EXTENDED ABSTRACT

Title: Territorial Morphology Dynamics in European Regions: patterns of demographic and spatial concentration between 2000 and 2015

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1. Introduction

The European Union strives to promote well-being and equality of its citizens, and solidarity among them. This foundational recognition stays upfront in the Lisbon Treaty (art. 1). The territorial dimension of European Integration gained new salience around mid-2000s. The European Union, with the adoption of the Lisbon Treaty in 2007 has set a new mission on Territorial Cohesion to complement the Economic and Social Cohesion policies. To foster Territorial Cohesion in its spatial, governance and budgetary components, the Treaty attributes a shared competence between the EU and Member States. While the tools have progressed, the degree, quality and pace of development among member states and their regions has remained unbalanced. Disparities at subnational level suggest that further commitment is needed to achieve a balanced development and to offer equal conditions for all Europeans.

The territorial cohesion of the Union is a key aspect of European integration, and several scholarships have analysed it providing social, economic, and spatial planning reasons supporting this.

In this study, we analyse the characteristics of territorial morphology of European regions (Nomenclature of territorial units for statistics - NUTS2), by taking a spatial analytics and big data perspective. The research develops from the Global Human Settlement Layer (GHSL), produced at the European Commission - Joint Research Centre by using a combination of remote sensing imagery and census data. This dataset is used as baseline data to extract the Degree of Urbanisation1 and of agglomeration2 of

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[1] Urbanisation is classically defined as: $U_t = P_u / P_T$, where the share of urban population at a given time (U_t) is determined by the ratio between the population of a given spatial unit accounted in urban areas (P_u), over the total population of the spatial unit (P_T – that is composed by urban population P_u, and rural

European regions and to identify their main urban centres, urban clusters and rural areas. The use of GHSL makes possible to extend the research on spatial patterns of urbanisation from limited case studies, at the level of major cities and metropolitan regions (Salvati *et al.* 2018), to NUTS2 level. In particular, in this analysis we classify the different patterns of region transformations in terms of demographic and spatial changes (built-up areas) between 2000 and 2015. The main inputs for the model are: i) the Degree of Urbanization of the NUTS2 in the two epochs; ii) the absolute population change in urban and rural areas between the two epochs; iii) the degree of agglomeration of the NUTS2 in the two epochs; iv) the absolute built-up areas change in urban and rural areas between the two epochs. The model outputs are: i) the classification of NUTS2 development patterns according to the concentration or dispersion of people and built-up areas in urban areas; and ii) the demographic and built-up areas balance in the time frame selected.

The paper proposes the theoretical adaptation of the "Demographic Factors of Change in National Degrees of Urbanisation" (Melchiorri *et. al.*, in preparation) to NUTS2 in combination with the dynamics of agglomeration. The patterns of development classified by the model help understanding the social, economic and territorial changes taking place across European regions.

2. Data description

Demographic analyses on urbanisation require two main types of information, one to quantify population distribution, the other to classify settlements hosting inhabitants in urban and rural classes.

The Global Human Settlement Layer (GHSL) is produced by the European Commission - Joint Research Centre and it is supported by the Directorate-General for Regional and Urban Policy. GHSL maps population density (GHS-POP) and rural/urban settlements (GHS-SMOD), for the epochs 1975-1990-2000-2015. An additional layer (GHS-BUILT) mapping presence and density of built-up areas for the corresponding years is available. All GHSL layers are consistently produced to allow comparisons across time and regions of the world.

In this study, we focus on the epochs 2000 and 2015 of the GHS-POP and GHS-SMOD. National population statistics for the test application of the methodology are extracted from GHSL in combination with the Database of Global Administrative Areas (GADM[3]). Countries in the Major Region "Europe" are identified from the World Population Prospects: The 2014 Revision, Classification of Countries by Major Area and Region of the World (United Nations, Department of Economic and Social Affairs, Population Division 2015).

2.1 Population

GHS-POP is a spatial raster dataset that depicts the distribution and density of population, expressed as the number of people per pixel. Residential population

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population P_r). This formalisation dates back to the traditional studies on urbanisation by Davis (Davis 1955).

[2] defined as: $A_t = B_u / B_T$, where the share of urban built-up areas at a given time (A_t) is determined by the ratio between the built-up areas of a given spatial unit accounted in urban areas (B_u), over the total built-up areas of the spatial unit (B_T – that is composed by urban built-up areas B_u, and rural built-up areas B_r) (Melchiorri *et al.* 2018).

[3] http://gadm.org/

estimates for target years 1975, 1990, 2000 and 2015 provided by CIESIN GPWv4 were disaggregated from census or administrative units to grid cells, informed by the distribution and density of built-up as mapped in the global GHS-BUILT layer in the respective epoch (Freire *et al*. 2015; Freire *et al.* 2016; JRC 2016).

2.2 Settlement Model

The SMOD data package (JRC 2016b) contains an assessment of the REGIO-OECD "degree of urbanisation" model (Tab. 1; Dijkstra and Poelman 2014) using as input the GHS-POP and GHS-BUILT in four epochs (2015, 2000, 1990, and 1975). Each grid has been generated by integration of the GHSL baseline data on built-up areas produced from Landsat imagery (Pesaresi *et al.* 2016), and population data derived from the CIESIN GPWv4 (Freire *et al.* 2015).

The GHSL SMOD is a 1-km grid layer that classifies each pixel into the following classes: a) unpopulated area; b) rural area (RUR); c) Low Density Cluster (LDC); d) High Density Cluster (HDC). Low Density Clusters and High Density Clusters together compose the urban class and the population hosted in these settlements is considered urban.

Table 1. Spatial concepts in relation to the revised degree of urbanisation (Source: Eurostat, the European Commission Directorate-General for Regional Policy, OECD)

Grid cell concept	Criteria
High density clusters (urban centres)	Population ≥ 50 000 inhabitants and contiguous grid cells of 1 km^2 with ≥ 1 500 inhabitants per km2
Urban clusters	Population ≥ 5 000 inhabitants and contiguous grid cells of 1 km^2 with ≥ 300 inhabitants per km2
Rural grid cells	Grid cells outside urban clusters and urban centres

Degree of urbanisation concept	Alternative terminology	UN classification	Criteria
Cities	Densely populated areas	Large urban areas	≥ 50 % of the population lives in high-density clusters
Towns and suburbs	Intermediate urbanised areas	Small urban areas	< 50 % of the population lives in rural grid cells and < 50 % of the population lives in high-density clusters
Rural areas	Thinly populated areas	Rural areas	> 50 % of the population lives in rural grid cells

2.3 Spatial Units of Analysis

Urban and rural population and built-up area statistics per NUTS2 2013 are obtained from the European Commission, EUROSTAT, GISCO Geodata platform – as reference data. The spatial units of analysis are processed in GIS environment in the ETRS LAEA 1989 coordinate system.

3. Methods

The workflow is implemented in three main phases. The first one consists in the selection of the temporal span of the analysis (2000 and 2015), and the NUTS2 to be analysed (spatial units of analysis -SUAs, obtained from the EUROSTAT Geodata platform). In the second step, the GHS P2016 layers (SMOD and GHS-POP) are injected in the GIS environment to extract zonal statistics over the selected SUAs (NUTS2). From these first two steps, it is possible to generate a geospatial layer and a multitemporal statistical dataset, for the year 2000 and 2015, containing: total NUTS2 population, urban and rural population per NUTS2, and the degree of urbanisation and agglomeration. In the third step, the Demographic Factors of Change in National Degrees of Urbanisation model is applied (i.e. the different cases of degree of urbanisation and agglomeration variation codified and labelled). The model outputs a comprehensive classification of NUTS2 according to the observed variation of population, built-up areas, Degree of Urbanisation and agglomeration.

4. Results & Discussion

The outcome of our research classifies NUTS2 according to the morphology of their settlements (Fig. 1) and identifies a core-periphery asymmetry. Further analysis of the demographic and spatial trajectories of change in European regions identifies that both peripheral and core regions experience substantial net population decline, that decline is oftentimes driven by loss of population from urban areas (Tab. 2), and that most rural NUTS2 encountered slight population decline (Tab. 3).

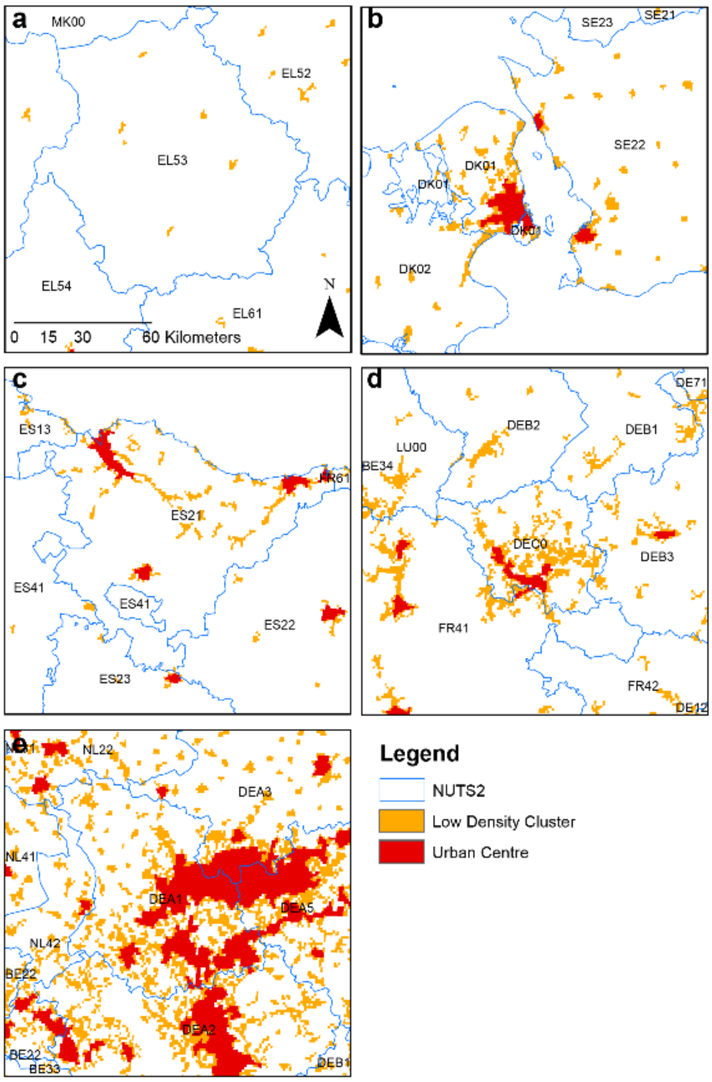

Figure 1 Typologies of urban territorial morphology: a) dispersed Urban Clusters in EL53; b) Single Urban Centre in DK01; c) Multiple Urban Centres in ES21; d) Multiple Urban Centres connected by Urban Clusters in DEC0; e) Multiple and connected Urban Centres in DEA1.

Table 2. Net and relative population change in selected Objective 1 NUTS2 disaggregated at urban class

NUTS2 ID	Name	NUTS2 Population change		Urban Population change	
		net	relative	net	relative
BG31	Severozapaden	-279,962	-27%	-200,901	-37%
RO21	Nord-Est	-883,854	-23%	-684,221	-34%
RO41	Sud-Vest Oltenia	-578,945	-24%	-401,800	-34%
RO22	Sud-Est	-697,740	-24%	-546,303	-30%
BG32	Severen tsentralen	-199,412	-20%	-145,132	-29%
RO42	Vest	-370,962	-18%	-292,236	-24%
RO12	Centru	-469,684	-18%	-365,777	-24%
RO11	Nord-Vest	-466,006	-16%	-330,403	-22%
LV00	Latvija	-399,890	-17%	-399,300	-22%
HU33	Dél-Alföld	-207,791	-14%	-201,845	-22%
DEG0	Thüringen	-349,658	-14%	-293,688	-22%
DED4	Chemnitz	-229,912	-14%	-250,884	-20%

Table 3. Share of rural population and 2000-2015 relative change in the 10 most rural NUTS2

NUTS2 ID	Name	Share of rural population in 2000	2000-2015 relative variation
AT11	Burgenland (AT)	81%	-6%
BE34	Prov. Luxembourg (BE)	75%	-1%
IE01	Border, Midland and Western	71%	-6%
ITF5	Basilicata	67%	-4%
DE22	Niederbayern	65%	2%
EL64	Sterea Ellada	64%	1%
FR53	Poitou-Charentes	63%	1%
DEB2	Trier	62%	-1%
EL42	Notio Aigaio	62%	-3%
PT18	Alentejo	62%	-3%

The main result of our study is displayed in Fig. 2 where we combine the trajectories of change in the degree of urbanisation and agglomeration. For example regions classified as 4a6 (according to the Demographic Factors of Change in National Degrees of Urbanisation model; Melchiorri *et al.*, in prep) identify a pattern of development subject to a regional population decline effect, where both urban and rural areas encounter net demographic shrinking, yet the decline is more substantial in urban areas. The degree of urbanisation also decreases. In terms of spatial changes, urban areas shrink and built-up areas that at regional level increase, disperse in urban areas.

Regions that fall in this category include BG32, HU33 and RO42 (among others). All these regions were eligible under Objective 1 of the Cohesion Policy (i.e. "Supporting development in the less prosperous regions").

The paper will develop trying to understand linkages between territorial development trajectories (characterised with demographic and spatial change motives) and eligibility under Objective 1 of the Cohesion Policy.

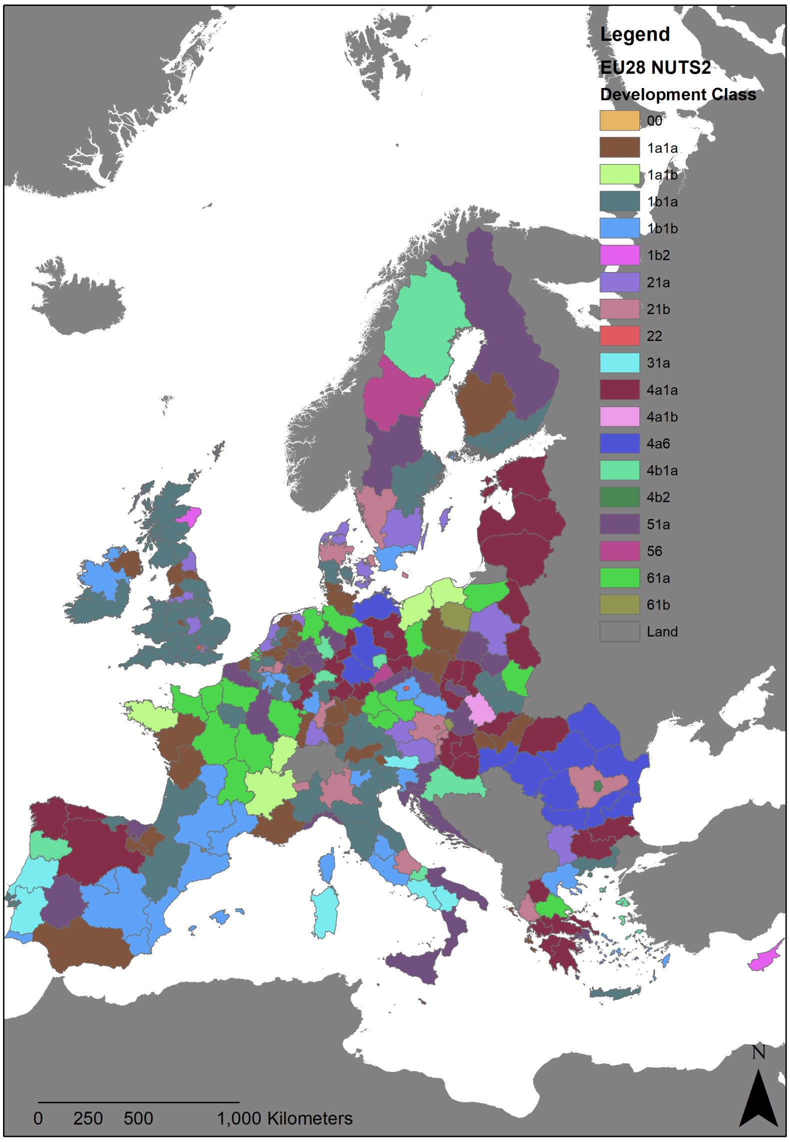

Figure 2 Classification of the NUTS2 according to Melchiorri *et al* in preparation

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