuous

[7] See European Environment Agency (2006), for a discussion about the main drivers of urban sprawl.
[8] See http://www.eea.europa.eu/publications/COR0-landcover
[9] We considered the Class 1.1 of the CORINE Land cover, "Urban fabric": Areas mainly occupied by dwellings and buildings used by administrative/public utilities or collectivities, including their connected areas (associated lands, approach road network, parking-lots). See Bossard *et al.* (2000) for the technical details.
[10] CORINE Land Cover, class 1.1.2 (Bossard *et al.*, 2000).

urban fabric (see figure 4). This would suggest that polycentricity, like sprawled patterns of development, is mainly related to a higher consumption of land. Regarding the weight of the prime city, this is not correlated with the land use indicators.

Lastly, when considering the number of building licenses (m^3 of new buildings every 100 inhabitants, year 2001, Source: Istat), we see that it is negatively correlated with the weight of prime city and positively with the entropy, while there are not significant correlations with rank size and OP. Hence, looking at the spatial development in terms of change in the demand for land does not highlight a role for polycentricity, while there is a positive correlation with the spatial entropy.

Figure 4: OP and discontinuous urban fabric.



Polycentricity, energy use and greenhouse emissions

A key link between spatial structure and emissions can be analysed looking at commuting patterns. Some authors recognised some environmentally virtuous effects of polycentricity on commuting flows (Tsai, 2001; Veneri, 2010), especially because of the proximity between work and home locations (Gordon et al., 1989). In fact, a pure monocentric region involves a huge amount of flow directed towards the centre, causing congestion and higher social costs, while a polycentric region would allow more sustainable commuting patterns, encouraging the proximity between housing and work. Moreover, the

emergence of high-density sub-centres might allow a more efficient supply of public, transport, especially as compared to sprawled areas, which on the contrary foster the use of private transport.

With reference to energy use for transport (per capita, year 2000. Source: ENEA), it can be noticed that the weight of the prime city is positively correlated with the energy consumption for transport while the other correlations are not significant. However, the signs of correlations give the indication that more polycentric regional structures, both from the morphological (rank-size) and the functional (OP) side, are correlated with less energy consumption (Table 5). This might be due to the highest use of public transport in polycentric regions (see the correlation between OP and public transport use in year 2001. Source: Istat). The correlation with the weight of the prime city suggests that monocentric regions show higher energy uses for transport. The correlations about final energy consumption (per capita, year 2000. Source: ENEA) show similar results, except for the correlation with the prime city, which is not significant.

Finally, when accounting for greenhouse gas emissions (per capita, year 2000. Source: ISPRA SINANET[11]) the findings show a slight positive correlation with OP and a negative correlation with Entropy index. Hence, greenhouses emissions are higher in polycentric regions and smaller in dispersed regions.

6 Concluding remarks

Since the Nineties the concept of polycentricity has gained a central role on the scientific debate on regional economic and planning. Following the ESDP, polycentric regions have been assumed to have the potential for virtuous performances– in terms of economic competitiveness, social cohesion and environmental sustainability. However, these hypotheses have not been corroborated with enough robustness. Moreover, despite the efforts to create new images and metaphors to conceptually represent polycentric regions, few attempts have been made to plan and regulate an efficient polycentric spatial organisation (Albrechts, 2001). A reason for these gaps, both in the analysis and in the policy actions, may be the fact that polycentric development is a fuzzy and multidimensional issue, involving several spatial scales and dimensions.

Given their importance in the scientific and policy debates, in this paper an attempt has been made to stimulate a discussion on the *concept* and on the *role*

[11] See http://www.sinanet.apat.it/it/emissioni.

of polycentricity, by reflecting on several issues where it would be worthwhile to carry out additional research.

The first issue regarded how to measure polycentricity, by stressing the differences between the two main perspectives adopted to analyse the concept in the literature (morphological vs. functional). By considering the Italian NUTS 2 regions, the results of the analysis showed that notwithstanding the differences between functional and morphological approaches, the two dimensions are highly correlated.

The second aspect regarded the effectiveness of polycentricity as a normative goal. This issue appears to be particularly challenging both from a theoretical and empirical point of view and promises to continue to be a stimulating field of research for the near future. The aim was to discuss the theoretical justifications of the potential for superior performances of polycentric regions. Then, an empirical analysis aimed to explore – following the ideas contained in the ESDP – to what extent the degree of polycentric development of Italian NUTS 2 regions is correlated with various key indicators of economic, social and environmental performance. The results show that polycentricity in Italian regions is not always a virtuous model of spatial development, especially in terms of social cohesion. This is in contrast with the idea of ESDP, but consistent with other European studies on this topic (Meijers and Sandberg, 2008). Correlations among polycentricity and environmental indicators are also not univocal, and the same happens when competitiveness is taken into account.

In summary, then, the analysis confirms the idea that the polycentric spatial structure – taken alone – is far from being an effective tool to reach those important policy aims highlighted by ESDP, at least when considering Italian NUTS 2 regions.

However, a central point that must be clarified, especially from a theoretical perspective, is the spatial scale at which polycentricity can exert a virtuous role – in other words, the level at which *regional* externalities can exploit – and thus the appropriate scale for potential policy actions. In order to do that, the concept of polycentricity, as well as its measures, needs to be developed further on.

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