How to measure territorial accessibility. An accessibility evaluation model applied in the European Union space

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Abstract

In this paper we propose a quantitative model of territorial accessibility provided by the endowment of transport infrastructure for the European Union reference space. For this purpose, we designed a composite index calculated at regional NUTS 2 level, which includes the following proxy variables representative for the assessment of territorial equipment with transport networks: the densities of the motorways network, the high-speed rails network and the inland waterways, the number of interregional links on the motorway, high-speed railway and inland waterway, the number of airports and ports of the trans-European core network. Based on said index values, we have developed a spatial model of the deficit accessibility in the Community space and a synoptic of the possible solutions for the development of transport networks, as a prerequisite for the homogenization of the territorial accessibility and the improve of the territorial cohesion.

Keywords: territorial accessibility, transport infrastructure, territorial cohesion, European Union

Introduction

Territorial accessibility is one of the relevant prerequisites for territorial cohesion and an indicator of it. Accessibility is usually ensured by equipping the territory with transport infrastructures (Gutiérrez and Urbano, 1996, p. 16), by the distribution with which all contributing elements depend on the completion of economic, social and territorial cohesion: economic development and integration, innovative elements, social development and inclusion, sustainable urbanization enlargement, public safety and environmental quality (Mathis *et al.*, 2005, p. 114). Transport networks are basically the essential vector of territorial cohesion, which

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justifies the policies, measures and strategies devoted to the development of transport infrastructures adopted in the European Union (EU) both at Community level and at the level of governments and regional authorities (Spiekermann and Wegener, 2006, p. 26). However, the economic growth recorded throughout the Community over the last decade has a very uneven spatial distribution in all its aspects: trade volume, foreign direct investment volume, purchasing power level, labour productivity. In context, Button (2003, 2010) and Rodrigue (2016, p. 596) argued that the inequality of the growth distribution is largely correlated with the uneven distribution of transport networks and the territorial accessibility provided by them. In this framework, equipping territories with transport infrastructure is the main objective of the European transport policy (Condeço-Melhorado *et al.*, 2014, p. 172), but at the same time it is a term dependent on the investment potential and the political will of national governments (Spiekermann and Wegener, 2006, p. 31). According to the New Politics of the European Union on Transport Infrastructure adopted on 17.10.2013, the structure of the transeuropean system (TEN-T) in the EU has been planned on two major structural levels: the TEN-T core network centred around the 9 main trans-European corridors and the TEN-T global network of adjacent infrastructure segments supporting convergent flows to the central network (European Commission, 2013).

In line with the above-mentioned imperatives and the recent research trends in the field, *the aim of our work is to quantify the degree of territorial accessibility in the European Union provided by the endowment of transport infrastructure.* In this context, we will address transport infrastructures exclusively in terms of their availability in the territorial space, and not as associated manufacturing facilities, as industrial economy research domain.

The majority of these specialized analyses, as well as the documents of the European bodies, deal with the issue of territorial accessibility either related to a mode of transport, distances and transport time (Keeble *et al.*, 1982; Schürmann and Talaat, 2002; Spiekermann and Schürmann, 2007) or in the form of applied impact in relation to different economic parameters (Chatelus and Ulied, 1995). On this background, we inquire the quantitative assessment of the affordability of space from the simultaneous perspective of endowing the territory with the whole range of transport infrastructures. For this purpose, in this study we will develop a tool for measuring the territorial accessibility, namely a complex index that synthesizes eight dimensions regarding the relations of the different transport networks with the territorial space. For calculating the above-mentioned index, we will consider only the higher-end infrastructure elements according to the accessibility requirements of the European Norms (Regulation (EU) No. 1315/2013): the motorway network, the high-speed rail network (that allow running speeds of over 200 km/h), inland waterway network, main airports and main ports of the trans-European TEN-T network.

The mapping of the specified index values at the level of NUTS 2 regions allowed us to establish a spatial model of the deficit / optimal territorial accessibility in the community space. The identified alternatives are due to the different accents in the Member States on the development of transport infrastructures, accents that correspond to spatial discrepancies on the EU map, even if the achievement of territorial cohesion is an objective assumed by all European states. The results obtained underpin the proposal of a map of the priorities for equipping transport infrastructure with the aim of improving territorial accessibility and territorial cohesion.

The paper is structured in the following parts: after introduction, the first section presents the main topics addressed in the literature on the role of transport infrastructures as a provider of territorial accessibility; the second section defines the variables and categories of data used to quantify territorial accessibility as well as the methodology used to prepare the Territorial Accessibility Index; the third section contains the results of the research, and finally, we present the conclusions and solutions proposed for the homogenization of the territorial accessibility in the EU.

1. Current approaches in the literature

The positive effects of a good territorial endowment with transport infrastructures on improving territorial accessibility are relevant to regional development, which raises the interest of research in the field focused on the interrelations between the two components. The issue of territorial accessibility, as a prerequisite for territorial cohesion, has been the subject of extensive evaluations in the literature, which emphasizes the role of spatial and intermodal connectivity of transport networks, as a provider of accessibility (Keeble, 1982; Hensher *et al.*, 2004; Condeco-Melhorado *et al.*, 2014). In addition, a series of recent empirical research, shows that multimodal integration of transport in the EU is the right solution for delivering accessibility capable of sustainably meeting the requirements of regional development in terms of economy, efficiency and environmental protection (Stead, 2010, p. 29).

Particularly for the post-2004 East European countries, the modernization and development of intermodal infrastructures appears to be one of the most important ways of economic growth and attraction of foreign investments, together with technological innovation and the establishment of modern logistics centres (Šakalys and Palšaitis, 2006, p. 151). Territorial accessibility and connectivity is also relevant from the point of view of logistics management in relation to supplier relationships, and from the "perspective of international trade, the territorial accessibility of transport networks enhances the ability to access different markets" (Calatayud *et al.*, 2016, p. 726).

Bertolini *et al.* (2005) have developed the concept of sustainable spatial accessibility as a basis for sustainable regional development through an integrated management of transport and land use. The integrated planning of the two elements

is quantified through the use of several working tools: indicators for the cost of accessibility for marginal areas (Spiekermann and Neubauer, 2002; Coppola and Papa, 2013), combined land use mapping and transport development plans (Curtis and Scheurer, 2010), perceptual behavioural representation of the opportunities offered by transport networks for satisfying socio-economic needs in a given space (Cascetta *et al.*, 2013). Insisting on the territorial planning dimension, Evers (2008, p. 312) argues that, in order to effectively contribute to achieving territorial cohesion, the motorways and high-speed rail networks must be equipped as intelligent transport systems and included of a pan-community program of systematic spatial planning. Thus, Moya-Gomez and Garcia-Palomares (2014) consider the integration of transport and land management as an essential solution for traffic flow and network decongestion.

A significant approach of the role of transport networks in delivering territorial accessibility and territorial organization depend by the spatial economy epistemology, whose theoretical background assigns for transport infrastructures a key place in conceptual configurations. Shaping growth poles in regions well connected by transport networks (but also by other local factors) will generate spatial developments of the centre-periphery type (Drăgan *et al.*, 2013, p. 33; Pascariu and Ţigănaşu, 2017). The most conclusive example in this respect in the EU is represented by the area comprising the London Basin, Northern France, Benelux and the West of Germany - an area of maximum capital and services accumulation, based on the accessibility provided by the high density of transport infrastructures (Spiekermann and Neubauer, 2002).

Along with the first studies in the field of new economic geography, Keeble *et al.* (1982) showed that regional accessibility in the sphere of the spatial economy is the decisive condition for capitalizing on local resources and regional economies in the community space. In consecutive approaches, Fujita and Krugman (2004) demonstrated the relevance of transport infrastructures for locating potential economic developers, while Krugman (1991, p. 495) and Spiekermann and Schürmann (2007) explained the valences of transport networks in shaping the spatial relationship between concentration and economic dispersion, showing that the economic dilemmas within the EU is due to non-homogeneous territorial equipment with transport infrastructure. The situation can be remedied according to Baldwin *et al.* (2003, p. 78, 172) through the effects of appropriate transport policies that take into account the relationship between the economies of scale and the transport costs responsible for generating agglomerations and economic and spatial dispersal at EU level.

On the dimension of the relationship between territorial accessibility and regional development, recent research quantifies and models through statistical and mathematical methods the relationships between regional development and the territorial extension of transport networks. In this regard, von Hirschhausen (2002), Stough *et al.* (2002) and Rodrigue (2020) revealed the positive correlation between

the availability of transport infrastructure and economic growth, and more recently Condeço-Melhorado *et al.* (2014, p. 86) identified a direct relationship between the accessibility of transport networks, spatial interaction and territorial cohesion. In another interdisciplinary analysis, Condeço-Melhorado *et al.* (2011, p. 401) revealed that the spillover impact generated by transport infrastructures on territorial cohesion is not uniform at EU level, and in some circumstances, for certain regions, the negative spillover effect may occur as compared to the contribution of other types of infrastructure (Moreno and López-Bazo, 2007, p. 65). More technical approaches in the area of regional research (Raicu and Popa, 2009, p. 8; Stead, 2010, p. 15) have also highlighted the capacity of intermodal nodes to increase regional accessibility, depending on the level of equipping with this type of infrastructures.

Over the last years research has shown that the expansion of transport infrastructure has a significant impact on increasing intra-community and global interdependencies (Howell, 2013, p. 17). Therefore, the development of transport networks has an effect on both the regional dimension and the process of globalization. On the one hand, the analytical efforts undertaken on both dimensions (Heshmati, 2013, p. 43; Godnič and Vodopivec, 2017, p. 8) attempted to design spatial models that quantified the interrelationship between the territorial accessibility and the infrastructure endowment; on the other hand, European decision-makers adapt transport development strategies taking into account both synergic paradigms in the international system (regionalization and globalization) (European Commission, 2013). Köhler (2014, p. 92) emphasizes the catalytic role of globalization agents in the sustainable development of transport networks. In the margins of the same thesis, Mesjasz-Lech and Nowicka-Skowron (2013) explain that global development generates territorial accessibility: the existence of economic concentrations due to globalization is an essential condition for the ubiquitous expansion of promotor transport accessibility networks. At the same time, Hae (2013), Warleigh-Lack (2015) and Panke and Stapel (2017) give regional actors the role they play in the development of transport infrastructure; on these basis, they consider it mandatory to include the abovementioned endogenous factors in the series of evaluable parameters in the development of the subsequent policies.

From the point of view of the investments needed to build high-reliability transport systems, Berg *et al.* (2017, p. 477) calculated the costs of accessibility and territorial cohesion. The results of their study have allowed them to assert that the price of globalization decreases with the expansion of transport networks and increased accessibility, which requires adjustment and flexibility of policies in the field of transport infrastructure design.

An important line of current research is devoted to analysing the efficiency of European funds allocation under the Cohesion Policy to expand transport networks. The expansion of transport infrastructure has been assessed by Baun and Marek (2008), Humphreys (2012) and Bueno *et al.* (2015) in terms of predictability, sustainability and investment capacity to produce cohesion. Investigating how much

accessibility and territorial cohesion cost, Lopez *et al.* (2008, p. 277) shows that investments in road infrastructure are more cost-effective for territorial accessibility (bring more cohesion) compared to investments in railways, these differences being due to the conjugation of the effects of various other causal factors (Puga, 1999, p. 303).

At the same time, the efficiency of investments in transport infrastructure is assessed annually by the European Commission (2018) by means of an indicator which shows the ratio between the length of the trans-European core road network and the total length of the road network. The evaluation shows that the most complete investment developments in recent years have been registered in Spain, Portugal, Slovenia and the United Kingdom, and the lowest in Estonia, Lithuania, Poland, Slovakia and Romania (European Commission, 2018, p. 20).

2. Research methods

The objective of our research is to establish a territorial accessibility measurement indicator, which will serve as basis for drawing up a map of accessibility deficits in the EU, deriving from insufficient equipment with transport infrastructures. Based on the map, we will outline the priorities and potential solutions for endowment with transport infrastructures to improve territorial accessibility in the Union. In fact, unlike the mainstream epistemic approaches that favour the factors distance, transport time and transport costs in the evaluation of territorial accessibility (Spiekermann and Neubauer, 2002; Schürmann and Talaat, 2002; Spiekermann and Schürmann, 2007), we aim to express territorial accessibility in relation with the endowment with high quality transport infrastructures (motorways, high-speed railways, inland waterways, major ports and major airports).

The working steps are as follows:

- establishing the criteria for assessing the territorial accessibility and the measurement variables corresponding to each evaluation criterion;
- creating the Territorial Accessibility Index and calculating its values for the 272 NUTS 2 regions of the Union;
- establishing spatial classes with different accessibility characteristics based on their homogeneity and preparation of the accessibility map;
- assessing the impact of TEN-T core-networks corridors on territorial accessibility;
- interpreting the results and substantiating solutions aimed at improving the infrastructure equipment in order to homogenize territorial accessibility in the EU.

2.1. Territorial accessibility: evaluation criteria, measurement variables, data

The territorial units on which the evaluation is based are represented by NUTS 2 regions. We have used three evaluation criteria, with a total of eight quantitative variables (Table 1).

Table 1. Evaluation criteria and measuring variables of territorial accessibility

Evaluation criteria	Measurement variables
Territorial transport infrastructure equipment	Motorway network density (km/ 1,000 km²)
	High-speed railway density (km/ 1,000 km²)
	Inland waterway density (km/ 1,000 km²)
Interregional territorial connection	Interregional connections on motorway (No.)
	Interregional connections on high-speed railway (No.)
	Interregional connections on inland waterway (No.)
High level intermodal connection	Major airports in the TEN-T trans-European network (No.)
	Major ports in the TEN-T trans-European network (No.)

Source: authors' representation

The first assessment criterion is to equip the territory with transport infrastructures and is expressed by three measurement variables: the density of the motorway network, the density of the high-speed rail network and the density of the inland waterway network.

The second criterion considered concerns the degree of territorial interconnection with the boundary spaces of the reference units. The quantitative dimensions associated with this criterion are represented by the following three parameters: the number of connections of each NUTS 2 region with neighbouring regions by motorway, by high-speed railway and by inland waterway.

The third criterion for assessing territorial accessibility is the level of intermodal top-level interconnection of each territorial unit, expressible by two quantitative variables: the number of main ports and major airports in the trans-European TEN-T network established by Regulation (EU) 1315/2013, Annex II, point 2. According to the requirements set by the New Policy of the EU in the field of Transport Infrastructure (European Commission, 2013), these major ports and airports meet or will have to fulfil the role of intermodal mega-hubs by 2030 when the motorways and railways (preferably high-speed railways) will be converting to the trans-European corridors TEN-T, under the conditions provided by art. 41, par. 3 of Regulation (EU) No. 1315/2013.

The data on the densities of motorways, high-speed railways and inland waterways were obtained by reporting the lengths of the respective networks (at the level of the year 2016 according to Eurostat, 2017) to the areas of the territorial units they are equipped with. The data on the number of interregional connections of the territorial units were obtained by identifying them on the thematic maps. Data on the

number of major ports and airports in the trans-European TEN-T network were extracted from Regulation (EU) No. 1315/2013, Annex II, point 2.

2.2. Territorial Accessibility Index (TAI)

The issue of spatial accessibility and centre-periphery relationships in the EU has been addressed in the literature by using indicators based on distances and travel times, such as the centrality and peripherality index (Chatelus and Ulied, 1995; Schürmann and Talaat, 2002), the cost of travel, daily accessibility and potential accessibility (Spiekermann and Neubauer, 2002; Spiekermann and Wegener, 2006). Somewhat more exotic, behaviourist approaches take into account the perceived opportunities in measuring territorial accessibility (Spiekermann and Neubauer, 2002; Spiekermann and Wegener, 2006).

In order to quantify the degree of territorial accessibility in a territorial reference unit depending on the level of equipment with transport infrastructures, we propose a Territorial Accessibility Index (TAI) as a composite indicator based on the eight variables presented above.

The procedure for developing the accessibility index comprises two stages of work. In the first stage, for each of the eight variables, the value of each territorial unit is calculated in relation to the maximum recorded value of the variable in the whole sample of territorial units considered:

$$k_i = x_i / x_u * 100 \quad (1)$$

where: k_i - the expression range value of the x variable in the *i* territorial unit;
x_i - the actual value of the x variable in the *i* territorial unit;
x_u - the maximum value of the x variable from the sample (registered in the *u* territorial unit).

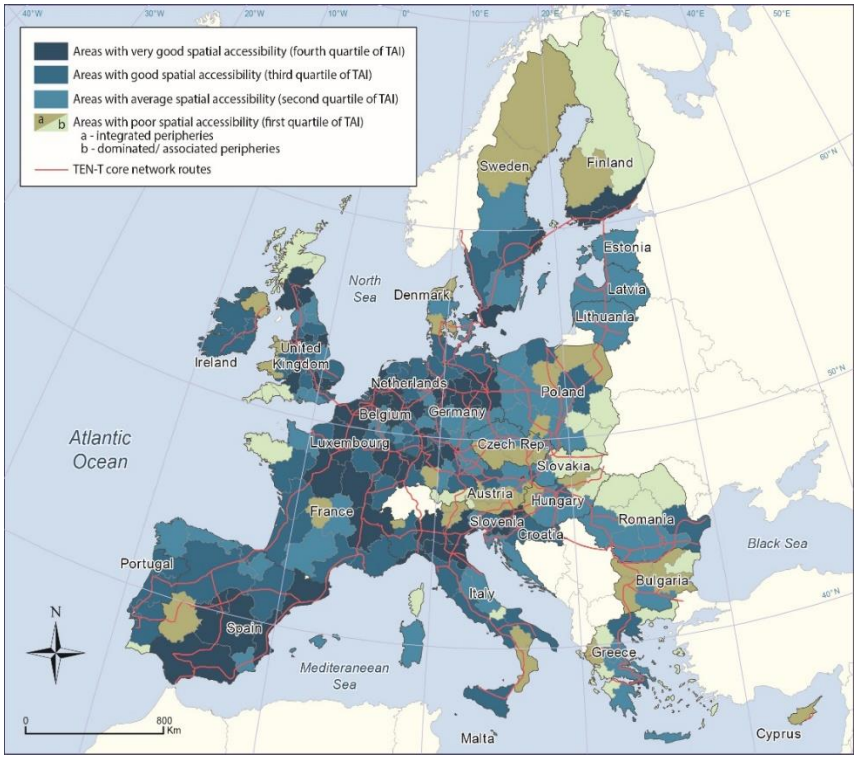
In the second stage, for each territorial unit, the value of TAI is calculated as the arithmetic average of the eight values corresponding to the eight proxy variables used.

The calculated accessibility index is a representative indicator because it synthesizes the contribution of the eight component variables in a non-discriminatory manner as an unmatched arithmetic average, thus avoiding the premeditated preferential allocation of some "weights" different from the component sizes in the quantification of territorial accessibility. For the realistic and coherent territorial accessibility assessment through the proposed index, we used a unitary expression range for each of the eight component variables by reporting their concrete values on a scale from 0 to 100, where 100 corresponds to the maximum value in the series of regions from the EU.

2.3. Drawing the territorial accessibility map

In order to prepare the Territorial Accessibility Map, we used a statistical and mathematical model to prioritize homogeneous spatial classes from the point of view of accessibility. In applying the model, the homogeneity test is based on the calculation of the variance coefficient (V) of the data series representing the TAI values for NUTS 2 regions. Applying this scale-wide working algorithm unifies the spatial classes with homogeneity features from the point of view of territorial accessibility (see Appendix 1). The above-mentioned working procedure reveals a large disparity in homogeneity of territorial accessibility across the Community, which is well emphasized only on the value ranges defined by the quartiles (Figure 1). Conventionally, we include regions with TAI values over the third quartile (Q3) as spaces with central location valences, those located between quarries Q1 and Q3 as intermediate spaces (with good and average accessibility) and regions with values below quartile Q1 define peripheral areas (spaces with poor accessibility).

Figure 1. Territorial accessibility in the European Union by NUTS 2 regions according to the values of Territorial Accessibility Index (TAI)



Source: authors' representation based on Eurostat (2017) and Regulation (EU) No.1315/ 2013

The group of spaces with values of TAI lowers than the first quartile forms a spatial category with poor accessibility but also with poor homogeneity, as evidenced by the high coefficient of variation (66.6%). These are the areas of the Community bloc with the weakest supply of transport networks, responsible for generating the least territorial accessibility. These areas are the most vulnerable spaces to the periphery, where the salvation stake from exclusion is driven by the development of infrastructure connections in order to increase accessibility and functional integration within the Community body. Because it is „the Achilles heel" in the EU space organogram, we will focus our attention on these liminal areas with low accessibility and homogeneity.

In the description of peripheral areas, the literature has operated in the last three to four decades with different conceptual models. In the conditions of post-war bipolar world, Reynaud (1981, p. 220) described integrated peripheries, perimeters associated with core areas, dominated peripheries, semi-isolated peripheries and dead corner peripheries. Under the conditions of current globalization, Scholz (2005, p. 9) identifies global regions (as central areas), globalized regions (spaces of varying degrees of dependence) and new peripherals (marginal neglected spaces).

Given that regions with TAI values under the first quartile make up a very heterogeneous group, as the coefficient of variation (66.6%) shows, we ask ourselves what kind of periphery they are, how vulnerable they are and what solutions could be proposed for their integration. To find out, we propose as an investigation method to divide this group of regions in a way similar to the one we initially did with the entire EU space (see Appendix 2).

The median of the group (2.96) shows a very homogeneous half (16.5% variation coefficient), mostly made up of regions with accessibility above the median value. Most of these spaces lie on the territory of developed countries of the EU, being virtually integrated peripherals near the central areas in the hinterland to which they gravitate. These „inner peripheries" occupy 16.9% of the EU and include regions relatively poorly equipped with transport infrastructures, usually located in other well-served infrastructure areas, either within the same state or on a transnational scale. Thus, the Limousin region (France) is located between the more accessible areas of Poitou-Charentes, Aquitaine and the Central region of France. The Valle d'Aosta region (northwestern Italy) functions as a „peripheral depression" between the more accessible areas of Lombardy (Italy), Rhone-Alpes (France) and the south-western region of Switzerland. The southern Tirol (northeast of Italy) and the western area of Austria together form a „transnational interior depression" located between the areas better served by transport networks and more accessible of Lombardy, Veneto (Italy), Bavaria (Germany) and Upper Austria.

The group of regions with TAI values below median level is heavily heterogeneous (90.9%) and is predominantly composed of Union marginal areas, many isolated or semi-isolated „end of line", even if they appear as dominated or associated peripheries. These dependent peripheries occupy 14.3% of the EU and are

usually located at the territorial extremities of the community space: the regions of northern Scotland, Northern Ireland, West Wales or the Cornwall Peninsula (UK); Bretagne and Corsica (France); Extremadura and the Ceuta and Melilla trans-Mediterranean possessions (Spain); the regions of Molise, Calabria and Basilicata (Italy); the septentrional halves of Finland and Sweden that present themselves as hostile peripheries, despite the very good accessibility of well-equipped southern regions with transport infrastructures and well connected to the outside.

The situation is different in the case of ultra-marginal spaces within national territories, but not in the EU, which are situated on the trans-European corridors and are very accessible. These regions have skilfully transformed the disadvantage of liminality into pragmatic opportunity, by making good use of their peripheral position for good connection with neighbouring spaces which are served by good networks as well. These spaces form very accessible global transnational areas (Scholz, 2005, p. 10), providing the necessary support and facilities for the development of economic and spatial agglomerations. In such a situation, there is the Danish capital area of Copenhagen (Hovedstaden region), which together with the Scania region (southern Sweden) forms a transnational bridge of good accessibility, which exploits the opportunity for straits and good connections with Scandinavia, despite the fact that the other regions of Denmark have at the most an average accessibility, according to the calculated value of TAI.

In Central-Eastern Europe, however, particular situations are encountered where some territorial-eccentric areas have a level of accessibility superior to the national average, but relatively weak at European level. In this position there are areas of the Bohemian quadrilateral and South-Eastern region of Romania, which appear as oases of good accessibility in their national territories, although they are far below the requirements of community-based interconnection. The situation is due to the fact that the regions concerned are better served by regional transport networks compared to the rest of their countries, but at the same time they are insufficiently connected to mainland hubs, despite the good premises given by their exposure to the trans-European routes they benefit from. In a contrary register, Ireland Republic has an unfavourable position in the EU, appearing as a periphery, poorly connected to the rest of Europe, but each of its component regions enjoys the condition of good territorial accessibility. This is due to good internal connections, including the profile of inland waterways, and links with Northern Ireland (UK).

2.4. The correlation between the spatial distribution of TEN-T core network corridors and territorial accessibility

Academic analyses in recent years have highlighted the decisive relationship between the distribution of trans-European corridors, territorial accessibility and regional development (López *et al.*, 2008; Cascetta *et al.*, 2013).

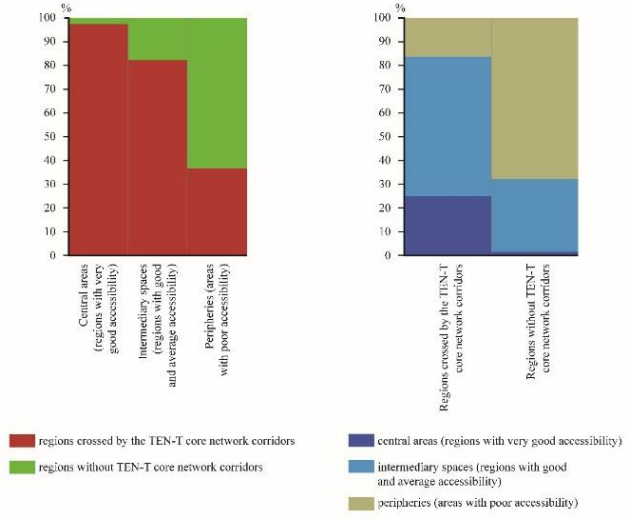
Our assessment of territorial accessibility in relation to the routes of the nine main trans-European corridors reveals significant differences between the accessibility of the spaces served by the central lines of the TEN-T core network compared to the spaces not served by the central corridors. Indeed, comparison of the weights of spaces with different levels of accessibility in relation to the trans-European main corridor routes reveals major discrepancies on the EU map. Practically, the spatial design of the TEN-T core routes (established by Regulation (EU) No. 1315/2013) privileges in a decisive manner the areas with good accessibility at the expense of poorly accessible peripheral areas (Table 2, Figure 2, and point 3.2 of Findings).

Table 2. Territorial accessibility related to the TEN-T core network corridors

Types of spaces depending on territorial accessibility	**Regions crossed by the TEN-T core network corridors** (km²)	**Regions without TEN-T core network corridors** (km²)
Central areas (regions with very good accessibility)	770,318	19,546
Intermediary spaces (regions with good and average accessibility)	1,831,912	393,359
Peripheries (areas with poor accessibility)	502,720	866,408

Source: authors' representation

Figure 2. Territorial accessibility by types of spaces related to the TEN-T core network corridors



Source: authors' representation

3. Findings

3.1. Mapping territorial accessibility in the European Union based on the endowment with transport infrastructures

Mapping the values of TAI reveals a series of spatial differentiations and allows the radiography of the centre-periphery relations in the Union space. There are 11 central areas in the Union, characterized by a very good territorial accessibility given by superior equipment with transport networks, trans-regional and intermodal connections: London Basin, Central England, Central and Southern Scotland, Paris Basin - Nord-Pas-de-Calais, the trans-national area Flanders - the southern part of the Netherlands, the Ruhr region, the central-eastern area of Germany, the Lombardy-Veneto-Emilia-Romagna area, the south-eastern half of Spain, the Scania-Copenhagen transnational area and southern Finland. These very accessible central spaces occupy a reduced part of the EU (18.3%), compared to the part of intermediate spaces (50.5%) and peripheral areas (31.2%), but represent the key element in the configuration of the centre-periphery architecture of the EU (ESPON, 2009, p. 17).

The proportion of nearly one-third of low-access peripheral areas gives the degree of territorial cohesion of the Community as yet far from the proposed desideratum. The vast majority of these peripheral areas overlap with areas with levels of development below the European average, so we can state that the territorial accessibility of transport networks is a valid indicator for the definition of peripheral areas delimited as a second category area of the European space.

3.2. Impact of TEN-T Trans-European Core Network Corridors on territorial accessibility

The results of the comparative analysis between the routes of TEN-T core network corridors and territorial accessibility show that the central areas (with the best territorial accessibility) are the main beneficiaries of the TEN-T central corridor routes: 97.5% of the very accessible regions of the EU (holding 18.3% of the EU surface) and 82.3% of the intermediate ones are crossed by one or several trans-European corridors. At the same time, only 36.7% of the poorly accessible peripheral areas (which hold 31.2% of the EU space) are on the route of a trans-European corridor.

Of the space categories served by the TEN-T core network corridors, 24.8% are central access areas, 59% are intermediate spaces and only 16.2% are peripheral areas. Spaces not covered by the trans-European corridors cover almost exclusively peripheral areas (67.8%) and intermediate areas (30.7%) and only 1.5% central areas. The most illustrative terms indicating intra-community disparities of territorial accessibility quantify the correlation of peripheral areas with the distribution of TEN-

T network corridors: 63.3% of the peripheral areas are not served by the main transport corridors and 67.8% of the areas not crossed by these corridors are peripheral areas. In the case of correlation of central areas with the distribution of TEN-T corridors, the terms are at the diametrically opposed pole: only 2.5% of the very accessible regions are not served by the trans-European main corridors and only 1.5% of the regions not traversed by these corridors are very accessible central spaces.

Therefore, the differences in accessibility within the Union area, as revealed by the mapping of TAI values, derive from differentiated equipped transport infrastructures belonging to different levels of the trans-European network. The endowment of infrastructures pending with central corridor paths makes an overwhelming contribution to the status of good accessibility for underserved spaces, while spatial positioning outside their paths condemns the presumption of territorial exclusion. These results, which are objectively revealed, could be subject to revision, as the effective infrastructure provision of the TEN-T corridors is different and even incomplete and the available data are not assigned to each sector of the trans-European corridors.

3.3. Proposals to reconfigure infrastructure priorities to homogenize territorial accessibility in the EU

According to Regulation (EU) No. 1316/2013, the European Interconnection Mechanism is privileged to allocate resources for the development/ finalization of infrastructure segments along the trans-European main corridors, which, given the affordability gaps, could increase the accessibility otherness and territorial cohesion deficit in the EU. In these terms, the possible solutions for homogenizing territorial accessibility can be identified in three dimensions: conceptual approaches, financial approaches and institutional-administrative approaches.

Reassessing the concept of developing transport networks could become an opportunity to improve territorial accessibility in less-favoured regions (Stead, 2010, pp. 28-29; Bueno *et al*., 2015, p. 623). Thus, the adoption of the concept of synchronous infrastructure arrangements could be a viable solution for the extension of transport networks in areas not found on the trans-European corridors of the TEN-T core network. According to this model of projective synchronicity, building / improving the infrastructure segments of the main corridors should be operated in parallel with the planning of infrastructure development from the rest of the core network and the global network in the regions not covered by the TEN-T core network corridors. This model of work would allow a dynamic balancing of the peripheral accessibility gap and could make it possible to meet the deadline of 31.12.2050 to achieve the cohesion objective, which stipulates that most of the EU citizens and businesses to be within the isochronous limit of 30 minutes to the trans-European global network (European Commission, 2013).

The financial approach aims to provide more generous funding sources for European grants for the construction of transport infrastructure in less accessible areas (Curtis and Scheurer, 2010, p. 54, 98). More consistent funding can catalyse the removal of the stigma liminality of poor accessibility spaces and their sustainable inclusion in the Community's territorial circuit. In this respect, the revision of the thresholds of financial support from the EU could become an unquestionable stimulus. This approach would aim at setting differentiated thresholds, depending on the category of infrastructure and the level of accessibility of the regions they serve. For the transport infrastructure projects executed in regions with poor accessibility, we propose that the maximum thresholds for European funding levels be applied to those applied to telecommunication infrastructures as provided by art. 10, par. (4) of Regulation (EU) No. 1316/2013, respectively 75% of the eligible costs of the works. The provision of the specified threshold for projects in disadvantaged regions in terms of accessibility should supplement the provisions of Regulation (EU) No. 1316/2013, as follows:

- at art. 10, par. (2), letter b, point (i), (ii), (iii), (v), (vi), (vii);
- at art. 10, par. (2), letter c, point (i), (ii), (iii), (iv).

At the same time, in order to open the possibilities for accessing the funds in question, the modification of art. 11, par. (5) of Regulation (EU) No. 1316/2013 and the provisions of Regulation (EU) No. 1303/2013 should be operated, to make all areas with accessibility deficits eligible for funding by exempting the regions concerned from the eligibility condition applicable to the States to which they belong for Cohesion Fund financing, according to Regulation (EU) No. 1303/2013.

The institutional-administrative approaches seek to find solutions to remedy the accessibility deficit by re-conceptualizing the institutional roles of the European fora with attributions in the field of regional development (Heshmati, 2013, p. 35; Berg *et al.*, 2017, p. 477). We are considering assigning executive powers to community institutions, which in this way could bring relevant added value to the expansion of transport infrastructures. In this context, we consider it appropriate to redefine the European fund management powers by sharing the powers to allocate these financial instruments between the European Commission (for the Member States) and the Committee of the Regions (for the level of NUTS 2 regions). Removing the Committee of the Regions from the expectation of its purely consultative dimension would have a constructive and stimulating contribution to the development of the necessary infrastructure at regional level. The confirmation of its attributions on the regional level in a manner similar to that of the European Commission on the level of the Member States would lead to the equalization of the importance and power of the three pillars of the European construction (Community, state and regional level) and in the plan of financial allocations, it would increase the consistency of the regional framework and its potential development. Such an institutional-administrative reconceptualization would have the effect of retaining in the management portfolio of the European Commission only the financial

instruments addressed to the Member States (Cohesion Fund) and those related to the areas covered by the common European policies (the European Agricultural Fund for Rural Development and the European Fund for Fishing and Maritime Affairs). The management and allocation of resources from the European Regional Development Fund would be entirely under the control of the Committee of the Regions and the European Social Fund could be divided between the managerial portfolios of the two European institutions.

At the same time, such a differentiation of the roles structure between the European Commission and the Committee of the Regions would still provide a positive element, namely to place the administrative authorities at the level of NUTS 2 regions at a common standard in all Member States, and on the other hand, would bring funding closer to concrete territorial needs. The most sensitive impact would be on transport networks, which, under the much more interested coordination of regional authorities, could be more easily extended to regions with poor infrastructure and lack of territorial accessibility.

Conclusions

In this paper, we have developed a model of quantitative measurement of territorial accessibility based on the degree of equipment with transport infrastructures in the European Union as well as a set of proposals for the extension of transport networks as a prerequisite for the homogenization of territorial accessibility in the EU.

First, we established the criteria for assessing territorial accessibility and the associated variables that we believe to play a significant role in generating territorial accessibility: the density of motorway networks, high-speed railway and inland waterway, the number of inter-regional connections provided by the three types of networks and the number of main hubs of the trans-European TEN-T core network.

Secondly, we have compiled a comprehensive index for assessing territorial accessibility, based on previously identified variables; the mapping of the values of TAI at the level of NUTS 2 regions allowed us to establish a spatial model of the deficit / optimal accessibility in the EU. Our research shows that intermediate spaces (relatively medium and relatively good accessibility) occupy half of the EU, while very accessible regions with central seat valences hold less than one fifth of the EU. Poorly accessible peripheral areas comprise almost one third of the Community's space, of which almost half are outermost regions with the weakest infrastructural equipment and the lowest territorial accessibility. The relatively high weight and the low level of supply with transport infrastructures define them as second-class European spaces and represent the barometer of the still precarious territorial cohesion of the EU body.

Thirdly, we tested the model designed by interpolating the results of territorial accessibility with the territorial distribution of transport corridors of the trans-

European TEN-T network. This allowed us to highlight the favourable contribution of the routes of the nine trans-European corridors to the configuration of territorial accessibility in the EU. Thus, we found that 97.5% of the very accessible central areas benefit from the central corridor routes, while only 36.7% of the poorly accessible peripheral areas are crossed by the main transport axes. At the same time, the spaces not found on the TEN-T corridors belong to two thirds of the poorly accessible domain and only 1.5% of the central areas. The trans-European main corridors risk becoming the engine of sustainable integration of territorial segregation source, but the assumption may be tenacious, given that the nine TEN-T corridors have different sectors equipped with infrastructures and for which the available data is not unitary.

On the basis of the obtained results, we put forward a set of proposals aimed at developing the transport infrastructure in the poorly equipped areas, as a prerequisite for the homogenization of the territorial accessibility in the EU and improving territorial cohesion. The synoptic of possible solutions comprises three categories of approaches: conceptual, financial and institutional-administrative. Conceptual re-evaluation of the development of transport networks implies a planned synchronization of the development of the infrastructure segments on the trans-European corridor line in the TEN-T core network and the global network as a solution to meet the objective of locating the majority of EU citizens and businesses up to 30 minutes from the trans-European global network by 2050. The financial approach proposes to reconsider the thresholds for financial support from the EU as an incentive element, namely the application of the maximum thresholds identical to those applied for telecommunication infrastructures, i.e. 75% of the eligible costs of the works. We also propose that all areas with accessibility deficits be eligible for funding irrespective of the eligibility condition applicable to the states to which they belong for Cohesion Fund funding. In addition, we think that reconfiguring the management / allocation of financial instruments between the European Commission (for the Member States) and the Committee of the Regions (for NUTS 2 level) would lead to pan-European standardization of regional administrative authorities and catalyse the development of transport networks in the regions poorly equipped and deficient in territorial accessibility.

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Appendix 1. Types of spaces by territorial accessibility in the EU

Benchmark Indicators	Ranges of the Territorial Accessibility Index (TAI)	Spatial categories	Standard deviation (σ)	Mean value (M)	Coefficient of variation (V)
Range of values of TAI	0 - 48.34		9.98	13.55	73.65%
Median value: 12.04	12.04 - 48.34		7.78	21.5	36.18%
	0 - 12.04		3.38	5.6	60.35%
Quartile 3: 19.87	19.88 - 48.34	Spaces with very good territorial accessibility (Central areas)	6.92	27.32	25.32%
	12.05 - 19.87	Spaces with good territorial accessibility	2.27	15.68	14.47%
Quartile 2: 12.04	5.50 - 12.04	Spaces with average territorial accessibility	1.85	8.34	22.18%
Quartile 1: 5.49	0 - 5.49	Spaces with poor territorial accessibility (Peripheries)	1.86	2.79	66.66%

Source: authors' representation using data from Eurostat, 2017 and Regulation (EU) No. 1315/ 2013, Annex 2

Appendix 2. Territorial accessibility of peripheral areas of the EU

Benchmark Indicators	Ranges of the Territorial Accessibility Index (TAI)	Spatial categories	Standard deviation (σ)	Mean value (M)	Coefficient of variation (V)
Range of values of TAI	0 - 5.48		1.86	2.79	66.66%
Median value: 2.96	2.96 - 5.48	Integrated peripheries	0.72	4.35	16.5%
	0 - 2.95	Dominated/associated peripheries	1.00	1.1	90.9%

Source: authors' representation using data from Eurostat, 2017 and Regulation (EU) No. 1315/ 2013, Annex 2