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Accessibility and connectivity – Movement between cities, as a critical factor to achieve success on cross-border cooperation (CBC) projects. A European analysis

Rui Alexandre Castanho[a,*], Ana Vulevic[b], José Cabezas Fernández[a], Luis Fernández-Pozo[a], José Manuel Naranjo Gómez[d], Luís Carlos Loures[c]

[a] Environmental Resources Analysis Research Group (ARAM), University of Extremadura, Badajoz, Spain
[b] Institute of Transportation – CIP, Department of Architecture and Urban planning, Belgrade, Serbia
[c] Polytechnic Institute of Portalegre (IPP), Portugal and Research Centre for Spatial and Organizational Dynamics (CIEO), University of Algarve, Portugal
[d] Polytechnic School, University of Extremadura, Caceres, Spain

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ABSTRACT

Nowadays, cross-border cooperation (CBC) is an undeniable reality in the space encompassed between European borders. This contributes to economical and social sustainable development, as well as to cohesion for trans boundary areas, which include administrative and territorial units from neighboring countries.

A correct conceptual basis for the methodological approach to connectivity lies in the fact that the development of transportation systems, as integrated networks at different scales, is deeply changing their operation and the way they induce urban and regional development patterns. Overloaded transport corridors in the context of changing transportation flows are becoming an important issue for accessibility, impacting CBC indirectly, but harshly.

Different modes of transport create different patterns of accessibility, with different influence in CBC accordingly. Throughout the present research, CBC European case studies, where connectivity-movement between cities, has been identified as a key factor for their territorial success, were assessed, described and analyzed.

In the period of 2001–2006, improvements and further imbalances have occurred in accessibility development across regions and modes. Some signs indicate that the core-periphery pattern is slowly changing which leads towards an upgrade on the accessibility of places, regions and cities.

1. Introduction

CBC Projects and Strategies are seen as pivotal for the territorial cohesion, not only in Europe, but also all over the World (Task Force on the United States-Mexico Border, 2009; Lee and Na, 2010; Fadigas, 2010; Fadigas, 2015; Batista, Cabezas, Fernández, & Pinto-Gomes, 2013; Castanho, Loures, Cabezas, & Fernández-Pozo, 2017).

Conversely, the European Project, given the recent developments, as example the deviation of United Kingdom from EU (Brexit), among many others events that occurred within the EU in the last few years, shows the gaps that still exist on this process (Holmes, 2016; Dale, 2016).

However, many CBC Projects, between EU boundaries, also demonstrate an example of the success of cross-border cooperation (LISER, 2015). Based on newer studies and researches (see: Castanho, Loures, Fernández, & Pozo, 2016; Nicolini & Pinto, 2013; Vulevic, 2013; Vulevic & Dordevic, 2014; Boehnke, Rippl, & Fuss, 2015; Domínguez, Noronha Vaz, & Vaz, 2015; Castro & Varela Alvarez, 2015; Kurowska-Pysz, 2016; among many others), critical factors for territorial success have already been identified. One of the most significant factors, according to researchers, planners, and decision makers, regarding CBC Projects is the promotion of connectivity and accessibility-movement between cities.

Due to the relevance of this specific factor, the present research, through the analysis of European CBC Projects, aims, on a more thoroughly way, to define how accessibility and connectivity influences their success.

According to ESPON (2009): “Accessibility plays a significant role in European policy discussions related to the development of regions and cities as well as the European territory as such. In several European

* Corresponding author.
E-mail address: alexdiazbrown@gmail.com (R.A. Castanho).

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policy documents over the last decade, latest in the European Commission Green Paper on Territorial Cohesion and in the Territorial Agenda of the EU involving all EU Member States, accessibility is seen as a key factor in improving the territorial balance in Europe and the attractiveness of the Members States, their regions, and cities. The newest European facts and evidence on trends in accessibility presented are providing an update on European accessibility patterns for the information of policy makers in regions and cities as well as on national and European level."

Based on the above-mentioned report put forward by ESPON (2009) It leads that: "to be able to support Europe playing a significant economic role in the World, European accessibility will have to satisfy a greater demand for transport of goods and people from European regions and cities".

Ever since CBC projects started growing, infrastructures and transportation were pivotal for CBC project success. Good accessibility and connectivity are critical preconditions to foster competitiveness on a European and global scale. Adequate internal and external paths, as a territorial indicator of transportation infrastructures, can strengthen the economical cohesion in a CBC area (Brown et al., 2010; Pain, 2010; Pain, 2011; Van Hamme & Pion 2012).

To analyze the potential of the previous and actual accessibility indicators on European case studies, regarding their accessibility and connectivity on CBC areas, the paper will evaluate, assess and compare the accessibility and connectivity levels of those areas.

The study also aims to formulate hypotheses for answering questions, such as:

- Which trends in regional accessibility have been the most important over the last decade in European analysis?
- Which regions in those CBC projects are in a most favorable position related to accessibility and regarding the different modes of transportation?

2. Accessibility, similar CBC projects and strategies

There are several definitions and concepts for accessibility. The concept was born in 1950 and is very useful in different fields (e.g., transport planning, urban and regional planning) and has acquired a variety of meanings over the years. Therefore, there is no single approved definition, and it may be argued that accessibility is an elusive concept, one of those common terms that everyone uses until the problem of its definition and measurement arises (Gould, 1969). However, all definitions of accessibility seek to give a measure of the separation of human activities or settlements that are connected through a transport system (Sherman, Barber, & Kondo, 1974). For this reason, the most used definition is: "accessibility indicators describe the location of an area with respect to opportunities, activities or assets existing in other areas and in the area itself, where 'area' may be a region, a city or a corridor" Biehl, (1991).

Accessibility measures become indicators through the use of mathematical terms. Accessibility indicators can differ in complexity. Their mathematical formulation is variable; therefore, their classification carried out by different authors is extensive (Morris, Dumble, & Wigan, 1979; Wegener, Schürmann, & Spiekermann, 2000; Baradaran & Ramjerdi, 2001; Geurs and Ritsema, 2001; Curtis & Scheurer, 2010). Moreover, in transport infrastructure planning, the analysis of territorial cohesion through these indicators is a recurrent theme in the research (Mérenne-Schoumaker, 2008; Bellet, Alonso Logroño, & Casellas, 2010) because it explains the interrelationships among human activities (Brocard, 2009). These indicators always include in their formulation a spatial impedance term that describes the ease of reaching other destinations. Accordingly, accessibility plays an important role in the European Observation Network, Territorial Development and Cohesion (ESPON, 2006)[i], which provides a wide range of indicators that describe the transportation system and their spatial implications and indicators accessibility.

The European regional policy has been directed towards the different regions' territorial cohesion since the Treaty of Maastricht in 1992, and for this purpose, it is essential that the socioeconomic structures of the different spaces benefit from the development of the new infrastructures. The adopted transport policies pay particular attention to territorial cohesion through different models of use and development (Frank et al., 2014; Martí-Henneberg, 2013).

Over the last decades, a growing number of accessibility models, studies and projects addressing Europe-wide accessibility have been developed, such as: ESPON TRACC; ESPON Transport Services and Networks; ESPON Territorial Impacts of EU Transport and TEN Policies; ULISSES; OTALEX-C; among many other projects. As well a large amount of researches and studies about transport accessibility have been produced (Bruinsma & Rietveld, 1998; Schürman, Spiekermann & Wegener 1997; Gutiérrez, 2001; López, Gutiérrez & Gómez, 2008; Chi, 2012; van den Heuvel et al., 2014; Palmateer, Owen, & Levinson, 2016; Castanho, Loures, Cabezas, & Fernández-Pozo, 2017; among many others). Accessibility indicators are used by planners to assess spatial effects of their proposals, and to identify the areas requiring actions to ensure minimum conditions for service. They are also used in the decision making procedure of new infrastructure projects or improvement of the existing infrastructure. Improvements in the accessibility of regions and places, currently underperforming, may provide cohesion and support to achieve a better balanced territory on a regional, national and/or European scale. Those improvements should also help to release potential territories, which are currently underused, aiming to benefit the European competitiveness. In this regard, the latest trends in European potential accessibility become important for policy makers at the area (ESPON Trends in Accessibility, 2013). It is assumed that regional accessibility is related with economic and social opportunities (Naranjo, 2016).

According to the Organization for economic cooperation and development (OCDE) report 1998–2000, two ways are critical to classify regions by their location in Europe, by their accessibility:

- Rank them by a decreasing accessibility order and define a suitable number of classes, from central (i.e. high accessible) to remote – central-peripheral dichotomy.
- Take their economic performance into account. Economic experts suggest that regions that have better access to raw materials, suppliers and markets are *ceteris paribus* – economically more successful than regions in remote/peripheral locations. As transport infrastructure is an important policy tool to promote regional economic development, it is highly policy-relevant to know which regions have been able to take advantage of their location and which regions have not (Vulevic, 2016). According to OCDE, generally the more accessible regions are also the most economically successful.

Back in 2006, ESPON has developed a study that compares the potential multimodal accessibility of regions with the GDP *per capita,* aiming to mapping those results.

Based on empirical and modelling analyses put forward by ESPON TRACC and previous ESPON projects, the impacts of changes in accessibility, competitiveness, cohesion and sustainability, leads to an increase on accessibility is a precondition for economic development (Gutiérrez, Naranjo, Jaraíz, & Ruiz, 2015). The accessibility modelling for the seven TRACC TRansport ACCessibility at regional/local scale and patterns in Europe case study regions selected: West Mediterranean in Spain and France, Northern Italy, Bavaria in Germany, Czech Republic, Poland, Baltic States and Finland; in ESPON TRACC was done with a rather strict definition of the accessibility indicators and a subsequent research program.

ULYSSES (Using applied research results from ESPON as a yardstick for cross-border spatial development planning) is an experimental and

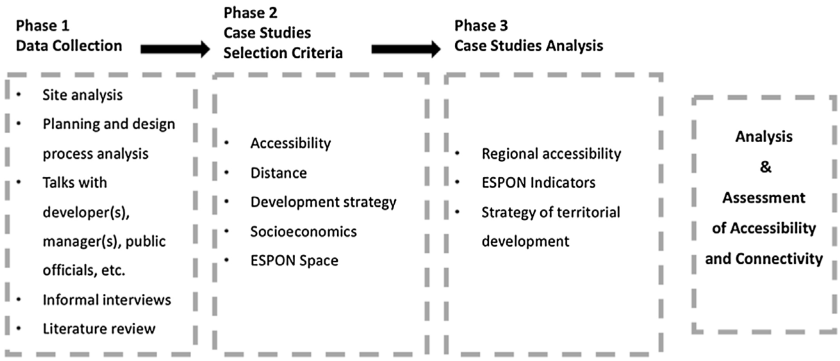


Fig. 1. Methodological approach.

innovative project supported by 18 European CBC areas, which applied results from ESPON as a yardstick for decentralized cross-border development planning.

A territorial profile refers to indicators of the five major ESPON themes: polycentric development; urban-rural relationship; accessibility, connectivity and demography. The territorial performance refers to their potential to achieve Lisbon/EU 2020 and Gothenburg strategy goals. The indicators of each CBC area were compared on different scales, (NUTS3 – NUTS2; cross-border areas and countries), through a reference index that can be established by the EU27 average (leading region in the EU27 they belong). The basic indicator used in ULYSSES for the accessibility analysis is the Potential Accessibility Index for road, rail or air, determined by two functions: (i) representing the activities or opportunities to be achieved; (ii) representing the effort, time, distance or cost needed to achieve them. OTALEX-C Project, between Portugal and Spain also uses a specific method to assess accessibility and infrastructures within EuroACE Space (Batista et al., 2013; Martín, 2013; OTALEX-C, 2013; Castanho, Cabezas, & Pozo, 2016). Accessibility and connectivity analysis was performed aiming to determine the general accessibility levels in CBC Projects.

The accessibility trends for transport by air, road and rail have been analyzed independently to show differences between transportation modes. Moreover, these findings have been combined into one indicator showing the multimodal potential accessibility of places by analyzing the joint effect of the three transport modes (Trends in Accessibility, 2013). Multimodal accessibility of regions can be used through study relationships between accessibility and economic development, also between accessibility and migration (policy documents related to the EU territory). Such as in ESPON Transport Services and Networks, each of the different accessibility type of indicators have been calculated and presented for the European territory. The accessibility model, based on the method put forward by Schürman et al. (1997), uses centroids of NUTS-3 regions as origins and destinations. That model calculates the minimum paths for the road network, i.e. minimum travel times between the centroids of the NUTS-3 regions. For each NUTS-3 region, the value of the potential accessibility indicator is calculated by summing the population in all other regions including those outside the ESPON space weighted by their travel time. Accessibility indicators are in non-familiar units, which leads to the need to standardized accessibility to the average of ESPON Space (Vulevic, 2016).

When transport systems are deficient in terms of capacity or reliability, they can have an economic cost such as reduced or missed opportunities, as well it reflects on the lifés standards (Rodrigue Comtois & Slack, 2013). Nevertheless, the accessibility measures in border regions trough European countries seem to be much lower than internal accessibility measures. New linkages for trans- boundary mobility and shortened travel times in many cases will create a functional CBC Strategy, where only limited interactions have existed so far. Connectivity as an accessibility indicator is especially useful for strategic, supply-oriented and long-term studies focused on exploring the spatial implications of transport infrastructures. The basis to a correct connectivity methodology lies in the fact that the development of transportation systems as integrated networks at different scales is deeply changing their operation and the way they induce urban and regional development patterns. Increasingly overloaded transport corridors in the context of changing transportation flows are becoming pivotal for accessibility. Accessibility and connectivity are seen as crucial preconditions to foster competitiveness on a European and global scale. (Kotavaara, Antikainen, & Rusanen, 2011a; Kotavaara, Antikainen, & Rusanen, 2011b; Salonen et al., 2012). Good internal and external accessibility, as territorial indicator of transport infrastructure, can help strengthen the economic cohesion in CBC areas.

3. Methodological approach

Considering the purpose of the present research, the researchers given a significant amount of time and attention to the development of the methodological framework (Fig. 1). The methodology was divided into three main phases, ending with the analysis and assessment of accessibility and connectivity on cross-border cooperation. The phases are: data collection; case studies selection criteria; case studies analysis, which might be schematized as follows:

3.1. Data collection

The collected data have been obtained from previous analysis of the sites, by analysing the process of planning and design of each case study, and even by talks and informal interviews with technicians, experts and main actors of the CBC process.

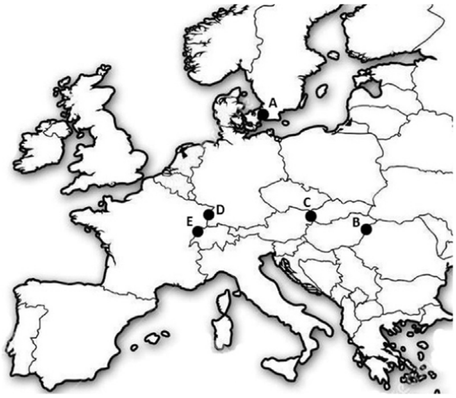
Aiming to cover a wide range of issues, the developed literature, such as the state-of-the-art, regarding accessibility, CBC projects and the main processes and legal schemes that frame the way border cities compete and cooperate.

3.2. Case studies selection criteria

As mentioned before, and based on a previous studies put forward by Castanho et al. (2016), Castanho et al. (2017), 5 European CBC case studies were selected. All of them already identified connectivity – movement between cities as a critical factor for their success, when analyzed and assessed (Fig. 2).

Besides, the aforementioned pre-established criteria, the selected CBC Projects should also meet five specific principles:

- Cities must be identified with the critical factor for their territorial success: connectivity-movement between cities.
- The distance between cities could not be greater than 60 km.
- Cities must have done previous work on CBC.
- A major socioeconomic flow may exist.
- The cities must be into ESPON Space.



(A) Copenhagen - Malmö; (B) Oradea - Debrecen; (C) Vienna - Bratislava; (D) Strasbourg - Khel; (E) Saint Louis - Basel;

Fig. 2. Selected case studies.

3.2.1. Data analysis

Regarding the analysis developed for each of the selected case studies, several sources of data were used and analysed in order to deeply understand not only the actual situation of accessibility and connectivity within EU, but also to identify how that factor may influence the performance of CBC Projects and Strategies, which results are summarized at Table 1.

ESPON potential accessibility Indicators by road; rail; air; multimodal; urban connectivity; access to high-level passenger transport infrastructure ICON had been studied and analysed (Table 2) (Schürman et al., 1997; Wegener et al., 2000; Spiekermann & Neubauer, 2002; ESPON 1.2.1, 2005).

We are using applied research results from ESPON data and ESPON Targeted and Applied Analysis.

For measuring accessibility the most important indicator that was used was the potential accessibility by different modes of transportation that has been developed by the ESPON 1.2.1. This indicator has further been updated in 2006 and re-calculated for fitting the then ruling NUTS 3 delimitation retroactively for 2001 and is therefore available for two different and comparable years. This is particularly useful as this indicator does not limit itself to measuring the transport network, but synthesizes the overall accessibility of the regions by relating the travel time (impendence function) with the population that can be reached (activity function).

Taken all the above-mentioned network improvements into account, the potential accessibility indicators for 2011 cannot be directly compared to the potential accessibility indicators currently in the ESPON database.; while the overall spatial patterns remained the same, the exact numbers between the old 2001, 2006 indicators and the newly calculated 2011 indicators may differ to a small degree because that is applied analyses for two different ESPON project: ESPON 1.2.1 and TRACC. All indicator values are expressed as index, i.e. related to the ESPON average.

"The ESPON project TRACC (**TR**ansport **ACC**essibility at regional/local scale and patterns in Europe) aimed at taking up and updating the results of previous studies on accessibility at the European scale, to extend the range of accessibility indicators by further indicators responding to new policy questions, to extend the spatial resolution of accessibility indicators and to explore the likely impacts of policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change." Because that we cant compare this indicators with ESPON 1.2.1 potencial accessibility indicators for 2001 and 2006. years. We are using TRACC indicators (for 2011 years): Potential Accessibility Travel Indicators and Conectivity indicators. Data is not readily available at the ESPON database for later years.

3.3. Indicators description

Potential accessibility is one of the most common and most extensively tested accessibility indicators (for reviews see Schürman et al., 1997; Wegener et al., 2000; Spiekermann and Neubauer, 2002; ESPON 1.2.1, 2005). Potential accessibility indicators by mode have been proposed by the Working Group "Geographical Position" of the Study Programme on European Spatial Planning (SPESP) as reference indicator concept (Wegener et al., 2000) and have been further developed and widely used in ESPON 2006, and later.

Table 1
Summary of the analysed topics on each case study.

Case study	Population	Distance between cities (Km)	Strategy of territorial development	Border typology	Languages	Currency	GDP/*capita* (million euros)
Copenhagen	569 500	30	Øresund Regional Development Strategy	Schengen Area	Danish, Swedish	DDK SEK	36 600
Mälmo	315 000						27 100
Oradea	200 000	60	Euroregion Hajdú-Bihar-Bihor	No Schengen Area	Romanian, Hungarian	RON HUF	10 100
Debrecen	205 500						12 500
Vienna	1 740 000	55	Centrope Strategy 2013	Schengen Area	Austrian, German, Slovakian	EUR	337 161
Bratislava	415 500						78 070
Strasburg Kehl	275 000 34 000	5	Cross-Border White Paper	Schengen Area	French, German	EUR	27 300 33 100
Saint Louis	20 000	4	IBA Basel 2020	Schengen Area	French	EUR CHF	25 600
Basel	174 000						87 000

Table 2
Indicators used[1] in the study.

Indicators	Geographical scale	Source	Time frame
ESPON Project 1.2.1. Transports services and networks: territorial trends and basic supply of infrastructure for territorial cohesion. Update 2006.			
Potential accessibility by road, rail, air, multimodal/Absolute level, standardized (ESPON = 100)	NUTS3	ESPON Data base	2001;2006
ESPON Project TRACC. TRansport ACCessibility at regional/local scale and patterns in Europe.2013.			
Potential accessibility Travel Indicators TRACC by road, rail, air, multimodal/Absolute level, standardized (ESPON = 100)	NUTS3	ESPON Data base	2011
Urban Connectivity	NUTS3	ESPON Data base	2011
Access to high-level passenger transport infrastructure ICON	NUTS3	ESPON Data base	2012

Potential accessibility is based on the assumption that the attraction of a destination increases with size, and declines with distance, travel time or cost. This concept is known as decay distance. According to (Rosik et al., 2015), there is a number of distance decay functions specified in the literature (Geurs and Ritsema, 2001; Reggiani et al., 2011). Nonetheless, a value of this parameter can be calculated based on the assumption the half-time value of destination attractiveness should be acquired at a median travel time typical for a specific travel purpose (Spiekermann et al., 2013). Destination size is usually represented by population or economic indicators such as GDP or income. Accessibility to population is seen as an indicator for the size of market areas for suppliers of goods and services; accessibility to GDP as an indicator of the size of market areas for suppliers of high-level business services. Potential accessibility is founded on sound behavioral principles but contains parameters that need to be calibrated and their values cannot be expressed in familiar units (ESPON 1.2.1).

Potential accessibility is a construct of two functions, the *activity function*

representing the activities or opportunities to be reached and the *impedance function* representing the effort, time, distance or cost needed to reach them (Wegener et al., 2000). For potential accessibility the two functions are combined multiplicatively, i.e. are weights to each other and both are necessary elements of accessibility:

$$A_i = \sum_i^{W_j^a} \exp(-\beta c_{ij})$$

where *Ai* is the accessibility of area *i*, *Wj* is the activity *W* to be reached in area *j*, and *cij* is the generalized cost of reaching area *j* from area *i*. *Ai* is the total of the activities reachable at *j* weighted by the ease of getting from *i* to *j*. The interpretation is that the greater the number of attractive destinations in areas *j* is and the more accessible areas *j* are from area *i*, the greater is the accessibility of area *i*. Occasionally, but not in this study, the attraction term *Wj* is weighted by an exponent α greater than one to take account of agglomeration effects. The impedance function is nonlinear. Generally a negative exponential function is

used in which a large parameter β indicates that nearby destinations are given greater weight than remote ones.

The accessibility model used (based on Spiekermann and Wegener, 1996; ESPON 1.2.1, 2005) uses centroids of NUTS-3 regions as origins and destinations. The accessibility model calculates the minimum paths through the networks, i.e. minimum travel times between the centroids of the NUTS-3 regions. For each NUTS-3 region the value of the potential accessibility indicator is calculated by summing up the population in all other European regions, including those outside ESPON space, weighted by the travel time to go there. For this weighting, the parameter β has been set to 0.005. That means that assuming a travel time between two regions of zero minutes (which does not occur in reality), the population of the destination region would be included with its full value in the potential accessibility of the origin region, while for a travel time of little more than two hours the weight is 0.5, and for a travel time of little more than five hours the weight goes down to 0.2 only.

Potential accessibility was calculated for road, rail, air and multimodal for the year 2006. Because the interest is in changes of accessibility during the past five years, the indicator values for the year 2001 were recalculated in order to match he improved database (ESPON 1.2.1.).

Multimodal Potential Accessibility – the previously described findings were combined into one indicator showing the multimodal potential accessibility of places by analyzing the joint effect of the three transport modes. The multimodal accessibility of regions may further be used for investigating relationships between accessibility and economic development and between accessibility and migration, issues that are particular in focus in policy documents related to the European territory (ESPON 1.2.1.).

Potential Accessibility Travel Indicators by road, by rail, by air, multimodal, intermodal reflect the situation in the year 2011. The data provide results of an accessibility model on potential accessibility of European NUTS-3 regions. Five potential accessibility indicators are included: by road, by rail, by air, multimodal, intermodal. Unit of measure – Index. For each NUTS-3 region the population in all destination regions is weighted by the travel time to go there. The weighted population is summed up to the indicator value for the accessibility potential of the origin region. All indicator values are expressed as index, i.e. related to the ESPON average. Multimodal accessibility is an aggregation of road, rail and air accessibility.

Connectivity indicators:

1. Urban connectivity/Availability of urban functions by road, rail (Number of cities of more than 50,000 inhabitants that can be reached within 60 min road, rail travel time). These numbers were calculated at raster level with a cell size of 2.5 × 2.5 km for entire Europe. Grid values were then aggregated to NUTS-3 level as weighted average, weighted by population.
2. Access to high-level passenger transport infrastructure (ICON indicator, defined as relative connectivity to available transport network). This indicator reports connectivity of territorial units (raster cells) to passenger transport networks. Connectivity is defined as an average access time to transport networks, all modes within reach included. Destination points are motorway getaways, rail stations and airports; access time is based on travel time by road; following the ICON approach, times to different networks and transport terminals are aggregated and averaged considering their relative utility (within a transport network, all access points within reach are considered).

Connectivity indicators:

1. Urban connectivity/Availability of urban functions by road, rail (Number of cities of more than 50,000 inhabitants that can be reached within 60 min road, rail travel time). Model output. How many cities of more than 50,000 inhabitants can be reached within 60 min' rail travel time. Initially, these numbers were calculated at raster level with a cell size of 2.5 × 2.5 km for entire Europe. Grid values were then aggregated to NUTS-3 level as weighted average, weighted by population.

[1] Used accessibility indicators are in non-familiar units they are standardized to the average accessibility of the European Union with 27 member states, i.e. the absolute values are transformed so that the European average is 100.

2. ccess to high-level passenger transport infrastructure. ICON indicator, defined as relative connectivity to available transport network.

ICON indicator, defined as relative connectivity to available transport network. This indicator reports connectivity of territorial units (raster cells) to passenger transport networks. Connectivity is defined as an average access time to transport networks, all modes within reach included. Destination points are motorway getaways, rail stations and airports; access time is based on travel time by road; following the ICON approach, times to different networks and transport terminals are aggregated and averaged considering their relative utility (within a transport network, all access points within reach are considered).

ICONi is calculated as the addition of the minimum access time by road to the closest connection node in the network plus an additional time which encapsulates a measure of the deficit of utility (in relation to a pre-defined quality level) not obtained from all available alternatives: this additional time can be called "generalized waiting time" (ESPON TRACC). According to this formulation, for any point (any location in Europe), ICON provides the measure of its connectivity to the transportation networks, basically considering the relative economic weight of each mode and the minimum time (or cost) required to reach the closest node in each network increased by the additional generalized waiting times in each node to get a pre-determined utility.

The minimum value of ICONi in a point should be the access time to reach by road the closest transportation node in the network, and the maximum value of ICONi should be, by definition, the minimum access time necessary to reach by road the closest node of the network with a service provision above a pre-determined quality level.

Travel time based on time from raster cells to transport network getaways.

Indicator computed over a road graph for all Europe with transport terminals included.

Access times calculated on a shortest cost path, taking into account different speeds for different road links in a European graph (TRANS-TOOLS road graph, with transport terminals included).

- Motorway entrances are defined as intersections between motorways and other roads.
- Rail stations from EIB IGIS database
- Airports from TRANS-TOOLS air network

Relative utilities

- Motorway utilities based on motorway speed and traffic (TRANS-TOOLS)
- Rail utilities based on rail speed and services available (TRANS-TOOLS)
- Airport utilities based on airport traffic (anna.aero database)

Indicator calculated at raster level: Raster cells 5 × 5 km

Indicator calculated at NUTS3 level: population average from raster cells

For further reference on this indicator, see: www.mcrit.com/IGIS/ICON.htm

4. Results and discussions

The results and consequently discussions, listed below are provided by the indicators analysis applied to the case studies.

4.1. Accessibility indicators

Potential Accessibility Indicators. The data provide results of an accessibility model on potential accessibility of European NUTS-3 regions. Five potential accessibility indicators are included: by road, by rail, by air, multimodal. For each NUTS-3 region the population in all destination regions is weighted by the travel time to go there. The weighted population is summed up to the indicator value for the accessibility potential of the origin region. All indicator values are expressed as index, i.e. related to the ESPON average. Multimodal accessibility is an aggregation of road, rail and air accessibility (ESPON 1.2.1, ESPON TRACC).

*Absolute level of accessibility **(i)**/Potential accessibility by road, standardized (ESPON = 100)2001, 2006/(relative change of accessibility)/(average relative change of accessibility) * 100/percentage of ESPON average.* Because the accessibility indicators are in non-familiar units they are standardised to the average accessibility of the European Union with 27 member states, i.e. the absolute values are transformed so that the European average is 100. By presenting the absolute values as such indices, it can be seen which regions are in a better or a worse position than the European average.

*Index change of accessibility **(i_ch)**/Potential accessibility by road, change of standardized (stand percentage of ESPON average/(standardized value average = 100 in 2006 – standardized value average = 100 in 2001).* The tables shows the change of the index values of potential accessibility between 2001 and 2006. For this, the accessibility values of 2001 are standardised to the EU27 average of that year and those of 2006 to the average of that year, each EU27 average is set to 100 and the regional values are transformed accordingly. The tables then shows the differences of the index values, i.e. the change of the position of the regions relative to other regions. Positive values express an improvement of the relative locational quality, while negative values express a loss in relative locational quality.

Regarding the results by the analyzes of indicators by road (Table 3), Vienna – Bratislava (AT130, SK010) and Saint Louis – Basel (FR421, CH032) appeared with a significantly higher cross border differences than that of the another three cases studies. Results also show that the potential accessibility by road for Saint Louis – Basel (FR422, DE134), Strasbourg – Khel (FR421, DE 134) and Vienna-Bratislava (AT130, SK010) appeared significantly higher than that in NUTS3 regions as Copenhagen-Malmö (DK012, SE224) and Oradea – Debrecen. In this regard, regions as: FR421; FR422; DE134; CH032; AT130; SK010, demonstrate higher potential accessibility by road (index), while: DK012; SE224; RO111; HU321, depict the lower values. A Clear growth of potential accessibility by road due to completed road infrastructure projects can be seen in RO111 and HU321. Values of potential accessibility index over the period 2001–2006 in Bratislava increases (from 110.9 to 112.9) due to infrastructure upgrading in where the combination of some infrastructure projects in the context of the EU enlargement has positive effects.

Within the period 2001–2006, the medium positive index change has been identified in: SKO10, RO111, and HU321 regions.

HU321 has improved positions by more than two index points, while zero or even slight negative standardized index can be found in: DK012; SE224; FR421; FR422 and CH032. All those regions, the combination of "good road infrastructure" in form of dense motorways and high concentration of population lead to their favorable positions. Accessibility by road decreases towards regions located outside the core.

Analyzing the results of the potential accessibility by rail (Table 4), Vienna and Bratislava show significantly higher cross border differences than the other four case studies. The average for potential accessibility by rail of: FR421; FR422; DE134; and CH032, presents higher values than: AT130; DK012; SE224; RO111; and HU321. However, the potential accessibility for Vienna (AT130) and Khel (DE134), shows a significant improvement over time, compared to the other NUTS3 studied. Regarding the temporal change during 2001–2006 period Vienna and Khel demonstrate a higher index-change while Copenhagen, Debrecen and Oradea, shows a slightly negative near to zero change group. The remaining case study with a negative index-change behavior was Saint Louis – Basel.

Regarding the results provided by the analyses of the average

Table 3
Analyzed indicators potential accessibility by road.

Case study	GEOTIME	NUTS3*	Potential accessibility by road			
			R_i 2001	R_i 2006	R_i_ch2001/2006	R_i 2011
Vienna	AT	AT130	124.4	124.7	0.3	118.2
Bratislava	SK	SK010	110.9	112.9	2.1	109.1
Copenhagen	DK	DK012	51.4	51.2	−0.2	46.1
Malmö	SE	SE224	48.3	48.7	−0.2	44.6
Oradea	RO	RO111	37.4	39.1	1.7	37.5
Debrecen	HU	HU321	50.8	53.5	2.7	49.2
Strasbourg	FR	FR421	197.1	192.1	−5.0	184.9
Khel	DE	DE134	195.7	190.6	−5.1	188.3
Saint Louis	FR	FR422	170.7	167.6	−3.1	162.3
Basel	CH	CH032	166.9	166.2	−0.7	166.0

*AT130–Wien; SK010 – Bratislavský kraj; DK012 – Københavns omegn; SE224 – Skåne län; RO111 – Bihor; HU321 – Hajdú-Bihar; FR421 – Bas-Rhin; DE134 – Ortenaukreis; FR422 – Haut-Rhin; CH032 – Basel-Landschaft.

potential accessibility by air (Table 5), Vienna, Bratislava, Copenhagen, Saint Louis, and Khel demonstrate higher values than Oradea and Debrecen. Moreover, the potential accessibility by air of Bratislava shows a significant improvement. In Vienna-Bratislava, the potential accessibility index by air over the period 2001–2006, has the highest score, but with significant differences between them; the same scenario can be found in Copenhagen – Malmo depict the medium negative values of index, and also have slightly differences between them. The region CH032 shows the highest negative index change (−9.4). Those values are even worst when compared with the neighborhood region FR422. Oradea- Debrecen, shows a positive tendency.

The results related to the multimodal potential accessibility can be seen at Table 6. The higher value can found in Oradea – Debrecen. In this regard, an improvement as been identified in Bratislava (SK010) since 2006; contrasting to that of Basel (CH032), Saint Louis(FR422), Copenhagen (DK012), and Malmö (SE224). A positive index change, has only found at: SK010, AT130, RO111, and HU321 NUTS3. With an opposite behavior, due to high negative change air accessibility are: CH032, SE224, and DK012.

Potential accessibility indicators of ESPON TRACC (2013), reflects the situation in 2011. The data provide results of an accessibility model on potential accessibility of European NUTS-3 regions. Five potential accessibility indicators are included: by road, by rail, by air, multimodal, intermodal. Unit of measure −Index for each NUTS-3 region the population in all destination regions is weighted by the travel time. The weighted population is summed up to the indicator value for the accessibility potential of the origin region. All indicator values are expressed as index, i.e. related to the ESPON average. Multimodal accessibility is an aggregation of road, rail and air accessibility. Results showed that the potential accessibility by multimodal for: Saint Louis – Basel, Strasbourg – Khel, Vienna – Bratislava and Copenhagen – Malmö are appeared significantly higher than Oradea – Debrecen, because their international airports improve their accessibility. A growth of potential accessibility by road due to completed road infrastructure projects and the reduction of border waiting times can be seen in several regions.

4.2. Connectivity

By analyzing travel time indicators (Table 7), it can be seen that an amount of urban functions is easily reached from any point in Europe in reasonable travel time in a regional context, through road and rail. Results clearly highlight Oradea has a region that does not have access to urban functions in reasonable time – even one urban center can be reached within 60 min' travel time, for both road and rail. High score of this indicators connectivity showed Basel region (CH032), in the case study Saint Louis – Basel, and these locations offer options to visit different cities offering a wider range of services: i.e. these locations provide more freedom of movement as well as more opportunities. A large gap is founded when compared Basel to the neighboring Saint Louis region, regarding to road and rail indicators where the number of cities that can be reached double less.

The highest connectivity between cities is in Khel and Copenhagen, however with significant differences related to Copenhagen neighbors,

Table 4
Analyzed indicators potential accessibility by rail.

Case study	GEOTIME	NUTS3*	Potential accessibility by rail			
			R_i 2001	R_i 2006	Ri_ch2001/2006	R_i 2011
Vienna	AT	AT130	112.5	119.1	6.6	102.1
Bratislava	SK	SK010	98.8	99.7	0.9	85.7
Copenhagen	DK	DK012	60.5	60.6	0.0	59.2
Malmö	SE	SE224	60.9	60.2	−0.7	58.3
Oradea	RO	RO111	44.4	43.1	−1.4	37.4
Debrecen	HU	HU321	47.6	46.5	−1.1	42.9
Strasbourg	FR	FR421	180.7	177.1	−3.6	196.1
Khel	DE	DE134	186.6	191.3	5.2	202.8
Saint Louis	FR	FR422	163.3	159.9	−3.4	175.2
Basel	CH	CH032	172.5	168.0	−4.5	187.4

*AT130 – Wien; SK010 – Bratislavský kraj; DK012 – Københavns omegn; SE224 – Skåne län; RO111–Bihor; HU321 – Hajdú-Bihar; FR421 – Bas-Rhin; DE134 – Ortenaukreis; FR422 – Haut-Rhin; CH032 – Basel-Landschaft.

Table 5
Analyzed indicators potential accessibility by air.

Case study	GEOTIME	NUTS3*	Potential accessibility by air			
			Air i 2001	Air i2006	Air i ch2001/2006	Air i 2011
Vienna	AT	AT130	168.5	172.2	3.7	169.5
Bratislava	SK	SK010	137.7	146	8.3	140.6
Copenhagen	DK	DK012	146.6	140.6	−5.9	138.5
Malmö	SE	SE224	142.6	136.8	−5.8	136.2
Oradea	RO	RO111	35.5	37.9	2.4	66.1
Debrecen	HU	HU321	36.7	38.5	1.8	52.3
Strasbourg	FR	FR421	142.5	140.3	−2.2	124.3
Khel	DE	DE134	130.8	128.2	−2.7	114.3
Saint Louis	FR	FR422	106.2	97.6	−8.6	96.2
Basel	CH	CH032	174.6	159.7	−14.9	163.7

*AT130 – Wien; SK010 – Bratislavský kraj; DK012 – Københavns omegn; SE224 – Skåne län; RO111 –Bihor; HU321 – Hajdú-Bihar; FR421 – Bas-Rhin; DE134 – Ortenaukreis; FR422 – Haut-Rhin; CH032 – Basel-Landschaft.

Table 6
Analyzed indicators by multimodal accessibility.

Case study	GEOTIME	NUTS3*	Multimodal accessibility			
			MM_i 2001	MM_i 2006	MM i _ch 2001/ 2006	MM_i 2011
Vienna	AT	AT130	155.2	157.3	2.1	149.4
Bratislava	SK	SK010	129.4	135.3	5.9	126.2
Copenhagen	DK	DK012	130.4	124.3	−6.1	119.2
Malmö	SE	SE224	126.7	120.9	−5.8	117.1
Oradea	RO	RO111	37.7	39.3	1.6	60.0
Debrecen	HU	HU321	40.5	42.1	1.6	51.0
Strasbourg	FR	FR421	146.5	143.4	−3.0	137.2
Khel	DE	DE134	140.1	138.9	−1.2	135.5
Saint Louis	FR	FR422	113.7	109.0	−4.7	116.3
Basel	CH	CH032	151.7	142.3	−9.4	145.3

*AT130 – Wien; SK010 – Bratislavský kraj; DK012 – Københavns omegn; SE224 – Skåne län; RO111 –Bihor; HU321 – Hajdú-Bihar; FR421 – Bas-Rhin; DE134 – Ortenaukreis; FR422 – Haut-Rhin; CH032 – Basel-Landschaft.

Malmo, particularly by rail.

In Bratislava region (SK010), only a few cities can be reach by rail. All case studies show that the disparities are greater for rail as for road.

Regarding to the ICON indicator (Table 7 and Fig. 3), the results show that Vienna (AT130), Bratislava (SK010), Copenhagen (DK012) and Basel (CH032), have better access to high-level passenger transport infrastructure than peripheral regions, as they tend to have denser

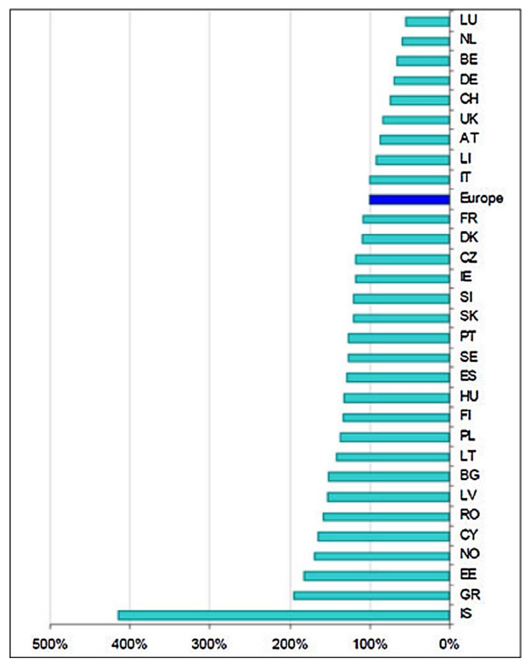


Fig. 3. Average travel time to high-level passenger transport infrastructure, per country. ICON formulation.

Table 7
Analyzed connectivity indicators.

Case study	GEOTIME	NUTS3	Urban Connectivity/ Availability of urban functions by road (number of cities)	Urban Connectivity/ Availability of urban functions by rail (number of cities)	Access to high level passenger transport infrastructure (ICON) (minutes – equivalents)
Vienna	AT	AT130	5.18	3.18	6.33
Bratislava	SK	SK010	4.48	1.98	7.53
Copenhagen	DK	DK012	8.77	7.82	7.30
Malmö	SE	SE224	3.15	2.44	12.34
Oradea	RO	RO111	0.70	0.41	33.28
Debrecen	HU	HU321	3.90	2.07	31.11
Strasbourg	FR	FR421	7.27	4.59	14.76
Khel	DE	DE134	9.01	8.11	12.98
Saint Louis	FR	FR422	8.19	6.04	15.19
Basel	CH	CH032	15.53	11.28	10.11

motorway networks, improved rail networks, and also, in some of them air hubs are concentrated. Which implies that citizens in those regions are more likely to seamlessly travel in Europe or easily access global transport gateways. They offer higher availability of transport services, of direct point to point connections to other European cities, and even shorter trip on local and regional road and rail networks.

A higher value can be seen in Strasbourg (FR421), Saint Louis (FR422), Khel (DE134), and Malmö (SE224). Some counties, outside the European core such as: Oradea (RO111) and Debrecen (HU321), have doubled their "negative" value of access to high level passenger transport infrastructure.

5. Conclusions

Generally, improving transport accessibility, as well to foster a sustainable transport, requires the implementation of innovative/creative indicators and concepts of accessibility which respond to actual challenges.

Through the present research the importance of accessibility as a measure of the quality of the interaction between transportation systems in CBC areas has been demonstrated. Moreover, accessibility has shown to be useful to transportation planners, in order to assess and define priorities, and also to rank areas according to a regional scale.

The performed research while presenting a variety of performance-based accessibility indicators, considering their application to case study area, enabled us not only to understand the distribution of the different regional accessibility levels, but also to extract lessons for establishing policies that reinforce accessibility as a mean to promote economic and social development in border areas, to strengthen cooperation in addressing common challenges (circulation, safety and security), and to grant better conditions for persons, goods and capital mobility.

It is a fact that since policies implemented between 2001 and 2006, promoted not only significant improvements but also further imbalances in accessibility development across regions and modes. The collected data indicates that these policies have contributed to small changes on the core-periphery relation, leading towards an upgrade on the accessibility of specific places, regions and cities, based on a European CBC perspective. However, the collected data showed that changes regarding accessibility were altogether minor in the short period from 2001 to 2006. Nevertheless, the development of new infrastructures for high-speed trains, influenced positively the potential accessibility of some European regions as well as the development of new road infrastructures.

However, it is a fact that best accesses continue to be found in the core area of Europe, where high citizenś densities, have contributed significantly to increase connectivity and mobility infrastructures. This scenario is also true for capital regions, particularly in central Europe, in which it is possible to find high levels of accessibility. Still, the performed analysis corroborates with the findings put forward on previous studies, according to which low accessibility continues to be an issue not only for regions located on the periphery of Europe, but also for some located in the core of Europe (ESPON, 2009). Same scenario applies to connectivity − movement between cities. The analysed case studies from centre Europe clearly show higher levels of connectivity to passenger transport networks than case studies in peripheral Europe. Core areas in Europe clearly show higher levels of connectivity to passenger transport networks than peripheral areas. The denser network of motorways and the fact that most intercontinental air hubs are located in this area is the main reason for these higher values of this indicator.

In general, one may say that road accessibility decreases when moving successively towards regions away from the European core area. In all these regions, the combination of good road infrastructure in form of dense motorways and high concentration of population lead to these favourite positions (ESPON, 2009). Anyway, even if these regions have basically a good position, they have been loosing some comparative advantage regarding location, as other regions are catching up. The lowest accessibility by road is found in peripheral regions. Due to specific characteristics of rail networks, the effects of high accessibility by rail are normally concentrated around city hubs (nodes) and along corridors of high-speed rail lines. The highest losses in relative position of multimodal accessibility were identified in peripheral regions, as is the case of Romania, which in 2001 scored below the average in multimodal accessibility, tendency that does not seem to be reversed.

Another important aspect is related to the fact that many regions in central Europe benefit from the location of major airports, which is not the case for more peripheral locations. A couple of regions had to face losses in accessibility by air due to a reduction of flight services in the period 2001–2006. These regions and this trend might also reflect the increased competition from improved rail services in these areas.

In summary it is possible to conclude that, the accessibility between places constitutes, as well as it has been identified in recent studies (Nicolini & Pinto, 2013; Vulevic, 2013; Castanho et al., 2016; Castanho et al., 2017), a critical factor for territorial development; also in policy considerations. In this regard, accessibility and connectivity become pivotal for policy makers at different levels, targeting three geographical scales: (1) accessibility within the CBC area; (2) between European countries (3) between the EU and other regions in the World. In this regard the obtained findings, identified clearly that such aspects need to be considered in CBC development policies, considering at the same level their capability to promote a viable economy and the attractiveness of the region, where inhabitants and visitors are able to enjoy resilient connections and accesses between, housing, services, natural and cultural assets on a sustainable way. Nonetheless, policy makers need to be aware that in order to promote economic and social development on both sides of common borders, while addressing common challenges in environmental, social, economic and cultural issues and promoting better life standards both for local citizens and visitors it is crucial to create conditions and modalities that enable people, goods and capital mobility.

Further research should provide insight about how the transport infrastructure potential of cross border regions should be characterized, in the broader international context, and how transportation infrastructure potential can be developed over time.

Conflicts of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

Baradaran, S., & Ramjerdi, F. (2001). Performance of accessibility measures in Europe. *Journal of Transportation and Statistics*, *4*(2/3), 31–48.
Batista, T., Cabezas, J., Fernández, L., & Pinto-Gomes, C. (2013). IDE-OTALEX C. The first crossborder SDI between Portugal and Spain: Background and development. *Journal of Earth Science an Engineering*, *3*(6).
Bellet, C., Alonso Logroño, M. P., & Casellas, A. (2010). Infraestructuras de transporte y territorio: los efectos estructurantes de la llegada del tren de alta velocidad en España [Transport infrastructure and territory. The structuring effects of the arrival of the high-speed train in Spain.]. *Bulletin of the Association of Spanish Geographers (Asociación De Geógrafos Españoles)*, *52*, 143–163.
Biehl, D. (1991). The role of infrastructure in regional development. In R. W. Vickerman (Vol. Ed.), *Infrastructure and regional development, European research in regional science. vol. 1*, (pp. 9–35). London: Pion.
Boehnke, K., Rippl, S., & Fuss, D. (2015). Sustainable civil-society engagement: Potencials of a transnational civil society in French-German, Polish-German, and Czech-German border regions. *Sustainability Journal*, *7*, 4078–4099.
Brocard, M. (2009). *Transport et territories. [Transport and territories] ellipses*.
Brown, E., Derudder, B., Parnreiter, C., Pelupessy, W., Taylor, P. J., & Witlox, F. (2010).

World city networks and global commodity chains: Towards a worldsystems' integration. *Global Networks*, *10*(1), 12–34.
Bruinsma, F., & Rietveld, P. (1998). The accessibility of European cities: Theoretical framework and comparison of approaches. *Environment and Planning A*, *30*(3), 437–456 499–521s, Vol. 7, No. 5.
Castanho, R., Loures, L., Cabezas, J., & Fernández-Pozo, L. (2017). Cross Border Cooperation (CBC) in Southern Europe – An Iberian case study the Eurocity Elvas-Badajoz. *Sustainability*, *9*(360), http://dx.doi.org/10.3390/SU9030360.
R.A. Castanho J. Cabezas L. Pozo, (2016). Territorial Planinng and Development Tools in Transboundary Areas. Study Case of the OTALEX-C Space. Conference Paper. Institute of Geography and Spatial Planning – University of Lisbon & International Journal of E-Planning Research. Institute of Geography and Spatial Planning, University of Lisbon 31 March – 1 April 2016. Lisbon, Portugal, 2016.
Castanho, R., Loures, L., Fernández, J., & Pozo, L. (2016). Identifying critical factors for success in Cross Border Cooperation (CBC) development projects. *Habitat International*. http://dx.doi.org/10.1016/j.habitatint.2016.10.004.
Dominguez Castro, L., & Varela Alvarez, E. (2015). Building Europolis on the basis of local informal cooperation in European cross-border spaces: The case of RIET. *Geopolitical Magazine – Studies of Space and Power*, *6*(2), 225–246.
Chi, G. (2012). The impacts of transport accessibility on population change across rural, suburban and urban areas: A case study of Wisconsin at sub-county levels. *Urban Studies*, *49*, 2711–2731.
Curtis, C., & Scheurer, J. (2010). Planning for sustainable accessibility: Developing tools to aid discussion and decision-making. *Progress in Planning*, *74*(2), 53–106.
Dale, G. (2016). *Karl Polanyi: A life on the left*. New York, USA: Columbia University Press.
Domínguez, J. A., Noronha Vaz, T., & Vaz, E. (2015). Sustainability in the trans-border regions? The case of Adalusia – Algarve. *International Journal of Global Environmental Issues*, *14*, 151–163 Nos. ½.
European Spatial Planning Observation Network. ESPON, 2002–2005. Territorial Development and Cohesion − ESPON projects 1.2.1., Transport Services and Networks. Retrieved from http://www.espon.eu/main/.
European Spatial Planning Observation Network. ESPON, 2002–2005. Territorial Development and Cohesion − ESPON projects 2.1.1. Territorial Impacts of EU Transport and TEN Policies. Retrieved from http://www.espon.eu/main/.
European Spatial Planning Observation Network. ESPON, 2006. Territorial Development and Cohesion − ESPON projects 1.2.1. Transport Trends. Retrieved from http://www.espon.eu/main/.
European Spatial Planning Observation Network. ESPON, 2009. Territorial Dynamics in Europe −ESPON. Retrieved from http://www.espon.eu/main/.
Fadigas, L. (2010). *Urbanismo e Natureza – Os Desafios*. Lisbon, Portugal.
Fadigas, L. (2015). *Urbanismo e Território – As políticas públicas*. Lisbon, Portugal.
Frank, A. I., Mironowicz, I., Lourenço, J., Franchini, T., Ache, P., Finka, M., et al. (2014). Educating planners in Europe: A review of 21 st century study programmes. *Progress in Planning*, *91*, 30–94. http://dx.doi.org/10.1016/j.progress.2013.05.001.
Geurs, K., & Ritsema, J. (2001). *Evaluation of accessibility impacts of land-use transport scenarios, and related social and economic impacts»*. Utrech: Urban Research Centre, 265.
Gould, P. R. (1969). *Spatial diffusion*. Association of American Geographers.
Gutiérrez, J. A., Naranjo, J. M., Jaraíz, F. J., & Ruiz, E. E. (2015). Estimation of social cohesion in the Spanish municipalities after the implantation of the high speed railway. *Boletén de la Asociacién de Geígrafos Espaóoles*, *69*, 113–138.
Gutiérrez, J. (2001). Location, economic potential and daily accessibility: An analysis of the accessibility impact of the high-speed line Madrid-Barcelona-French border. *Journal of Transport Geography*, *9*(4), 229–242. http://www.spiekermann-wegener.com/pro/pro1_e.htm.
Holmes, R. (2016). Fascism 2. *Anthropology Today*, *32*(2), 1–3.
Kotavaara, O., Antikainen, H., & Rusanen, J. (2011a). Population change and accessibility by road and rail network: GIS and statistical approach to Finland 1970–2007. *Journal of Transport Geography*, *19*(4), 926–935. http://dx.doi.org/10.1016/j.jtrangeo.2010.10.013.
Kotavaara, O., Antikainen, H., & Rusanen, J. (2011b). Urbanization and transportation in Finland, 1880–1970. *Journal of Interdisciplinary History*, *42*(1), 89–109. http://dx.doi.org/10.1162/JINH_a_00206.
Kurowska-Pysz, J. (2016). Opportunities for cross-border entrepreneurship development in a cluster model exemplified by the Polish-Czech border region. *Sustainability Journal*, *8*(230) 10.3390.
López, E., Gutiérrez, J., & Gómez, G. (2008). Measuring regional cohesion effects of large-scale transport infrastructure investments: an accessibility approach. *European Planning Studies*, *16*(2), 277–301.
LISER, (2015). Opportunities of cross-border cooperation between small and medium cities in Europe. Report written in the scope of the Observatory of Territorial Development, in partnership with the Department of Spatial Planning and Development – Ministry of Sustainable Development and Infrastructure, Luxembourg Institute of Socio – Economic Research. Luxembourg.
Lee, S., & Na, S. (2010). E-waste recycling systems and sound circulative economies in east asia: a comparative analysis of systems in Japan, South Korea, China and Taiwan. *Sustainability Journal*, *2*, 1632–1644.
Mérenne-Schoumaker, B. (2008). *La localisation des industries. Enjeux et dynamiques [Localising industries Issues and dynamics]*. Presses Universitaires de Rennes.
Martí-Henneberg, J. (2013). European integration and national models for railway networks (1840-2010). *Journal of Transport Geography*, *26*(0), 126–138. http://dx.doi.org/10.1016/j.jtrangeo.2012.09.004.
Martín, G. (2013). *Border space as a vehicle for Territorial Cooperation in the New Programming period 2014-2020*. Badajoz, Spain: OTALEX-C.
Morris, J. M., Dumble, P. L., & Wigan, M. R. (1979). Accessibility indicators for transport planning. *Transportation Research Part A: General*, *13*(2), 91–109. http://dx.doi.org/10.1016/0191-2607(79)90012-8.
Naranjo, J. M. (2016). Impacts on the social cohesion of mainland Spain's future motorway and high-speed rail networks. *Sustainability*, *8*(7), 624–646. http://dx.doi.org/10.3390/su8070624.
Nicolini, E., & Pinto, M. (2013). Strategic vision of a Euro-Mediterranean port city: A case study of Palermo. *Sustainability Journal*, *5*, 3941–3959.
OTALEX-C (2013). *ATLAS*. Merida, Spain: OTALEX-C.
Pain K., (2010). The Emerging Metacity in North Western Europe and Policy Ramifications for Sustainable Transport Networks. in The emerging cross-border mega-city region and sustainable transportation, KOTI-EWC 2010 Special Report, C, Mo, YH, Kim, Hawaii/Korea, East-West Center/The Korea Transport Institute, pp. 2–27.
Pain, K. (2011). New worlds' for 'Old'? Twenty-first-century century gateways and corridors: Reflections on a European spatial perspective. *International Journal of Urban & Regional Research*, *35*(6), 1154–1174.
Palmateer, C., Owen, A., & Levinson, D. M. (2016). *The Synergistic Effects of Transit Oriented Development and Transit Hubs on Accessibility in the San Francisco Bay Area*. University of MinnesotaHttp://hdl.handle.net/11299/181535.
Reggiani, A., Bucci, P., & Russo, G. (2011). Accessibility and impedance forms: Empirical applications to the german commuting network. *International Regional Science Review*, *34*, 230–252.
Rodrigue, J. P., Comtois, C., & Slack, B. (2013). *The geography of transport systems*. New York, USA: Routledge.
Rosik, P., Stępniak, M., & Komornicki, T. (2015). The decade of the big push to roads in poland: Impact on improvement in accessibility and territorial cohesion from a policy perspective. *Transp. Policy*, *37*, 134–146.
Salonen, M., Toivonen, T., Cohalan, J.-M., & Coomes, O. (2012). Critical distances: Comparing measures of spatial accessibility in the riverine landscapes of Peruvian Amazonia. *Applied Geography*, *32*(2), 501–513.
Schürman, C., Spiekermann, K., & Wegener, M. (1997). *Accessibility indicators Berichte aus dem Institut für Raumplanung, 39*. Dortmund: IRPUD.
Sherman, L., Barber, B., & Kondo, W. (1974). Method for evaluating metropolitan accessibility. *Transportation Research Record*, 499.
Spiekermann, K., Wegener, M., Květoň, V., Marada, M., Schürmann, C., Biosca, O., et al. (2013). Tracc transport accessibility at regional/local scale and patterns in Europe; draft final report. *ESPON Applied Research*.
Task Force on the United States-Mexico Border (2009). *Managing the united states-Mexico border: Cooperative solutions to common challenges. Full report of the binational task force on the United States-Mexico border* .
Van Hamme, G., & Pion, G. (2012). The relevance of the world-system approach in the era of globalization of economic flows and networks. *Geografiska Annaler: Series B* Forthcoming.
Vulevic, A., & Dordevic, D. (2014). Importance of passenger railway traffic in definning criteria transport acessibility of the areas of danube districts. *Scientific-expert conference on railways. RAILCOŃ14*.
Vulevic, A. (2013). *Infrastructural corridors and their influence on spatial development example corridor VII in Serbia. Doctoral dissertation*. Serbia: University of Belgrade – Faculty of Geography, 14601.
Vulevic, A. (2016). Accessibility concepts and indicators in transportation strategic planning issues: theoretical framework and literature review. *Logistics & Sustainable Transport*, *7*(1), 58–67. http://dx.doi.org/10.1515/jlst-2016-0006 ISSN (Online) 2232-4968, October 2016.
Wegener N., Schürmann C., Spiekermann K., (2000). The SASI Model: Model Software. Deliverable D13 of the EU Project Socio-Economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements (SASI). Universität Dormund, Institut für Raumplanung, Dormund. http://www.raumplanung.tu-dortmund.de/irpud/fileadmin/irpud/content/documents/publications/ber40.pdf.
van den Heuvel, F. P., Rivera, L., van Donselaar, K. H., de Jong, A., Sheffi, Y., de Langen, P. W., et al. (2014). Relationship between freight accessibility and logistics employment in US counties. *Transportation Research Part A*, *59*, 91–105.