A METHOD FOR ASSESSING TERRITORIAL COHESION EFFECTS OF TRANS-EUROPEAN RAIL NETWORKS

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Enschede, the Netherlands,
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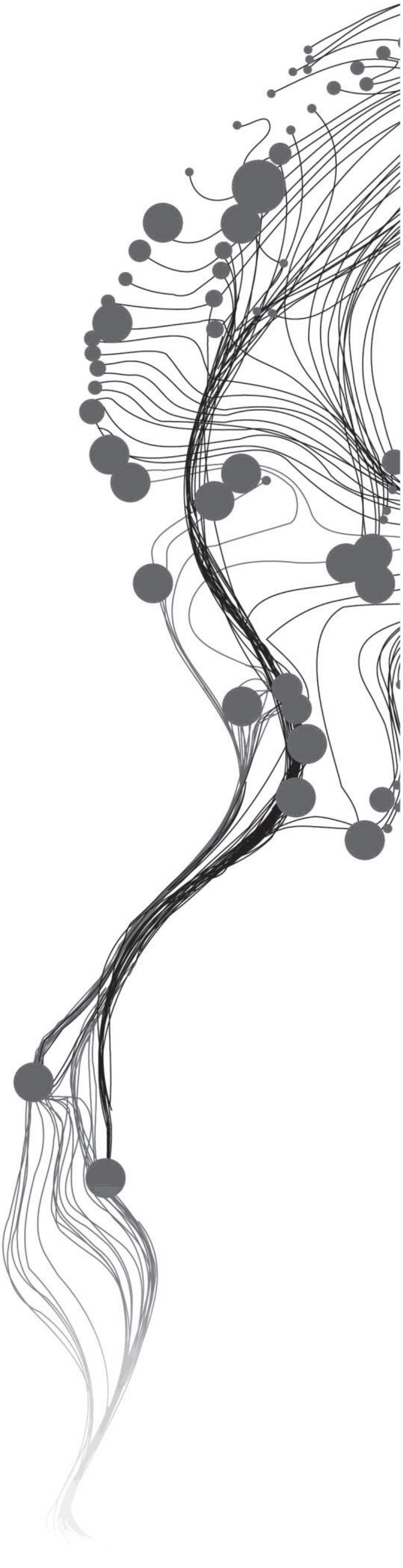

A METHOD FOR ASSESSING TERRITORIAL COHESION EFFECTS OF TRANS-EUROPEAN RAIL NETWORKS

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A thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements of the degree of Master of Science in Geo-Information Science and Earth Observation
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Disclaimer

ABSTRACT

The Trans-European Transport Network (TEN-T) is one of the most important transport policies in the EU since 1990s'. Its aim is to connect and benefit all the member states in light of the common European interest. TEN-T is expected to contribute to the general 'territorial cohesion' objective of the EU, benefiting largely from the Cohesion Fund in practice. However, territorial cohesion is a rather vague and complex concept and its definition is still in debate. This fact poses a challenge to measure territorial cohesion and even greater one to evaluate the impacts of TEN-T, on territorial cohesion. In order to meet the EU's requirement in policy consistency and justify TEN-T's contribution to territorial cohesion to various stakeholders, analysing the relationship between TEN-T and territorial cohesion is highly relevant. .

Therefore, the general goal of this study is to develop a method for measuring and evaluating territorial cohesion effects of a sub-network of the TEN-T, i.e. the trans-European rail network for passenger transport. This method tries to answer a main question: What effects can the trans-European rail network for passenger transport have on territorial cohesion at the EU scale?

Integrating different perspectives about territorial cohesion from literature and policy documents and observations from participation in related workshops, this study analyzes territorial cohesion as a desire for regional balanced development in multiple-dimensions. Lacking-behind regions are meant to benefit more than non-lacking-behind regions from TEN-T to enhance territorial cohesion. According to previous studies, territorial cohesion is supposed to contain three dimensions: territorial efficiency, territorial quality and territorial identity. Concreting the three dimensions, the nine most relevant core issues have been identified: 1) Infrastructure endowment, 2) External accessibility, 3) Network efficiency for territorial efficiency; 4) Fair accessibility, 5) Environmental risk, 6) Sustainable transport for territorial quality; 7) Local identification, 8) Land and landscape, 9) Knowledge and innovation for territorial identity. The three dimensions and nine issues have become the criteria and sub-criteria in the method. The issues have been further developed into a set of corresponding indicators with data definitions.

The method is operationalized through three phases to allow judging the territorial cohesion effects from trans-European rail network. Phase Ⅰ evaluates basic territorial indicators on moments in time. Phase Ⅱ evaluates territorial impact through analysing change in the basic territorial indicators between two time points. Both phases generate figures and maps to analyze and visualize influence of trans-European rail network on individual regions. Phase Ⅲ analyses territorial impact results in terms of individual issues from Phase Ⅱ for different regional groups and comprehensively evaluates territorial cohesion effects at the EU scale.

This study tests the developed method with available datasets for year 1996 and 2008 on 255 NUTS2 regions covering most territories in the EU. Although, due to data limitation, only eight of the nine issues have been implemented, this test has still proved that territorial cohesion effects from TEN-T at the EU scale can be measured, evaluated and judged through the shown method. Results from the test show that the trans-European rail network for passenger transport has general explicit but complex effects on territorial cohesion. At the general EU scale, territorial cohesion is either promoted or hampered in various extents in terms of different dimensions. This conclusion suggests more careful TEN-T policy to avoid serious conflicts between TEN-T development and the EU's territorial cohesion objective in some territorial issues.

Largely limited by data and time, the proposed method certainly needs improvement from multiple aspects. Further study is suggested in 1) more discussion about indicators including relevant assumptions, thresholds, norms and classification; 2) deeper analyse in reasons resulting certain territorial impacts with sufficient consideration in local context; 3) development of packaged toolbox for easy method operation; 4) sensitivity analysis and noise analysis to increase method reliability and stability 5) operationalization of the method at regional scale

Keywords: territorial cohesion, territorial impact, TEN-T, evaluation method

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LIST OF ABBREVIATIONS

CBA	Cost Benefit Analysis
CEC	Commission of the European Communities
EEA	European Environment Agency
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMU	Economic and Monetary Union
ERTMS	European Rail Traffic Management System
ESDP	European Spatial Development Perspective
ESPON	European Observation Network, Territorial Development and Cohesion
EU	European Union
GDP	Gross Domestic Product
GISCO	the Geographical Information System at the COmmission
HRST	Human Resources in Science and Technology
IA	Impact Assessment
INTERCO	INdicators of TERritorial COhesion project of ESPON
ITC	Faculty of Geo-information Science and Earth Observation or International Training Center
MCA	Multi-criteria Analysis
NUTS	Nomenclature of Territorial Units for Statistics
RRG	Büro für Raumforschung, Raumplanung und Geoinformation
SCGE	Spatial Computable General Equilibrium
SEA	Strategic Environmental Assessment
SPSS	Statistical Package for the Social Sciences
TA	Territorial Agenda 2020
TCEI	Territorial Cohesion Effect Indicator
TEN-T	Trans-European Transport Networks
TEN-T EA	Trans-European Transport Networks Executive Agency
TEQUILA	Territorial Efficiency QUality Identity Layered Assessment model
TIA	Territorial Impact Assessment
TIPTAP	Territorial Impact Package for Transport and Agricultural Policies (ESPON project)
TSP	Territorial State and Perspectives
UPM	Urban Planning and Management

1. INTRODUCTION

As one of the most influential economic and political union in the world, the European Union (EU) has committed itself to achieving high European integration throughout its territories for decades. Leading by this general orientation, a number of important programmes were adopted in the early 1990s, among which the White Paper on Transport Development (Commission of the European Communities, 1992) outlined the intension towards common EU transport policy. This document further led to the EU's ambitious plan in 1996 for the establishment and development of trans-European transport networks (TEN-T) (Commission of the European Communities, 1996). This trans-European transport system was expected to connect and benefit all the member states in light of the common European interest by integrating all modes of transport to provide sustainable mobility of persons and goods under the best possible social, environmental and safety conditions. However, since such large-scale and long-term transport infrastructure programme was believed to have complex relationship with regional development due to its explicit spatial effects (ESPON, 2005a; R. Vickerman, 2007; R. W. Vickerman, 1995), relevant territorial impacts should always been considered seriously during its plan and implementation.

Thus, TEN-T needs comprehensive territorial impact assessments, especially for further adaption to the new environment with various territorial challenges due to the recent crisis that the EU faces nowadays. Moreover, since the EU calls for coherence between sectoral policies and the recently quite heighted territorial cohesion objective (CEC, 2004, 2010c); considering responding to it, assessing territorial impact of TEN-T concentrating on territorial cohesion is definitely valuable, specifically for decision making in the future.

1.1. Background and Significance

1.1.1. TEN-T: towards common EU transport policy

The intension of developing trans-European transport networks may be traced back to the Treaty of Rome. It judged the creation of a Single Market for intra-Community transport as a necessary condition for achieving the free movement of goods, services, capital and labour, namely the 'four freedoms' that the EU purchased (Giorgi & Schmidt, 2002a). This orientation has not been largely driven forward in practice until 1990s, when the Commission's Maastricht Treaty formulated the idea of TEN (Giorgi & Schmidt, 2002a) and White Paper on the Future Development of the Common Transport Policy (Commission of the European Communities, 1992) was adopted. The White Paper enlarged the EU transportation objectives in reinforcement and proper functioning of the internal market that it further included sustainability and social cohesion in and explicitly called for integrated transport systems and infrastructure for strengthening economic and social cohesion to reduce regional disparities. Moreover, it directly resulted to the decision on the establishment and development of TEN-T in 1996 (Commission of the European Communities, 1996). TEN-T was expected to contribute to the attainment of the main objectives of the EU, such as smooth functioning of the internal market and the strengthening of economic and social cohesion. This is the initial of the real establishment and development of the on-going TEN-T, which has been the focus of the EU's transport policy for decades.

Mainly due to the EU's several organisational, structural and territorial changes, the plan for TEN-T development also has experienced changes or adaption during the past decades. For integrating various modes of transport networks throughout the territory of the EU, the original 1996 decision proposed to establish the TEN-T gradually by 2020 with a list of 14 priority projects. However, the initial period of TEN-T development in the 1990s showed the over-optimism in the programme implementation either in speed or the ease of programme implementation. As Sichelschmidt claimed, the 1992 version White Paper remained more a vision of the EU transportation future rather than a real Agenda for implementation (Sichelschmidt, 1999). Thus, an updated edition of the White Paper was created in 2001(Commission of the European Communities, 2001). In 2004, the list of Priority Projects was extended to 30 projects to take account of the accession of ten and then two more countries to the EU.

The current TEN-T system, with 30 TEN-T Priority Projects supposed to have high European added value, is now coordinated by TEN-T Executive Agency (TEN-T EA) within the 2007-2013 programme. Intended to be completed by 2020, these Priority Projects include 18 railway projects, three combined rail and-road infrastructure, and two inland waterways transport projects. Supported through different programmes, projects in this network are eligible to receive EU grants notably either from the TEN-T Programme, or one among Cohesion funds, European Regional Development Fund (ERDF) and the Research Framework Programme. TEN-T projects may also benefit from loans and guarantees from the European Investment Bank (EIB) (European Commission, 2010).

1.1.2. TEN-T's spatial impacts and debatable effects in territorial cohesion

Since initiated in 1996, about €400 billion has been invested in TEN-T. Almost a third came from EU sources and much of it was from the Cohesion Fund. According to the European Commission (CEC, 2010a), another €82 billion (23.7% of the total allocation) will be allocated for transport (with a priority for TEN-T projects) from the Cohesion Fund during the current programming period of 2007-2013.[1] This is an increase of 65% compared to the previous programming period (2000-2006). These funding figures confirm government documents about TEN-T development that, TEN-T projects are expected to enhance cohesive regional development, or in other words, much in line with the territorial cohesion objective. But how reality coherent with the good will?

As a sectoral policy with explicit spatial impacts, transport policy was early paid attention to in territorial studies (e.g. Bonnafous, 1987). It was believed to have an inevitable impacts in territory cohesion (CEC, 2010c). Thus, as core of the EU's transport policy, TEN-T has been a hot topic in territorial cohesion related discussion since early time (e.g. R. W. Vickerman, 1995).

A pragmatic doubt lies in what extent that TEN-T projects can stand in line with territorial cohesion. Actually, critical arguments in territorial impact of TEN-T development have already existed in reports or articles (e.g. ESPON, 2005a; Serrano, Ortuno, Bazo, & Caralt, 1997; R. W. Vickerman, 1995). For instance, as stated in the report of ESPON's 2.1.1 project, the three fundamental political goals - economic efficiency and spatial equity and environmental sustainability were proved in tension with each other, that trade-offs and compromise were in need.

As time goes by, whether the mentioned tension has been relieved, or in contrast, become more stressed? How much can the TEN-T development contribute the territorial cohesion? Following previous discussions, this study initially holds a critical perspective in the territorial cohesion effects of TEN-T as a starting point.

1.1.3. Measuring territorial cohesion effects

With highlighted importance and frequent adoption recently, however, "territorial cohesion" can hardly be measured and further integrated into policy appraisals and decision making process. Academic and institutional efforts are entailed for "a better and shared understanding of territorial cohesion and its implications for policy making" in both breadth and depth (CEC, 2008a). The main reason might be territorial cohesion's trans-sectoral, fussy and complex nature that different people have different understanding about it. However, studying territorial cohesion in a context can be easier, since the context helps in concreting the vague concept by anchoring it to specific issues within an interested scope.

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1 Cohesion Fund is important among policy instruments guided by the EU's cohesion objectives, which is confined to financing investment in Member States with relatively low income levels with obvious intension to help the lagging areas. It has apparent desire and responsibility to serve the new territorial cohesion goal.

To measure territorial cohesion, analysing territorial impacts should be the first step. It is necessary to comprehensively assess both revealed and potential territorial impacts of TEN-T. Nevertheless, specific approaches and tools with strong applicability are rare.

Territorial impact assessment (TIA) is one most recently emerging approach proposed for assessing policy in the sense of territorial cohesion. It is conceived as a strategic assessment for sectoral policies in terms of their impacts on territorial cohesion (Golobic & Marot, 2011). Despite the variability of approaches regarding the territorial level, generally, TIA leads to better integrating territorial cohesion in sectoral policies (Golobic & Marot, 2011), while saying the TEN-T policy in this study.

A TEN-T project, usually involves multiple regions/ nations, not only causing direct and/or indirect changes in transport network itself and local traffic, but also influencing socio-economic activities' distribution, land use dynamic, as well as behaviours of individuals or groups. Considering the multi-dimensions and their complex interactions, individual measures such as accessibility indicators can hardly provide comprehensive information for policy makers. TIA has advantages in addressing this problem by checking issues from complementary perspectives and conducting assessment on different aspects with systematic methodology, especially when facilitated by advanced Geo-information techniques. Camagni's integrated simulation package for TIA, TEQULA (Camagni, 2009), was But large an impressive attempt of TIA and has been demonstrated its application in TEN-T policy. Improvable space, e.g., interaction consideration between issues, integration to decision making process, criteria and indicators, etc., has been left to further studies.

1.1.4. Interested mode in Trans-European network: rail

As mentioned in previous section, TEN-T contains projects in different modes, of which about 70% priority projects are rail or rail-road combined corridors. A trans-European rail network is obviously building up, which draws my attention and become the focus of this study.

The interested Trans-European Rail Networks consists of both high-speed and conventional rail lines and their related infrastructures and facilities. There are different types of TEN-T rail projects – new railway lines (high-speed or conventional) construction, conventional rail lines upgrading, high-speed rail lines upgrading and European Rail Traffic Management System (ERTMS) implementation as well. Most of them serve for passenger transport with only a few exceptions, such as the Priority Project 16 - Freight railway axis Sines/Algeciras-Madrid-Paris[2]. Figure 1-1 shows status of and progress on TEN-T rail priority projects until the beginning of 2010. In brief, most of the priority projects in EU 15 have been completed until 2009 or in working, while projects connecting Eastern and Southern Europe still remain a lot of work or even in plan.

Such a rail network covering the whole pan Europe explicitly can enhance international connections at the EU level. However, other territorial aspects beyond connectivity, such as accessibility and environmental effects, can be hardly interpreted from these figures, particularly when regional units with more diverse context rather than countries are in concern. Thus, much work is required to have some conclusions or remarks about what role trans-European rail network play on the way towards territorial cohesion.

2 http://tentea.ec.europa.eu/en/ten-t_projects/30_priority_projects/priority_project_16/priority_project_16.htm

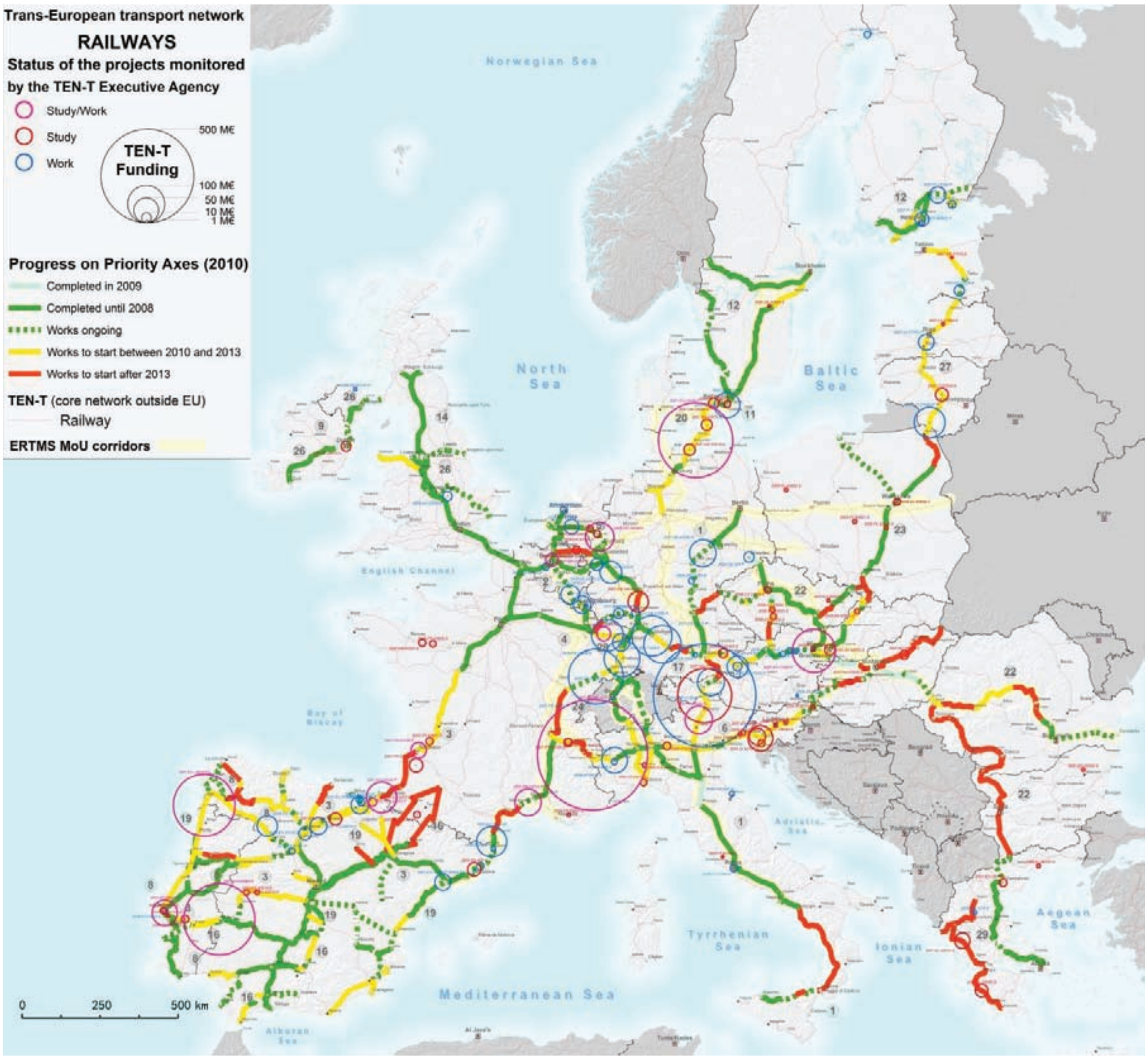


Figure 1-1 Trans-European rail network: projects status and progress until 2010

1.2. Research Problem

Knowledge about territorial impacts from trans-European rail network, as well as applicable measures, is fundamental for robust decision making in programme and project to guarantee the expected coherence between this sectoral policies and the new territorial cohesion objective3 (CEC, 2004; Hübner, 2005). However, current relevant knowledge and applicable assessment methodology that can serve decision making are insufficient. Existing TIA models and tools have provided valuable ideas and pilot case references (Camagni, 2009; Golobic & Marot, 2011); however, few of them were developed focusing on policies impacts to territorial cohesion at the European scale. Nearly none of them served specifically for trans-European rail network. In this case, very little practical information can be used to discuss and further implement territorial cohesion in trans-European rail network practice. Therefore, there is an obvious need for a systematic, comprehensive and applicable TIA methodology to assess trans-European rail network in light of territorial cohesion at a European scale. Considering significantly different

3 Workshop "Cohesion and the Lisbon Agenda: The Role of the Regions", 3 March 2005, Brussels. Final conclusions by Mrs. Hübner: "… It is of utmost importance to ensure coherence and consistency between cohesion policy and other EU policies, especially competition policy."

characteristics between passenger transport and freight transport (e.g. different speed and management), it is necessary to split the network into passenger network and freight network for individual analysis and assessment. Limited by time and spirit, this study only concentrates on passenger transport. The only-freight railway and their related infrastructures and facilities are excluded in the analysis.

Although this study involves in a core concept of territorial cohesion with strong EU policy background, the method to be developed should capture a global value in TIA for large-scale rail infrastructure programme rather than limited European usability mainly due to the close relationship between territorial cohesion and sustainable development. It is expected applicable or adaptable wherever there is a need in TIA for railway network of passenger transport serving for balanced/ integrated regional development. For instance, in China, currently many regional rail projects are newly put in use or still in construction (e.g. the Chinese high speed railway network). Scientific monitoring and assessment is definitely necessary to keep the plan and implementation of these projects in line with the Chinese central government's crucial goal in reducing regional disparities and more collaborative regional development (Wei, 2009).

1.3. Research Objectives

1.3.1. General objective

The general objective of this study is to develop a TIA methodology for assessing territorial cohesion effects of Trans-European Rail Networks focusing on passenger transport to translate and integrate the complex and fussy concept of territorial cohesion at EU level into systematic and operational appraisal approach, which can provide valuable information for decision making in practice.

1.3.2. Specific objectives

Leading by the general objective, four specific objectives are defined as below:

1. **Scoping Objective**: To review existing territorial cohesion concepts, TIA approaches and tools, as well as experience in large-scale rail infrastructure assessment to identify issues that should be covered by the expected methodology.

2. **Framing Objective**: To develop a conceptual framework for assessing Trans-European Rail Networks focusing on passenger transport.

3. **Designing Objective**: To operationalize the conceptual framework into applicable and user-friendly tools aiming at providing useful information for the policy making process.

4. **Operating Objective**: To assess territorial cohesion effects of Trans-European Rail Networks focusing on passenger transport at the general EU scale of territorial level 2 (NUTS 2).

1.4. Research Questions

Table 1-1 Research questions

Specific objectives	Research questions
Scoping Objective	1) How existing literature understood territorial cohesion? 2) What views relevant stakeholders and experts have in this problem? 3) What are the existing methods to measure/assess territorial cohesion or territorial issues? 4) What valuable experience has been accumulated in large-scale rail infrastructure assessment? 5) What are the issues that should be analysed quantitatively or qualitatively in terms of territorial cohesion with context of Trans-European Rail Networks for passenger transport?
Framing Objective	6) How to delineate territorial cohesion in an operational TIA approach through identified issues?
Designing Objective	7) What are the potential and practical individual measures of territorial impacts from the trans-European rail network focusing on passenger transport? 8) How can these territorial impact indicators offer information for understanding and assessing territorial cohesion in the EU? 9) What are the synthesis strategies for indicators and how to interpret them in order to provide useful information to policy makers? 10) What materials and techniques are principally necessary?
Operating Objective	11) Whether and up to what extent can the Trans-European Rail Networks for passenger transport contribute to the territorial cohesion at the general EU level? 12) What useful information can be extracted from the results that can serve the decision making process?

1.5. Thesis Outline

The overall thesis is logically divided into six chapters as follows: Introduction; Literature Review; Methodology; A proposal for an assessment method; Method application; and, finally, Conclusions and Reflections.

Chapter 1 gives a brief introduction to the study. With explaining the background of the EU's TEN-T policy and territorial cohesion orientation, research problem and corresponding research objectives and questions are defined.

Chapter 2 reviews previous scientific experience in large-scale infrastructure study in light of regional development, territorial cohesion issues, as well as Territorial Impact Assessment (TIA) in Europe.

Chapter 3 is the design and explanation of methodology applied to achieve the research objectives including conceptual frameworks, approaches and activities, an introduction of the study area and data issues along with desired software to adopt as well.

Chapter 4 shows the framework design of the expected method for the trans-European rail network with discussion in the issues and indicators that concrete the structure.

Chapter 5 displays a testing method application based on available data. It also represents analysis and discussion of results delivered in the test, which finally lead to remarks about effects from the trans-European rail network on territorial cohesion at the EU scale.

Chapter 6 makes conclusions and takes reflection for the whole study with recommendations in further study.

2. LITERATURE REVIEW

This chapter aims at reviewing relevant literatures mainly in three fields: Economic, social and environmental impacts of transport infrastructure to regions; Territorial cohesion and; Territorial Impact Assessment. Section 2.1 and 2.2 mainly contribute to identifying and classifying dimensions and issues that need to be covered in the study to assess the trans-European rail network for passenger transport in terms of territorial cohesion effects. While section 2.3 reviews the methodological base for developing a specific assessment framework.

2.1. Economic, Social and Environmental Impacts of Transport Infrastructure to Regions

Large-scale transport infrastructure development is one of the most favoured means to achieve objectives in regional development policy according to a global observation. For instance, China, which is a country with large gaps in socio-economic development across its regions, is making efforts in reducing such regional disparities by developing national transport networks and focusing on transport infrastructure development for less developed areas (Giorgi & Schmidt, 2002b). Similar transport policy is also adopted by the EU, that the on-going TEN-Ts are expected to contribute to both competitiveness and cohesion objectives of its regional policy (R. Vickerman, 2007). However, although there is long and strong belief in the positive effects that transport infrastructure can bring to regional development, relationship between transportation and regional development is not always convincing. For the sake of sustainable regional development, effects from transport infrastructure are necessary to be examined from three dimensions of sustainability - economic, environmental and social, which can further contribute to ideal transport policy appraisal.

2.1.1. Economic impacts from transportation infrastructure

In the eyes of most people, transport infrastructure leads to regional economic growth through multiple ways. First of all, investing in infrastructure itself increased demand for goods, services and employment for construction and maintenance (Fan, Treyz, & Treyz, 2000). Secondly, as the main function of transport infrastructure, travel time saving benefits both passengers and freights directly (Grant-Muller, Mackie, Nellthorp, & Pearman, 2001). Economic consequences are yielded not only due to the decrease in travel time cost, but also come from better access for users to larger area which means extended potential opportunity (K. Geurs, Zondag, de Jong, & de Bok, 2010; Gutierrez, Condeco-Melhorado, & Martin, 2010). Shirley and Winston (2000) also claimed that highway infrastructure investment can lower firms' inventories that obvious generate benefits for the whole economy. Thirdly, as necessary input for economic activities, better transport infrastructure adds attraction for regions to gain foreign direct investment, which is convinced by the economic growth experience in countries and regions with high growth rates, such as China (Fan et al., 2000). Fourthly, lower transport and trade cost is supposed to accelerate industrial agglomeration (Mackie & Preston, 1998), while labour productivity can increase from the concentration of economic activities (Sichelschmidt, 1999). Lastly, as claimed by the EU to justify TEN-T, globalisation makes such large-scale transport network with multi-modes integration more critical as the development of seamless connections between transport modes is a major factor in determining both trade flows and the location of footloose industries (R. Vickerman, 2007).

However, crisis was raised in economic effects of infrastructure in term of balanced local economic development among regions, especially between core and peripheral regions, that in some case the local or regional impacts of such infrastructure may be mixed or even negative (R. Vickerman, 2007). For example, the regions along a corridor, but where there is no access points to the corridor (e.g. limited access highways or high-speed rail lines) or where the level of services is reduced through lower frequencies (e.g. high-speed rail lines), are highlighted.

In order to predict or reveal economic effects from transportation infrastructure, tools such as Spatial Computable General Equilibrium (SCGE) models are widely used in studies in general sense or under special context. For example, Bröcker J. et al.(2010) used a SCEG to examine economic effects of transport infrastructure projects from the TEN-T priority list focusing on return rates and the spillover effects that would arise due to project implementation. They concluded that only 12 out of 22 projects have an annual return rate for the EU above 5%, while the rest of the projects can be considered unprofitable. Ivanova (2005) applied a SCGE model for Norway for empirical analysis to understand whether the economic effects of transport infrastructure provision exist and are significant enough to be accounted in policy decision making. The conclusion is that provision of transport infrastructure by itself does not lead to economic growth; however, positive welfare effects are significant and increase over time considering future production growth.

2.1.2. Social impacts from transportation infrastructure

Compared to economic and environmental impacts, social impacts of transport are underexposed in scientific studies and transport project appraisals. Particular impacts that are difficult to quantify or monetize include the temporary impacts of transport investments, health impacts, social cohesion, the distribution and accumulation of impacts across population groups and social justice. In practice, it is the problems with time and budget restraints, data collection and a lack of research methods and/or appropriate evaluation tools that make social impacts difficult to be integrated into appraisals.

Geurs et al. (2009) pointed this problem out and provided a relatively comprehensive review about social impacts from transport in their study based on large amount of literature.

As Geurs et al. (2009) defined, social impacts of transport is 'changes in transport sources that (might) positively or negatively influence the preferences, well-being, behaviour or perception of individuals, groups, social categories and society in general (in the future)'. Based on their earlier conceptual models (Karst T. Geurs & van Wee, 2004; Van Wee & Hoorn, 2002), Geurs presented a conceptual model (Figure 2-1) to describe the main categories of determinants for social impacts, as well as their relationships. As the model shows, three categories, namely people, transport and land use, influence social impacts of transport, which might also reinforce each other. According to this conceptual model, they categorized social impacts by source and levels of human needs (Figure 2-2).

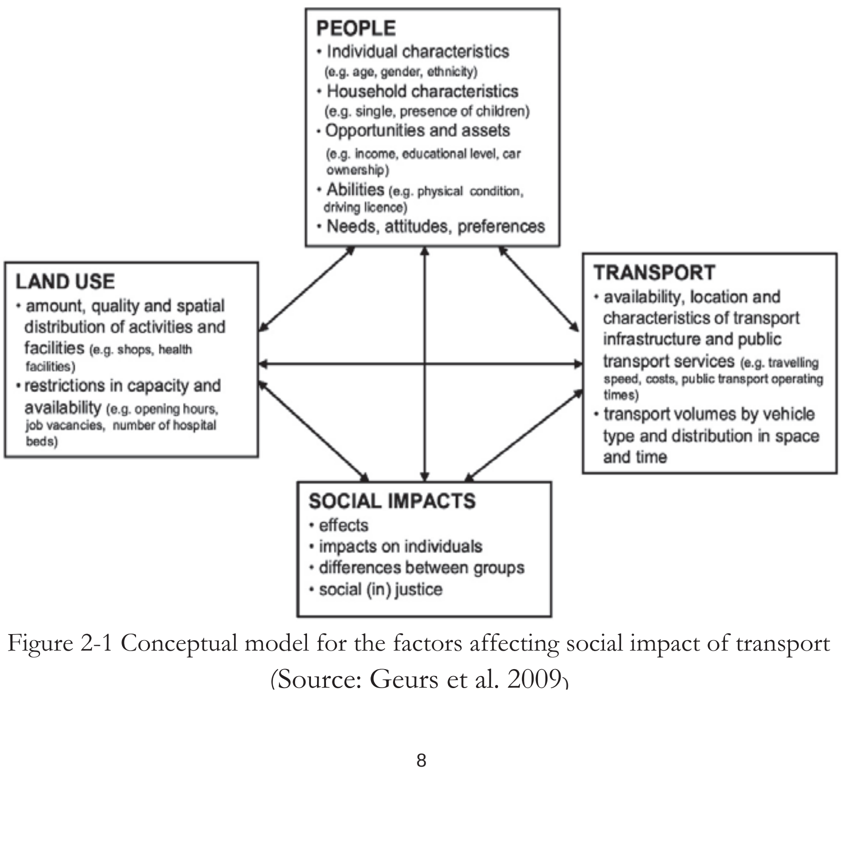


Figure 2-1 Conceptual model for the factors affecting social impact of transport

(Source: Geurs et al. 2009)

Theme	Sub-themes	Impact
Presence of infrastructure	Structurally	Visual quality
		Historical/cultural resources
		Severance/social cohesion
	Temporarily (construction)	Noise nuisance
		Barriers and diversions
		Uncertainty of construction
		Forced relocation
Presence of parked vehicles		Visual quality
		Use of space
Presence of transport facilities, services and activities	Transport facilities	Availability and physical access
		Level of service provided
		Transportation choice/option values
		Cultural diversity
	Land use	Access to spatially distributed services and activities
Traffic (movement of vehicles)	Safety	Accidents
		Averting behaviour
		Safety perceptions
		Public safety (dangerous cargo)
	Environment	Noise levels, nuisance
		Soil, air and water quality
Travel (movement of people)		Intrinsic value, journey quality
		Physical fitness
		Security

Figure 2-2 Categorising social impacts by source and levels of human needs
(Source: Geurs et al. 2009)

From the study of Geurs et al. (2009), it can be learnt that it is hard to separate social impacts completely from economic and environmental impacts. From a broad point of view, any impacts affecting human beings can be accounted as social impacts. Considering the current study's core concern on people's well-being as indicated in Chapter 1, Geurs et al.'s review study provide a crucial theoretical base for this thesis.

2.1.3. Environmental impacts from transportation infrastructure

The popular problem about environmental impacts from transport sector has been discussed for decades. Moreover, Environmental Impact Assessment (EIA) and/or Strategic Environmental Assessment (SEA) have already been statutory in transport project appraisal in many countries around the world.

Rodrigue, Comtois and Slack (2009) categorise environmental impacts from transport into three classes:

Direct impacts: The immediate consequence of transport activities on the environment where the cause and effect relationship is generally clear and well understood.

Indirect impacts: The secondary (or tertiary) effects of transport activities on environmental systems. They are often of higher consequence than direct impacts, but the involved relationships are often misunderstood and difficult to establish.

Cumulative impacts: The additive, multiplicative or synergetic consequences of transport activities. They take into account of the varied effects of direct and indirect impacts on an ecosystem, which are often unpredicted.

Growing levels of motorization and congestion largely contribute to the tension between transportation and environment. Generally, the most important impacts of transport on the environment, which are usually undesired, relate to climate change, air quality, noise, water quality, soil quality, biodiversity, energy consumption and land take. However, environmental impacts from a specific transport network or project need to be analysed considering multiple factors, such as network structure, traffic level, modes, and land use that interacting with the transport system.

According to the introduction of sustainable transportation from Schiller, Bruun and Kenworthy (2010), among modes for regional transport, rail is one of the most sustainable, energy-efficient and least polluting of modes for moving people and goods. But it also depends on rail's characteristics. Traditional rail using diesel can cause minor air pollution (e.g. CO emissions) relative to passenger load, but when electrified, it causes no local air pollution. Noise from rail depends on load and speed – rail overhead or high-speed rail conducted in high speed cause significant noise. In terms of energy efficiency which measured in average energy usage in miles per gallon, rail generally has the best performance among all the land passenger modes. But it still depends on the rail type. For instance, intercity rail is usual less energy-efficient than high-speed rail. (Schiller et al., 2010)

2.2. Territorial Cohesion: More Than a Political Objective

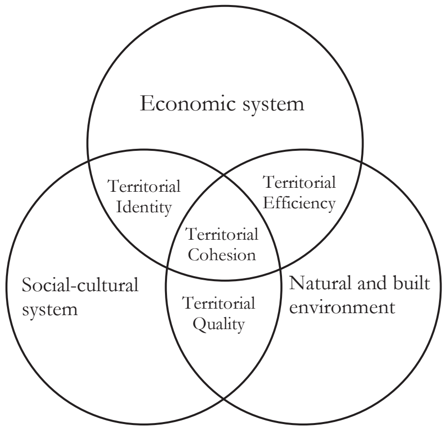
Territorial cohesion, a term has been highlighted recently in European political arenas from European level to local level. As a "European" saying, territorial cohesion is an currently aimed objective of the EU's cohesion policy, which was early explicitly introduced by the third Cohesion Report (CEC, 2004). But relevant discussion and debates can be traced back to 1990s, when the initial intension of European integration to enhance territorial convergence sprouted, or even earlier in regional development of EU member states such as France (Faludi, 2004). The debates led to adoption of the European Spatial Development Perspective (ESDP) in 1999 (CEC, 1999). ESDP further led to a number of important initiatives, such as the establishment of the European Spatial Planning Observatory Network (ESPON), which coordinate research programmes and projects about European territorial development and territorial cohesion in the Europe mainly for better governance. Facing increasingly territorial challenges due to the crisis, territorial cohesion has become the centre of EU's cohesion policy together with the traditional economic cohesion and social cohesion objectives.

But what exactly is territorial cohesion?

Although piles of documents (e.g. CEC, 2004, 2007, 2008a, 2010c) and studies (Faludi, 2004) have confirmed the high significance of territorial cohesion, unfortunately, so far there is neither consensus in a rigorous definition, nor sufficient prescribed or common measurement about territorial cohesion (CEC, 2008a; ESPON & University of Geneva, 2011). For decades, territorial cohesion has been discussed and interpreted in different point of views from European institutes, stakeholders and public (e.g. Camagni, 2002; 2009; CEC, 1999; 2004, 2007, 2008a, 2010c; ESPON & University of Geneva, 2011; Faludi, 2004).

In ESDP, none territorial cohesion has been mentioned, but spatial approach is considered crucial and territory is taken as an essential dimension of European policy. From this sense, thus, territorial cohesion is not only a third dimension of cohesion to complement economic and social cohesion, but a new territorial perspective to adopt, crossing economic and social fields. The Territorial States and Perspectives and the Territorial Agenda continued and developed this perspective.

As stated in the Lisbon Treaty (October 2007), a central aim of the EU is 'to promote economic and social progress and a high level of employment and to achieve balanced and sustainable development, in particular through the creation of an area without internal frontiers, through the strengthening of economic and social cohesion and through the establishment of economic and monetary union...’. The third Cohesion Report consider this statement implying that people should be equally equipped no matter where they happen to live or work in the EU. With this the basic implication of territorial cohesion, the third Cohesion Report outlines that the objective of territorial cohesion is to help achieve a more balanced development by reducing existing disparities, avoiding territorial imbalances and by making both sectoral policies which have a spatial impact and regional policy more coherent (CEC, 2004). It also claims that territorial cohesion has close links with social and economic cohesion by “both adding and reinforcing” them from a territorial perspective, but has far wider scope in terms of notions such as “more balanced development”, sustainability, territorial integration, etc.



Source: ESPON 3.1, 2004b

Figure 2-3 Components of territorial cohesion.

With new territorial challenges faced by the EU (e.g. those defined in Regions 2020, CEC, 2008b) and responding strategies/ policies (e.g. European 2020, CEC, 2010b), this concept of territorial cohesion even keeps developing dynamically with changing contents. Therefore, it seems hard to set a universal concept for territorial cohesion, but it is better to embed it in specific contexts.

This study will be developed mainly based on the notion of territorial cohesion linking with sustainable development shared by official documents such as the Territorial State and Perspectives (TSP) (CEC, 2011b) and the Territorial Agenda 2020 (TA) (CEC, 2011a), and scholars such as Camagni (Camagni, 2009). It is more a way to organize its components rather than define it. The following three dimensions are considered:

Territorial Efficiency: resource-efficiency with respect to energy, land and natural resources; competitiveness and attractiveness; internal and external accessibility; capacity of resistance against de-structuring forces related to the globalization process; territorial integration and cooperation between regions;

Territorial Quality: the quality of the living and working environment; comparable living standards across territories; fair access to services of general interest and to knowledge;

Territorial Identity: presence of “social capital”; landscape and cultural heritage; creativity; local know-how and specificities; productive “vocations” and “uniqueness” of each territory.

These three dimensions integrate the three elements of sustainability in terms of economic, socio-cultural and physical environment objectives as indicated by the model in a Venn’s diagram from ESPON (ESPON project 3.2 TIPTAP, 2010) as Figure 2-3. This universally understood diagram not only clearly presents the relationship between territorial cohesion and sustainable development, but also indicates the non-linear interrelations between the three basic components.

Based on this conceptual framework, this study will try to identify and analyse issues and indicators crosscutting economic, social and environmental dimensions relevant to the interested network. Results are expected to have synthesis for territorial efficiency, territorial quality and territorial identity separately, but synthesis for the three may not be necessary.

2.3. Territorial Impact Assessment in the EU

Despite the variability of approaches referring to different policy sector and/or territorial level, TIA reflects the complexity of the territorial cohesion concept. But it still follows the general process of any impact assessment (Golobic & Marot, 2011) with rich theoretical background. Most of them derive their evaluation frameworks either from ESDP (CEC, 1999), updated with Territorial Agenda (2007) (BMVBS, 2007) and the Green Paper (CEC, 2008a) or from national spatial policy documents (Golobic & Marot, 2011).

But so far, TIA is seldom an independent part in the regulatory process. They are mostly integrated in other assessment or just appearing as complementary analysis. For example, in UK, TIA is integrated in its impact assessment (IA) as part of their Better Regulation Initiative (Golobic & Marot, 2011).

The most influential works on TIA are within the program scope of ESPON, which take territorial cohesion as a priority in its research framework. It mainly analyse potential effects of a series of sectoral policies in a systematic way on NUTS 2 and NUTS 3 level (ESPON, 2005a, 2005b, 2005c, 2005d, 2005e, 2006a, 2006b, 2006c).

Among all the approaches and tools developed in these studies, the TEQUILA model, developed by Camagni in ESPON project 3.2 (ESPON, 2006d), most explicitly builds on a territorial cohesion concept assessing territorial impacts in two levels - the first general EU level and the later regional level. As a multi-criteria model, TEQUILA examines territorial impacts of policy in multi-dimensions with considerations of quantitative and qualitative integration, specificities of the single regions such as "vulnerability", and synthesis of components with flexible weights (Camagni, 2009). Therefore, TEQUILA seems a quite comprehensive and pioneering model for TIA insofar. But as Golobic and Marot (2011) pointed, by treating the impacts as a one-way cause-effect relation and using simple weighted summation to aggregate different criteria, TEQUILA does not overcome the common weakness also revealing in other TIA approaches – the inconsistency between the applied highly simplified linear perspective and the complex nature of the based-on territorial cohesion concept. Besides, according to the experiment of TEQUILA application on European transport policy on NUTS 3 level (Camagni, 2009), this model is still lacking operability. In the pilot case, the sub-criteria and indicators are defined without a well-developed indicator-based framework, but rely largely on data and knowledge available. As a result, it is still difficult to expect existing TEQUILA model and tools to be easily applicable in a real policy making context.

Another valuable study from ESPON is INTERCO (Indicators of Territorial Cohesion) leaded by University of Geneva. It has been in the final implementation phase after two earlier phases and supposed to be finalized in the February of 2012. INTERCO aims at developing indicators and indices to measure territorial-related effects and issues with emphasis in territorial cohesion at different geographical levels and types of regions. With well-organized literature review and stakeholder involvement, it offers comprehensive and rich information in territorial measures. Since indicators and indices are crucial elements in TIA, it could be expected that INTERCO has large value as TIA support.

3. METHODOLOGY

3.1. Conceptual Framework

3.1.1. Evaluation focus adopted from a new Logical Framework

Focusing on effects and impacts from the interested network, this study takes actual people's well-being of regions as the highest priority in evaluation. Thus, in the classical logical framework, outcome and impact are the interest of this study, instead of the other two components, saying input and output. Considering outcome indicators are the base of further analysis in effects and impacts, this study adopt an appraisal framework based on a new logical framework for performance oriented policy.

The referred framework is proposed by a team of academics and experts coordinated by Fabrizio Barca and Philip McCann for the EU as a revised monitoring and evaluation system of logical framework (Barca, McCann, & ;, 2011)[4] It was presented and discussed in the workshop "Outcome indicators and targets: towards performance oriented policy" in the 9th European Week of Regions and Cities, the so-called OPEN DAYS[5], held in Brussels in October, 2011. As a guideline of programme and project appraisal, it focuses on clarifying outcome, selecting outcome indicators and setting outcome targets as Figure 3-1 presents.

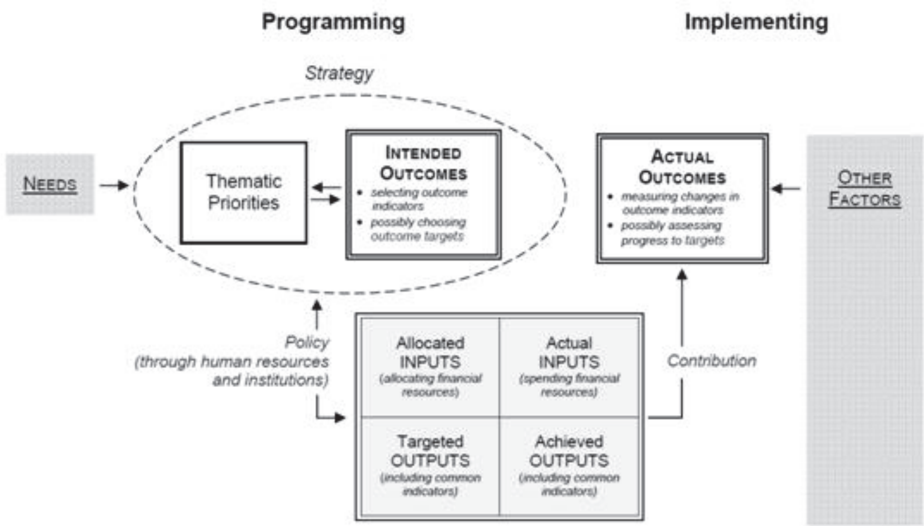


Figure 3-1 Input, Output and Outcome: a framework. Source: Barca, McCann et al. 2011

Adopting essential perspectives about "outcomes" from this framework, an adapted conceptual evaluation framework for this study is designed as Figure 3-2. This framework considers the interested network as output of the EU's policy for a common transportation market, which needs TIA to keep policy consistency. Outcome indicators grouped by thematic priorities are selected to reveal the "actual outcomes" focusing differences and changes in people's well-being in different regions. Finally, territorial cohesion effects, which should be talked at a wider EU or European scale, can be analysed through based on these actual outcomes.

4 http://ec.europa.eu/regional_policy/sources/docgener/evaluation/doc/performance/outcome_indicators_en.pdf
5 See http://ec.europa.eu/regional_policy/conferences/od2011/index.cfm

This framework is the guideline to conduct this study involving multiple themes, spatial unites and time points (or scenarios). Issues and indicators to be measured will be discussed in details again in other sections of this thesis.

Besides, during the whole process, other factors, such as influence from other policy, crisis and globalization, etc., may be "noise" that are difficult to avoid; therefore, noise analysis is necessary.

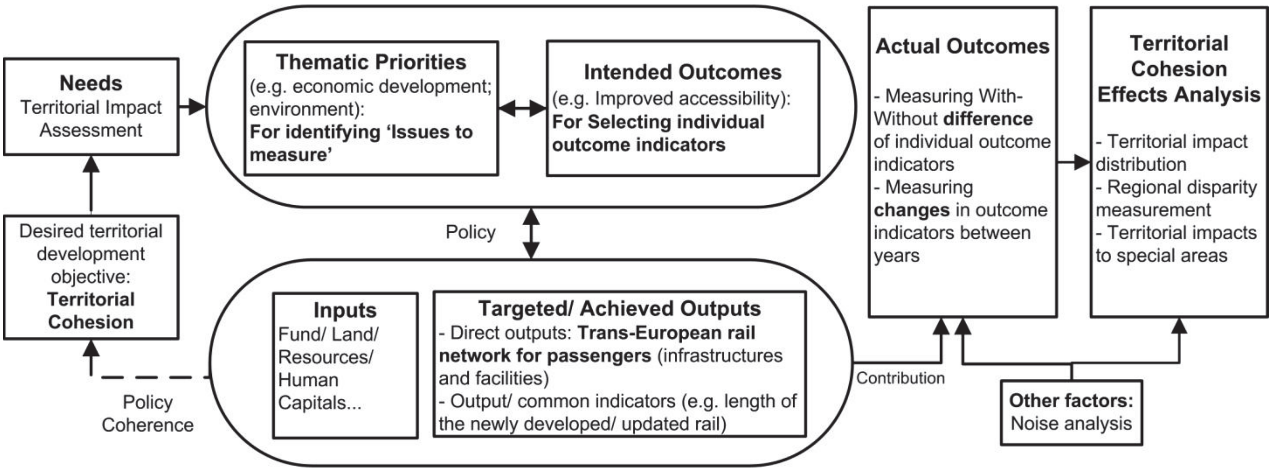


Figure 3-2 Adapted conceptual evaluation framework

3.1.2. Basic paradigm: Territorial Impact Assessment

This study will develop the expected methodology following the paradigm of TIA. It will analyse the problem in two phases (analytical-synthesis) and consider multiple dimensions/scales/perspectives as well as their interactions. In this way, the assessment results can largely serve relevant policy making process by delivering comprehensive, useful and easy-communicable information. Besides, more knowledge about territorial cohesion and targeted sectoral policy can be gained during the methodology development and application processes.

Some norms are set for developing the expected TIA:

1) Necessary links with the theoretical components and interrelationships between these components in the territorial cohesion concept that it built on;
2) Able to have an integrated assessment of the territorial effects of Trans-European Rail Networks for passenger transport at least in the general EU level;
3) Consider multiple and complementary dimensions and work as a multi-criteria assessment, in which the three dimensions (territorial efficiency, quality and identity) of the TC concept and their subcomponents base on sustainability become the criteria and sub-criteria in the model.
4) Consider data limitation for reality;
5) Capable to be adopted in other similar rail-passenger context rather than only specialized for the EU context;
6) Able to deliver useful information for the decision making process;
7) Operational and as user-friendly as possible.

3.2. Study Area

As indicated in the previous section, territorial cohesion is a policy orientation at a wide scale of the EU or even the pan Europe; therefore the ideal study area in this research should cover all the regions in Europe that can be directly or indirectly affected by the trans-European rail network. However, for the sake of ease of data collection and processing, this study only covers EU 27 territory expect for foreign departments of France and the Netherlands, Orkney Islands, Greenland, Canary, and Azores Islands, etc., which do not participate in TEN-T. The countries with the official status of the EU candidates, namely Croatia, Macedonia, Turkey and Iceland are not included due to insufficient socio-economic data or the current segregation from the TEN-T.

Keeping a completed one common EU/EEA transport space and rail network, the areas of European microstates as well as Norway and Switzerland are used when necessary, but excluded in analysis and discussions.

3.2.1. History and administration

The European Union (EU) was formed originally by six countries, namely Belgium, France, Germany, Italy, Luxembourg and the Netherlands in 1958, when the six founders united as the European Coal and Steel Community (ECSC) and the European Economic Community (EEC). The community had its first enlargement in the beginning of 1973 that Denmark, Ireland and the United Kingdom joined and raised the number of member states to nine. In 1981, Greece became the 10th member of the EU, while Spain and Portugal followed five years later in 1986. The year 1993 is an important milestone for the EU, when the Maastricht Treaty came into force. It not only established the European Union under its current name, but completed the Single Market through the 'four freedoms' of movement of goods, services, people and money. The newly established EU gained Austria, Finland and Sweden in 1995, while saw its biggest enlargement in 2004, when another 10 countries (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia) from Eastern Europe joined. Since Romania and Bulgaria became the EU's newest members in 2007, the EU has grown into an economic and political union of 27 independent member states (EU 27) until today.

During the past half century, the EU has grown not only in size through accession of new member states, but also in power by the addition of policy areas to its remit. With the three official capitals, Brussels, Strasbourg and Luxembourg, the EU united its member states by a series of policies in socio-economy development, environment and governance. Establishment of the Eurozone is among the most important EU policies - in 2002, 12 member states replaced their national currencies to euro notes except for the UK, Finland and Sweden and since then, the Eurozone has been enlarged and encompassed 17 member states nowadays. Schengen passport agreement also contributes significantly to the Union without frontiers. The latest amendment to the constitutional basis of the EU, the Treaty of Lisbon, came into force in 2009.

3.2.2. Geography and demographics

Being a part of a larger EEA, the EU covers a total area of 4,423,147 square kilometres. It has its highest peak Mont Blanc in the Graian Alps (4,810.45 metres above sea level) and the lowest point Zuidplaspolder in the Netherlands (7 metres below sea level). Only after Canada, the EU has the world's second longest coastline of 65,993 kilometres. It shares land borders with 19 non-member states for a total of 12,441 kilometres.

Population of the EU has exceeded 500 million since 2010, while the figure reaches 502.5 million according to the estimation of Eurostat on 1 January 2011. Population growth in the EU 27 is uneven that 20 of the 27 EU Member States population have increased population while population in the other seven declined in 2010-2011. The crude birth rate in the EU-27 was 10.7 live births per 1 000 inhabitants and the crude death rate was 9.7 per 1 000 inhabitants. Many regions face population aging problem.6 This large population is highly urbanised with 75% inhabitants living in the urban, which is projected to be 90% by 2020 (CEC, 2008b).

6 See more information about Population Statistics:http://epp.eurostat.ec.europa.eu/portal/page/portal/population

3.2.3. Socio-economic development

The EU has generally established a single economic market across the territory of all its members. In 2010 the EU generated an estimated 26% share (16242 billion international dollars) of the global GDP making it the largest economy in the world. Benefiting from the high growth rates of the less developed and moderately developed its Member States, the EU experienced higher economic growth per head than the US and Japan between 2000 and 2007(CEC, 2010c).

Today, the European Union is on the step of forming an Economic and Monetary (EMU), which represents a major step in the integration of EU economies. It involves the coordination of economic and fiscal policies, a common monetary policy, and a common currency, the euro. Until 2011, the euro area has covered 17 EU Member States. The euro is the single currency shared by 17 of the Member States, which together make up the euro area.

The EU has created a unique environment for individuals to live and work and business to trade freely in the Single Market. It achieves social-economic integration through large amount of flows of goods, services, investments and people. However, regional disparity among the EU's regions is also considerable. The recent economic crisis has also been more extreme in some regions than the others. To have more balanced development, regional policies of the EU are always considered as high priorities.

3.3. Analysed Units and Regional Typology

3.3.1. Analysed units

Eurostat introduced Nomenclature of Territorial Units for Statistics (NUTS) as unite multi-level statistical sub-divisions for the member and candidate states. It includes 4 levels (0-3) of division mainly based on population, but not rigidly referred. NUTS 0 is national level. NUTS 1 is the highest statistical division level, which is mainly represented by regions with population of 3-7 million. NUTS 2 contain middle-sized regions with population of 0.8-3 million. In the Netherlands, NUTS 2 represent provincial units. The current smallest statistical units, NUTS 3, are regions with 0.15-0.8 million inhabitants, for example the Twente Region. The current NUTS classification valid from 1st January 2008 until 31 December 2011 lists 97 regions at NUTS 1, 271 regions at NUTS 2 and 1303 regions at NUTS 3 level.[7]

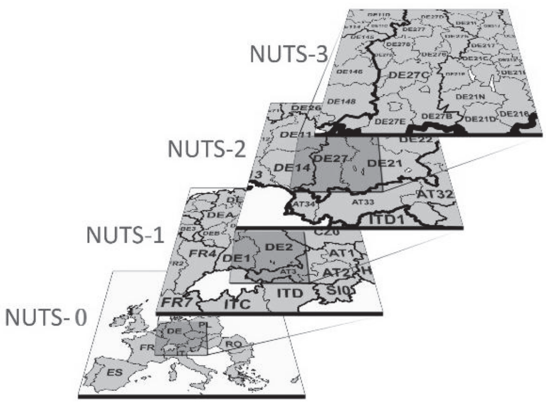


Figure 3-3 NUTS system in the EU. Source: Eurostat

Figure 3-3 shows different levels of NUTS. Among the 4 levels, NUTS 2 is considered as the basic analysed regional unites in the study. There are several reasons. Firstly, NUTS 2 is the basic regions for the application of regional policies and the most wide-spread type of administrative units across the EU. Secondly, most of the existing studies (e.g. the 5th Cohesion Report) were conducted on the NUTS 2 level. Lastly, statistics from Eurostat is more completed for NUTS 2.

7 See http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

3.3.2. Regional typology

Regions were grouped in this study based on EU's regional policy to distinguish different types of regions that played different roles in territorial cohesion practice. For the ease of comparison, this study only focused on two basic regional groups according to EU's "Convergence objective" and "Competitiveness and Employment objective". Convergence regions were concerned specifically since territorial cohesion largely accounts for reducing regional disparities.

The whole European Union is covered by one or several objectives of the cohesion policy to "promote harmonious development" and aims particularly to "narrow the gap between the development levels of the various regions". To determine geographic eligibility, the Commission bases its decision on statistical data. Europe is divided into various groups of regions corresponding to the classification known by the acronym NUTS.

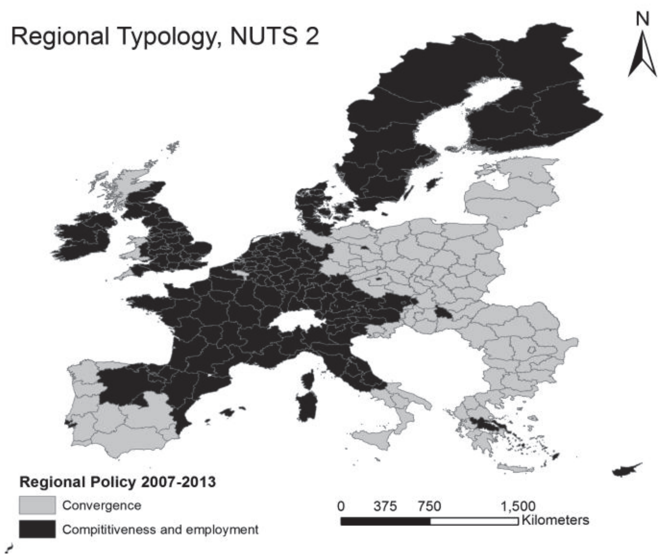


Figure 3-4 Regional typology in EU based on regional policy 2007-2013

Convergence objective (Objective 1 of the Structural Funds) is the main priority of the European Union's cohesion policy, which is set to promote growth-enhancing conditions and factors leading to real convergence for the least-developed Member States and regions. All these regions have a number of economic signals/indicators "in the red": low level of investment; a higher than average unemployment rate; lack of services for businesses and individuals and; Poor basic infrastructure. In EU-27, this objective concerns – within 18 Member States – 84 regions (NUTS 2 level) with a total population of 154 million, and per capita GDP at less than 75 % of the Community average, and – on a "phasing-out" basis – another 16 regions with a total of 16.4 million inhabitants and a GDP only slightly above the threshold, due to the statistical effect of the larger EU. The amount available under the Convergence objective is EUR 282.8 billion, representing 81.5 % of the total. It is split as follows: EUR 199.3 billion for the Convergence regions, while EUR 14 billion are reserved for the "phasing-out" regions, and EUR 69.5 billion for the Cohesion Fund, the latter applying to 15 Member States.

The Regional Competitiveness and Employment objective (Objective 2) aims at strengthening competitiveness and attractiveness, as well as employment, through a two-fold approach. First, development programmes will help regions to anticipate and promote economic change through innovation and the promotion of the knowledge society, entrepreneurship, the protection of the environment, and the improvement of their accessibility. Second, more and better jobs will be supported by adapting the workforce and by investing in human resources. In EU-27, a total of 168 regions will be eligible, representing 314 million inhabitants. Within these, 13 regions which are home to a total of 19 million inhabitants represent so-called "phasing-in" areas and are subject to special financial allocations due to their former status as "Objective 1" regions. The amount of EUR 55 billion – of which EUR 11.4 billion is for the "phasing-in" regions – represents just below 16% of the total allocation. Regions in 19 Member States are concerned with this objective.

3.4. Work Flow

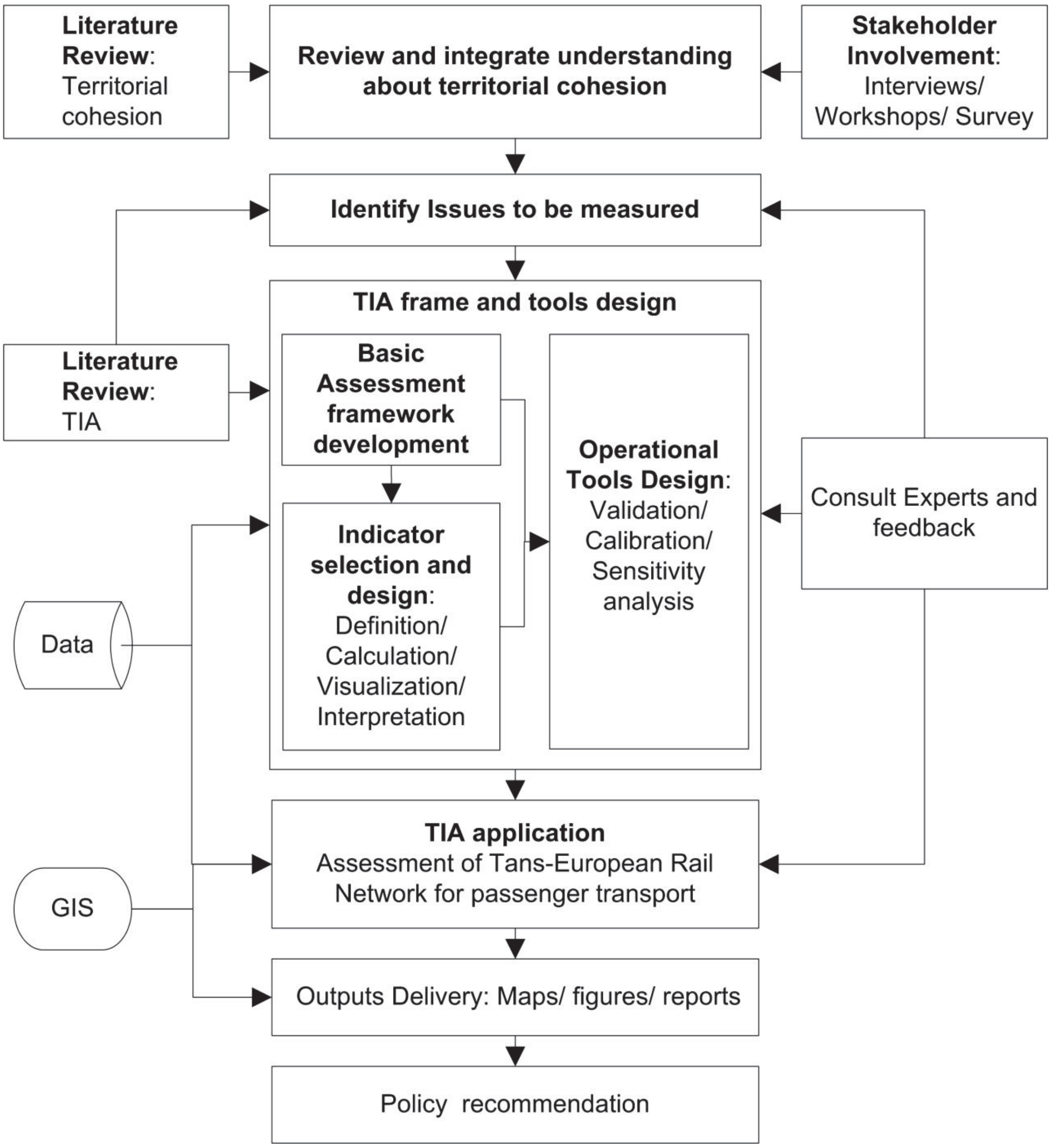


Figure 3-5 Flowchart for conducting the current study

3.5. Data and Materials

This section gives description of data and materials that desired and currently available for this study. These data and materials include transport networks and attributes, other spatial datasets with attributes such as protected sites, non-spatial data such as regional socio-economic statistics, maps, and software. Source, quality and usability of data, as well as difficulties and limitations noticed during data collection are discussed. But constraints and limitations faced during the data processing and analysis are expected to be identified and discussed in the later chapters.

Although data availability should not be considered before the methodology development, minimum data should be available to achieve expected methodology implementation including remarks about territorial cohesion effects from the network.

Indicators need to be available at sub-national level (expected NUTS-2 or NUTS-3), and for different points in time to look at the state and at the trend (development) of each indicator. The spatial dimension is vital to analyse regional disparities, while different points in time, at minimum for two different years, make it possible to reveal outcomes and trend.

Generally speaking, most of required data and materials for this study are available and can be downloaded from open sources of EU organizations, such as Eurostat, ESPON, TEN-T EA and EEA. Besides, considering the importance of networks in different time points for this study, trans-European rail network in time point 2008 was requested from RRG at a reasonable price.

Table 3-1 Data overview

Data Description	Format	Source
Trans-European Rail Network (1999)	Line and point-based shape-file	Eurostat-GISCO
Trans-European Rail Network (2005)	Line-based shape-file	The 5th Cohesion Report
Trans-European Rail Network (2008)	Line and point-based shape-file	RRG
NUTS	Polygon-based shape-file	Eurostat-GISCO
Regional socio-economic statistics	Database/Spread sheet	Eurostat
Territorial indicator values	Spread sheet	The 5th Cohesion Report/ ESPON/ Eurostat
Natural 2000	Polygon-based shape-file	EEA
Corine Land Cover 2000 (CLC 2000)	seamless vector data	EEA
Population density using CLC 2000	Raster grid	EEA
Specific locations/ Facilities (e.g. ports, airports)	Point/ Polygon-based shape-file	Eurostat-GISCO
Transport networks in other modes	Line-based shape-file	Eurostat-GISCO
Urban audits (2007/2009)	Database	Eurostat

3.5.1. Trans-European rail networks and relevant attributes

As the core datasets, trans-European rail networks in two different time points (1990s and 2008) are available from different sources.

The network from GISCO (European railway network, Version 4) for Pan Europe provides essential infrastructure (lines and nodes) information that can be used to extract the base network in the current study. Created in 1995, this network contains infrastructure railways originally digitised from 1991-1997 depending on different countries. Updating work has been conducted for several times until 2003. Different themes of attributes were available in tables within the package including the planned TEN project data according to DG TREN (Report on implementation guidelines 1996/1997), traffic data 1995 and 1997, infrastructure data and railway line project infrastructure data for the reference year.

Another well-organised network dataset comes from Büro f. Raumforschung, Raumplanung u. Geoinformation (RRG), which owns an overall database with digital data on geographical objects for Europe developed from IRPUD trans-European Transport Network Database (IRPUD, 2003; Mantyk and Altenhoff, 1992). Considering the budget limitation and data consistency with other datasets, a sub-database including the pan-European rail network (with stations) in the time point of year 2008 is requested. Basically, this railway network database contains 65,348 links and 60,231 nodes in total of 38 European countries. It fully codes TEN-T projects and provides attributes for transport modelling at regional level (e.g. link capacities, speed limits, timetable travel time, etc.). Thus, this network is the one to generate indicators for comparison with results of the network from GISCO.

Noting the original datasets are inconsistent in spatial reference and attributes, data processing has been done for further necessary network analysis. More details can be found in Appendix 1.

3.5.2. Other spatial datasets

The basic spatial dataset contain general geographical information about EU. Considering data consistency, NUTS 2006 is used for analysis in the current study. NUTS in form of polygon-based shapefiles have been downloaded from Eurostat under GISCO Reference8. NUTS 0, 1, 2, 3 levels are in a single shapefile originally, for the sake of convenience of further conduction, they are sorted and divided into 4 individual layers. All NUTS units have basic attributes and can be joined with statistics through unique codes.

3.5.3. Regional statistics

Eurostat, the EU Agency responsible for statistics, is the major source for socio-economic statistics in various themes for this study. The most recent and historical datasets are stored in databases available to download by the public. Useful regional statistics, such as economic data, population and employment, are acquired for NUTS in multiple available years.

All the datasets were downloaded in spread sheets that can easily processed and analysed in MS Excel and SPSS. They can also be joint to spatial data through consistent NUTS codes as attributes.

3.5.4. Techniques and software

In this study, GIS is the core tool to be applied for spatial analysis, while network analysis is among the most important applications to produce indicator values. GIS is also the main platform for data and results visualization.

Statistics analysis is another crucial approach for this study. Since a large amount of regional statistics will be used in the assessment, data management and analysis rely on professional software such as SPSS and MS Excel. They are also in charge of producing necessary figures and tables.

3.5.5. Limitations and comments

As to the mentioned different time points concern in this study, according to available data and their quality, at least two time points can be analysed – 1996 and 2008. Considering budget only available for one time point and the completeness of statistics in Eurostat, network in 2008 is chosen instead of more recent year of 2010 or 2011. In this case, the picture for the whole completed network in the future cannot be addressed from available data. Even RRG has already generated network projection for future years such as 2020; this study cannot have access to it due to budget limitation. On the other hand, since TEN-T is still an on-going programme, large uncertainty makes it less justified to assess such an estimated network.

Therefore, this study will focus more on (1) existing TEN-T infrastructure' effect rather than (2) effects from the expected completed network in the future. Possible difference in results from (1) and (2) can be foreseen; because uncompleted TEN projects' effect might totally change the value of TEN-T to territorial cohesion due to their unique territorial and non-territorial characteristics. This study will be unable to implement the real value from the expected methodology, but only demonstrate it on TEN-T in developing to make a starting point. Remained work is needed and principally feasible in further study by conducting scenario analysis or after interested TEN-T is completed.

8 http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/geodata/reference

Basically, there will be two well-developed rail network datasets for analysis: one as the base without TEN network in 1990s', one current network after TEN has developed for around ten years. Analysing the difference between the values for a same indicator based on the two networks is the most basic approach to examine territorial impacts. However, the mentioned territorial impacts are not the net impacts from TEN-T development rigorously, but the total one from entire European rail system development during the years. Other rail development (e.g. national rail development) is also included in DATA from RRG which can be identified.

To extract the TEN-T part, the two network themselves should be compared at least in terms of TEN and non-TEN. If comparing to TEN, other rail development has insignificant impact in territorial cohesion at the scale of the whole Europe, the difference between results from the two years' networks can be proxy of that between with and without TEN scenarios, which is wanted in the study. This assumption need to be generally verified in later sections. Or, more actions are needed in noise analysis to get reliable conclusions.

3.6. Theoretical and Participatory Approaches

Large amount of relevant information is needed for methodology development in this study, especially in the early phase of scoping. Information from different sources, e.g. political documents, scientific reports, presentations, and interviews, needs to be collected, reviewed and reorganized for structuring frame, identifying issues, as well as selecting and designing indicators. Two types of approaches will be applied:

1. Theoretical approaches: literature review and information integration. Relevant literatures include official documents from CEC, reports from organizations and institutions (e.g. ESPON), scientific articles in related topics, and web-sources, etc.

2. Participatory approaches: stakeholder interview/ survey and expert consultancy. Stakeholders and experts are contacted, consulted or interviewed through face-to-face conversations and on-line communication during the whole study.

3.7. Fieldwork and Activities

As important implementation of the participatory approaches, two events were participated to learn, communicate and network. One is the 2011 OPEN DAYS - the 9th European Week of Regions and Cities, which took place in Brussels in October of 2011. While the other one is a one-day workshop ESPON Workshop "Assessing Indicators for Territorial Cohesion" also held in Brussels in October 20th. Through the two events, better understanding in territorial cohesion and project appraisal have been formed, based on which diverse perspectives about territorial cohesion and transport were collected from contact with experts and regional stakeholders. These views contribute to sharpening scope of the expected method and selecting most relevant issues in it.

3.7.1. 2011 OPEN DAYS - the 9th European Week of Regions and Cities

Gathering around 6000 participants, the OPEN DAYS is the annual key event for EU, national, regional and local authorities to showcase and discuss EU cohesion policy's management, results and prospects. Its objectives are to exchange good practice in regional and urban development, to facilitate networking among administrations from different countries on structural funds' interventions, and to contribute to an in-depth debate on cohesion policy's achievements and prospects. The 2011 OPEN DAYS, with it headline of 'Regions and cities delivering smart, sustainable and inclusive growth', has organized 110 workshops during four days focusing on three themes - Europe 2020, Better delivery and Geography matters. 5700 participants communicated and debated the EU's newly proposed cohesion policy and the three themes.[9]

During the four days' event, I participated in different workshops mainly covering topics about impact evaluation methods, territorial cohesion views, regional project practice and regional studies involving territorial indicators. Among all these workshops, three were highly-relevant to the current study; however, even the 'non-relevant' ones also brought new ideas and potential contacts. Attending presentations and communicating with other participants were the main activities to gain knowledge and materials for this study.

3.7.2. ESPON Workshop "Assessing Indicators for Territorial Cohesion"

This workshop was organized by ESPON to have public discussion and consultancy for its on-going Indicators for Territorial Cohesion project (INTERCO). The main purpose was to review and discuss indicators' usefulness, relevance and meaningfulness based on a manageable short list of indicators proposed by the INTERCO project team after studying, discussing and testing a wide range of indicators and indices. [10]

More than 30 participants from diverse institutions and organizations, who are working on or interested in territorial relevant issues, presented in the workshop. Through presentations, group discussions, debates, panel discussion and conclusion, this workshop delivered impressive comments, remarks, proposals and suggestions for INTERCO team to better complete the project. Moreover, this workshop enhanced the understanding of territorial cohesion both in its connotation and operationalization, which has provided a guiding framework for developing specific studies in contexts, such as my current study, saying in the specific context of Trans-European rail network development in passenger transport.

9 2011 OPEN DAYS' website:
http://ec.europa.eu/regional_policy/conferences/od2011/index.cfm?nmenu=1&sub=100

10 Web page for more information about ESPON Workshop 'Assessing Indicators for Territorial Cohesion': http://www.espon.eu/main/Menu_Events/Menu_Workshops/workshop111020after.html

4. A PROPOSAL FOR AN ASSESSMENT METHOD

This section is a proposal for a TIA method which is supposed to reveal territorial impacts with specific consideration in territorial cohesion in the context of TEN passenger rail sector.

The term "territorial impacts" was interpreted as impacts on regional socio-economic development, considering both real effects from the trans-European rail network and sensitivity to these effects from different regions(Camagni, 2009). For example, impacts on the distribution and location of economic activities, on regional labour markets and commuting flow, impacts on population distribution and migration, and on local environment and resources and so forth.

4.1. General Frame

This TIA method is basically a multi-criteria model based on the multiplicity of its heart – territorial cohesion. Multi-criteria assessment approach is scientifically well-developed and widely followed in practice such as the Strategic Environmental Assessment (SEA). The three dimensions of the favoured territorial cohesion concept naturally become the criteria in this method. Sub-criteria inside the three criteria are from more concreted issues selected and organised according to pre-study and interactive public presentations and discussions. More details will be discussed in the next section.

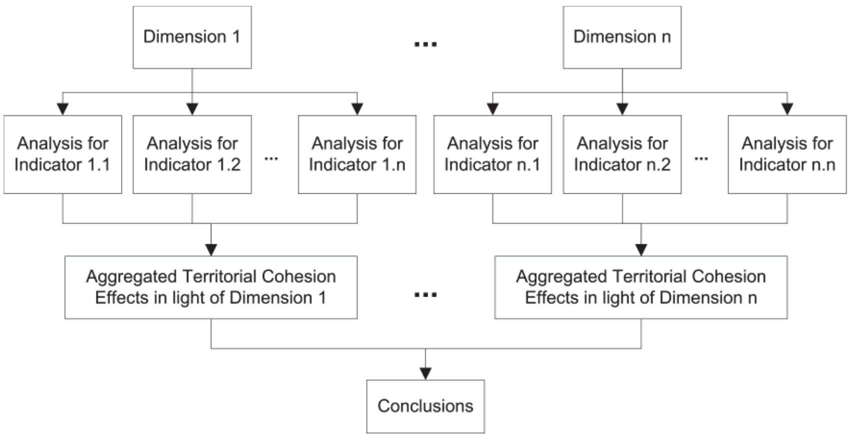


Figure 4-1 General way from territorial indicators to territorial cohesion

As shown in Figure 4-1, for the three dimensions, namely territorial efficiency, territorial quality and territorial identity, there are multiple issues. They structure the criteria tree together with relevant complementary indicators and contribute to the general conclusions in terms of territorial cohesion. Quantitative-based analysis for individual sub-criteria and followed qualitative-based analysis for comprehensive territorial cohesion indications lead to final results and conclusions. Analysis for a single territorial indicator and its extension only reflects some extent of territorial cohesion but act as facets in the whole story of territorial impacts and territorial cohesion. To avoid bringing transparent results of criteria into simple aggregated values with unconvincing meanings, synthesis of criteria is conducted in a qualitative way so that more information can be kept in discussion.

4.2. TEN Rail Relevant Issus in Light of Territorial Cohesion

When selecting issues, different level of comprehension needed to be taken into account. Table 4-1 lists factors that may determine territorial cohesion effects from in the sustainability framework. These factors are foundations for issues and indicators as key components in the assessment frame developed in this study.

Table 4-1 Sustainability dimensions and factors that may determine territorial cohesion effects

Sustainability Dimensions				
Economic	Socio-Cultural	Physical		Institutional
		infrastructure	Non-infrastructure	
– Productivity/ GDP; – Local productivity; Development trend; – Income – Economic activity – agglomeration; – Labour market; – Labour cost; – Travel cost; – Innovation	– Population/inhabitants – Population density – Household amount – Age and gender – Commuter/ workforce – External commuting population – Cross-board traffic flows – Immigration – Urbanization – City size – Potential integration areas (geographic nearby) – Location (core-peripheral) – Unemployment/ employment – Safety	– Rail infrastructure endowment (Rail length/ density; vehicle amount; stations, etc.) – Supporting infrastructure endowment (e.g. bus line to train stations) – Sustainable infrastructure – Facility capacity	– Green land; – Fuel resource; – Air quality; CO2/ NOx; – Noise; – Land; – Habitat	– Organizations; – Institutional cooperation; – Governance

To further develop indicators for real operation, it was necessary to sharpen the understanding of what territorial cohesion may comprise about passenger rail in this study according to literature review and the conducted several activities that bring knowledge and perspectives.

In discussion for transport impacts, accessibility is always the most highlighted aspect, under the umbrella of which variance of accessibility indicators have been developed in previous studies (e.g. ESPON, 2005a). In this study, a few of typical accessibility indicators were selected and applied following different rationale with their specific interpretation. Consequently, other transport-relevant concerns including connectivity, transport fairness, sustainable transport and infrastructure endowment have also been raised to complement accessibility to assess effects from trans-European rail network in the territorial cohesion frame. A set of core issues have been extracted:

Territorial Efficiency

1) Infrastructure endowment: regional inventory of infrastructures for current use and developing potential, e.g. rail length, rail density, rail station amount, rail station level and capacity, etc.
2) External accessibility: regional accessibility to external developing opportunities, services, social connections, which is a crucial attractiveness and capital for a region in globalization and collaborative development.
3) Network efficiency: rail network performance in travel speed, connectivity, operation stability, etc.

Territorial Quality

4) Fair accessibility: spatial equity in terms of accessibility including access to the network and accessibility to facilities and services gained from the rail network
5) Environmental risk: Either existed or potential environmental risk directly or indirectly caused by the rail network.
6) Sustainable transport: environmental- and social-friendly infrastructure and management covering aspects of energy consumption, noise, emission, safety, etc.

Territorial Identification

7) Local identification: Awareness and identification of regions through train stations and passing-by traffic flows.
8) Land use and landscape: rail related or influenced land occupation, land use change and relevant activity change, landscape visualisation, etc.
9) Knowledge and innovation: physical environment for developing innovative economy and society in terms of accessibility to high educational institutions, cultural institutions, high-tech hubs, high-educated workforce, etc.

4.3. Three Types of Indicators

Sharing by global impact assessment (IA) approaches, indicators take crucial roles in the assessment. In this study, indicator selection will follow the general steps applied in policy appraisals (e.g. ESPON, 2005a, 2005b, 2005c, 2005d, 2005e, 2006a, 2006b, 2006c; Golobic & Marot, 2011).

There are three kinds of indicators applied in different phases of the method. The first kind is called 'basic territorial indicators', which measure territorial-relevant situation of a region in a scenario. The second kind is called 'territorial impact indicator', which is generated from the change in basic territorial indicator in different scenarios. The last kind of indicators is named 'territorial cohesion effect indicators', which are further generated in the analysis of territorial impacts in regions grouped as lagging and non-lagging. For each single basic territorial indicator, there are corresponding territorial impact indicator and territorial cohesion effect indicators. So the first step to operate indicator analysis is selecting the basic territorial indicators for chosen criteria or sub-criteria.

4.3.1. Basic territorial indicator

Sources for the basic territorial indicator inventory mainly come from institutions such as ESPON, OECD, World Bank, etc., as well as relevant academic studies (e.g. Bröcker et al., 2010; Condeco-Melhorado, Gutierrez, & Garcia-Palomares, 2011; Karst T Geurs, van Wee, & Rietveld, 2006; Gutiérrez, Condeço-Melhorado, López, & Monzón, 2011; Lopez, Gutierrez, & Gomez, 2008; Lopez, Monzon, Ortega, & Quintana, 2009).

Each of the raised issue can be principally indicated by multiple basic territorial indicators according to specific data conditions.

Table 4-2 displays example indicator alternatives for the nine issues as initial indicator selection and design. Most of these indicators were proposed or applied in previous study by researchers or institutes.

Table 4-2 Example territorial indicators per issue

Dimensions	Issues	Example basic territorial indicator alternatives
Territorial Efficiency	Infrastructure endowment	Inhabitants per train station
		Rail length per million inhabitants/ GDP
		Amount of high speed rail stations
	External accessibility	Potential accessibility to flights
		Travel time to the closest top ten MEGAs
		Potential accessibility to employment
		Daily accessibility to population within 5 hours
	Network efficiency	Average on-network travel speed
		Average Hours delayed per day in stations
Territorial Quality	Fair accessibility	Regional disparity in fastest travel time to the regional centre
		Regional disparity in fastest travel time to the closest international airport
		Regional disparity in potential accessibility of employment/ GDP/ population
	Environmental Risk	% of protected natural areas within risk distance to rail infrastructure
	Sustainable transport	Annual energy consumption per GDP
		Annual Spending on fuel as % of GDP
		CO2/ NOx emission per year per passenger/ GDP
		% of population influenced by noise from rail traffic
		Loss of postponement of other transport due to construction (e.g. road/rail blocked)
		Annual number of accidents
Territorial Identity	Local identification	Annual external visitors through rail
		Annual trains/ passengers passed by
		% of fund that comes from the EU for rail projects in a region
		Number of trans-border collaborative projects
	Land and landscape	% Area of land occupied by TEN rail development for passengers
		Occupied Land value depreciation per unit area
		Commercial area/ profit developed around TEN stations
		Land fragmentation level
	Knowledge and innovation	Daily accessibility to UNESCO heritage sites within 5 hours
		Potential accessibility to potential innovative human resource
		Daily accessibility to universities and research institutions

4.3.2. Territorial impact indicator

Territorial impact indicators are simply taken as either the absolute or relative change of basic territorial indicators. The values can indicate different types and levels of territorial impacts according to applied classification methods. Basically, there are three types of territorial impacts – positive, no/ marginal and negative territorial impacts, which are identified by the marginal range around zero value.

For more detailed regional analysis, positively (or negatively) impacted regions can be subdivided into more groups based on levels of the positive (or negative) territorial impact. In the later described method demonstration, positively impacted regions are subdivided into two groups with high and low levels of positive impact. The two groups contain same number of regions, which means the high level and low level here are relative. Similar classification is also conducted for regions with negative territorial impacts.

4.3.3. Territorial cohesion effect indicator

For a quick judgement in the research question of whether the checked trans-European rail network contributes to or hampers territorial cohesion in the study area, territorial cohesion effect indicators are designed based on a core principle: territorial cohesion is enhanced if lagging regions gain more or lose less than that non-lagging regions gain or lose. To be comparable, relative portion, instead of absolute number, of lagging regions are compared with that of non-lagging regions. The principle is translated as: territorial cohesion is enhanced in terms of a certain dimension,

1) if the portion of lagging regions with positive territorial impact is larger than the portion of non-lagging regions with positive territorial impact, or

2) if the portion of lagging regions with negative territorial impacts is smaller than the portion of non-lagging regions with negative territorial impacts.

Based on the two Ifs, territorial cohesion effect indicator in terms of a certain type of territorial impact i (positive impact or negative impact) and a certain issue j (e.g. external accessibility) ($\mathrm{TCEI_{ij}}$) can be calculated by:

$$\mathrm{TCEI_{ij}} = \frac{\mathrm{NL_{ij}}}{\mathrm{NL_j}} - \frac{\mathrm{NN_{ij}}}{\mathrm{NN_j}},$$

NL: number of lagging regions
NN: number of non-lagging regions.
NL_i number of lagging regions with i type territorial impact
NN_i: number of non-lagging regions with i type territorial impact

Possible values of TCEIij range between -1 to 1. Table 4-3 displays how $TCEI_{ij}$ indicates territorial cohesion effects. Absolute value of $TCEI_{ij}$ indicates extent.

Table 4-3 Indications of $TCEI_{ij}$

	i= positive impact/high positive impact	i= negative impact/ high negative impacts
$0 < TCEI_{ij} \leq 1$	Pleased	Unpleased
$TCEI_{ij} = 0$	Fair	Fair
$-1 \leq TCEI_{ij} < 0$	Unpleased	Pleased

Combinations of TCEIs in both positive and negative territorial impacts need to be examined for more comprehensive judgement about territorial cohesion effects. More discussion about combination is available in the next section.

4.4. Individual Sub-criterion Analysis

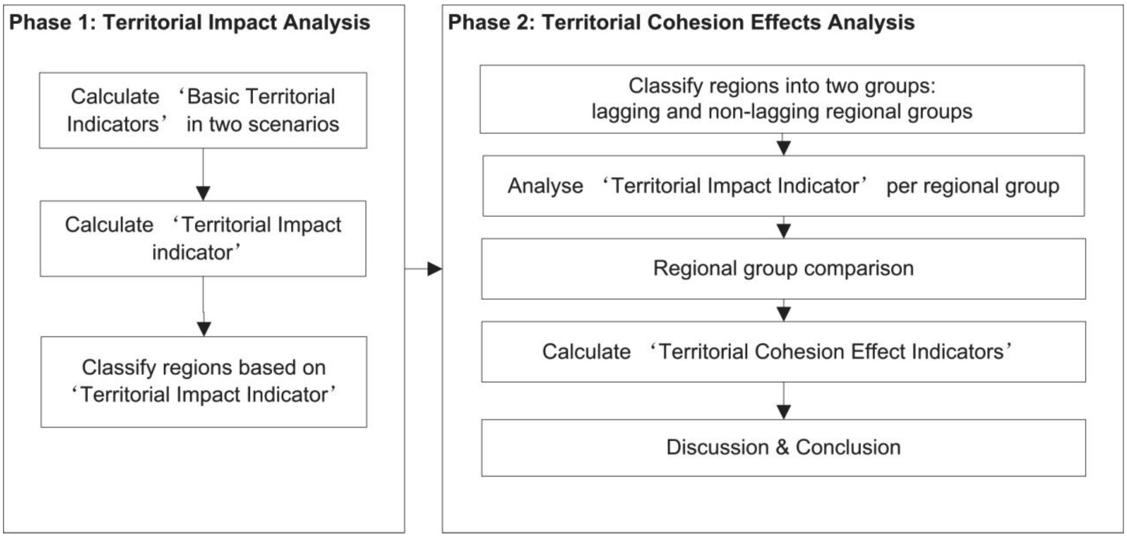


Figure 4-2 Phases and strategies to analyse individual indicators towards territorial cohesion effects

To perform the "analysis of sub-criterion"-step as indicated in the general framework, a series of actions are conducted for each individual basic territorial indicator to reveal partial territorial cohesion effects of the trans-European rail network. Basically, two phases are conducted as showed in Figure 4-2.

Phase 1 is focusing on generating basic territorial indicators and relevant territorial impact indicator for each single spatial unit (region). All basic territorial indicators are analysed to reveal territorial impacts in at least two basic scenarios with explicit time points or assumed with-without scenarios. Territorial impacts are mainly measured by the change between results of selected basic territorial indicators in a pair of scenarios. Finally, regions are classified according to values of territorial impact indicator into three basic classes (positive, no/marginal and negative) or five classes by subdividing positive and negative ones again into two subclasses. In this phase, maps are output from ArcMap for visualisation, which can show information such as distribution and variance in territorial situation and relevant territorial impacts throughout interested territories. However, none explicit conclusions can be made in the sense of territorial cohesion. Classified regions on the base of territorial impacts generated in this phase are input into analysis in phase 2.

Phase 2 is aiming at examining territorial cohesion effects caused by trans-European rail network development. Considering regional disparity reduction as the most explicitly expected result of territorial cohesion policy, this phase focuses on regional differentiation. Unlike analysing regions as individuals as in phase 1, here regions are analysed in groups in terms of lagging and non-lagging classifications. In this study, lagging regions are identified as regions under the convergence objective of the EU's regional policy, while non-lagging regions refer to regions under the competitiveness and employment objective. In other cases, lagging and non-lagging regions can also be based on urban-rural, countries, or policy-orientated types. But no matter which typology is used, the focus of this analysis will be on the effects, relatively between lagging regions and their gaps to developed regions. The actual applied typology needs to be selected according to its specific indicator context. Territorial cohesion effect indicators in terms of different territorial impacts are generated and combined to have final discussions and conclusions. For one dimension, two pairs of TCEIs are analysed together:

1) TCEIs based on positive impact and negative impact ($TCEI_p$ and $TCEI_n$); and
2) TCEIs based on high positive impact and high negative impact ($TCEI_{hp}$ and $TCEI_{hn}$).

Values of TCEIp and TCEIn (or TCEIhp and TCEIhn) can have nine combinations indicated in Table 4-4.

Outputs of this phase are more in forms of tables, figures and texts.

Table 4-4 Value combination of TCEIs and relevant interpretation and overall judgement

Value combination of $TCEI_p$ and $TCEI_n$ (or $TCEI_{hp}$ and $TCEI_{hn}$)	**Interpretation**	**Overall Judgement**
$TCEI_p > 0$, $TCEI_n < 0$ ($TCEI_{hp} > 0$, $TCEI_{hn} < 0$)	Larger portion of lagging regions are positively impacted and smaller portion of lagging regions are negatively impacted. Territorial cohesion effect is positive in terms of either positive or negative territorial impacts.	Good
$TCEI_p > 0$, $TCEI_n > 0$ ($TCEI_{hp} > 0$, $TCEI_{hn} > 0$)	Larger portion of lagging regions are positively impacted, but larger portion of lagging regions are negatively impacted as well. Territorial cohesion effect is complex. Lagging regions are impacted more significantly by the interested network than non-lagging regions.	Complex
$TCEI_p < 0$, $TCEI_n < 0$ ($TCEI_{hp} < 0$, $TCEI_{hn} < 0$)	Smaller portion of lagging regions are positively impacted, but smaller portion of lagging regions are negatively impacted as well. Territorial cohesion effect is complex. Lagging regions are impacted less significantly by the interested network than non-lagging regions.	Complex
$TCEI_p < 0$, $TCEI_n > 0$ ($TCEI_{hp} < 0$, $TCEI_{hn} > 0$)	Smaller portion of lagging regions are positively impacted and larger portion of lagging regions are negatively impacted. Territorial cohesion effect is negative in terms of either positive or negative territorial impacts.	Bad
$TCEI_p > 0$, $TCEI_n = 0$ ($TCEI_{hp} > 0$, $TCEI_{hn} = 0$)	Larger portion of lagging regions are positively impacted and equal portion of lagging regions are negatively impacted. Territorial cohesion effect is overall positive.	Good
$TCEI_p = 0$, $TCEI_n > 0$ ($TCEI_{hp} = 0$, $TCEI_{hn} > 0$)	Equal portion of lagging regions are positively impacted, but larger portion of lagging regions are negatively impacted. Territorial cohesion effect is overall negative.	Bad
$TCEI_p < 0$, $TCEI_n = 0$ ($TCEI_{hp} < 0$, $TCEI_{hn} = 0$)	Smaller portion of lagging regions are positively impacted, and equal portion of lagging regions are negatively impacted. Territorial cohesion effect is overall negative.	Bad
$TCEI_p = 0$, $TCEI_n < 0$ ($TCEI_{hp} = 0$, $TCEI_{hn} < 0$)	Equal portion of lagging regions are positively impacted and smaller portion of lagging regions are negatively impacted. Territorial cohesion effect is overall positive.	Good
$TCEI_p = 0$, $TCEI_n = 0$ ($TCEI_{hp} = 0$, $TCEI_{hn} = 0$)	Equal portion of lagging regions are positively impacted or negatively impacted. Territorial cohesion effect is overall fair	Fair

5. METHOD APPLICATION

This Chapter reports a testing method implementation based on available datasets. Section 5.1 describes indicators and scenarios used in this experiment; the following three sections mainly display results and discussions for these indicators organised by the three components of territorial cohesion; while the last section concludes the implementation from a more aggregated view.

5.1. Implemented Indicators and Scenarios

Inside each of the three dimensions of territorial cohesion and the nine issues under each of the three dimensions, multiple indicators can be used. However, in the pioneering experiment, only eight territorial indicators have been selected as listed in Table 5-2. The sub-criterion 'local identification' under 'Territorial identity' has not been included in the analysis among the nine issues proposed in the previous section, because no proper indicator can be realised. Although 'Local identification' is supposed to be an important issue and relevant data should be available in EU's statistics agencies, unfortunately, this study is not able to have access to such data. Only single indicator has been selected for each of the other eight sub-criteria for the ease of understanding and operation.

All selected territorial basic indicators were analysed to reveal territorial impacts based on two basic scenarios with explicit time points, indicators coded by 2, 3, 4 and 9 have also been calculated for an assumed scenario as explained in the following table (Table 5-1).

Table 5-1 Scenarios for indicator calculation

Scenarios	Description
Basic A	Based on rail network around year 1996 with data source of Eurostat-GISCO
Basic B	Based on rail network around year 2008 with data source of RRG
Assumed C	Based on assumed rail network, in which all rail projects in plan or in construction had been completed. Developed from RRG rail dataset.

Territorial impact is simply indicated by the absolute or relative change in values of basic territorial indicators in different scenarios. These territorial impact indicators, which are further analysed to judge territorial cohesion effects mainly through comparing convergence regions and competitiveness regions. They finally lead to empirical judgement about whether trans-European rail network for passenger transport is consistent with territorial cohesion.

Table 5-2 displays the basic territorial indicators and relevant territorial impact indicators with consideration in practical conditions in terms of available data and time limitation. Detailed description about design of these indicators can be found in the appendix. It also displays desired direction of each indicator, where '+' means higher value is desired, while '-' means lower value is desired.

Maps of basic territorial indicators and territorial impact indicators are made for visualisation, while statistics analysis is the major mean to scientifically read all these indicators.

According to territorial impact indicator values, regions are classified into three categories – (1) positively impacted regions, (2) not/ marginally impacted regions and (3) negatively impacted regions. Standards of the classification can be found in the appendix. Based on two attributes of regions, namely the territorial impacts and regional objectives, territorial cohesion can be discussed in the EU level, which can be found in the last section of this chapter.

Table 5-2 Final realised basic territorial indicators and territorial impact indicators

Dimension	Code	Issue	Basic territorial indicators (desired direction)	Territorial impact indicators (desired direction)
Territorial Efficiency	1	Infrastructure endowment	Million inhabitants per train station (-)	Absolute change between values of BTI in scenario A and B (-)
	2	External accessibility	Fastest travel time to the closest top 10 MEGAs according to GDP rank (-)	Relative change between values of BTI in scenario A and C (-)
	3	Network efficiency	Average potential capacity in travel speed (+)	Relative change between values of BTI in scenario A and C (+)
Territorial Quality	4	Fair accessibility	Regional disparity in fastest travel time to the closest international airports (-)	Absolute change between values of BTI in scenario A and C (-)
	5	Environmental risk	Percentage area of Natural 2000 within 1km distance to rail infrastructure (-)	Absolute change between values of BTI in scenario A and B (-)
	6	Sustainable transport	Share of electrified rail length out of the total rail length (+)	Absolute change between values of BTI in scenario A and B (+)
Territorial Identity	7	Local identification		
	8	Land and landscape	Rail density level as proxy to land fragmentation (-)	Absolute change between values of BTI in scenario A and B (-)
	9	Knowledge and innovation	Potential accessibility to human resource in science and technology (+)	Absolute change between values of BTI in scenario A and C (+)

5.2. Territorial Impact Anlysis

5.2.1. Infrastructure endowment

Infrastructure endowment is a kind of physical capital for a region to rely on for transport development. Moreover, existing infrastructure pattern has explicit influence in allocating updating and new rails. Among all kinds of rail infrastructure, train stations play extremely important roles. Since train stations are the only entrances and exits of rail network, their quantity and distribution largely determine how much and how well inhabitants in a region can take advantage of the whole network. Therefore, number of train stations of a region can be one proxy of regional benefit from the trans-European rail network development. When diverse regional demography characteristics have also been considered, real utility of infrastructure endowment in a region can be revealed in some extent. Considering regional population largely determines regional rail passengers, million inhabitants per rail station has been selected as a proxy for revealing utility of these train stations, or in other words, as the basic territorial indicator for the sub-criterion of infrastructure endowment.

This basic territorial indicator can indicate the status of infrastructure endowment for each region, and the general distribution of train station in the study area. The principal desire is that the more inhabitants have to share a station, the lower level of infrastructure sufficiency a region has, the less advantage a region has in terms of infrastructure endowment. Absolute difference (unit: thousands inhabitants) in the values of this basic territorial indicator in Scenario A and B is used as the territorial impact indicator.

Table 5-3 below shows the basic statistics of the basic territorial indicator in two scenarios and the territorial impact indicator. From statistics of the basic territorial indicator, decreased mean and median reflects years of rail development in the EU generally improves rail stations' sufficiency for inhabitants in European regions; while the smaller standard deviation shows reduction in regional disparity in infrastructure endowment. From the territorial impact indicator, correspondingly, negative values in mean and median, together with a smaller standard deviation convinces the general improvement.

Table 5-3 Statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'infrastructure endowment' criterion

Items	Basic territorial indicator: Thousands inhabitants per rail stations		Territorial impact indicator: Changed inhabitants per rail stations
	Scenario A (1996)	Scenario B (2008)	
Number of valid regions*	248	255	248
Mean	34615	26689	-7664
Median	23673	19534	-322
Std. Deviation	39834	31171	25931
Minimum	2394	2313	-127053
Maximum	336000	352000	51000

* There are 255 interested NUTS2 regions, but some of them may have no data for indicator analysis.

Figure 5-1 is the map of potential territorial impact of infrastructure endowment change showing the result of territorial impact indicator derived from the basic territorial indicator (see the maps in Appendix 4) including a histogram showing the distribution of the territorial impact indicator. It is obvious that values around 0 revealing marginal territorial impacts take the largest portion. It can be observed that the potential impacts of rail development in terms of infrastructure endowment vary considerably across the EU. Most of the regions have no/marginal impact mainly locating in western and central Europe. Particularly negatively affected regions are primarily found in Spain, Portugal and Italy in the southern Europe, Belgium, the Netherlands, Germany and Poland, as well as a couple of regions in Finland. The main reason is that these regions have reduced number of rail stations but increased population during 2000 to 2008. In this case they have less sufficient infrastructure per capita in rail station endowment than other analysed regions. While, a number of regions in France, the Eastern and Southern Europe are witnessing positive potential impacts benefiting mainly from significant increase in number of rail stations. The variance reflects uneven infrastructure development in the EU during the analysed time period. Situations are also quite different from region to region in the convergence group impressively, e.g. convergence regions in Ibérian Peninsula and Germany are negatively impacted, but those around the Baltic Sea, in Greece, Bulgaria and Romania are benefited.

Figure 5-2 is a boxplot for comparing territorial impacts in infrastructure endowment to convergence regions and competitiveness regions. Generally, this boxplot shows that the two groups do not significantly differ according to the major T-bar. But the convergence group has obviously smaller degree in dispersion more or less around 0, which means the development of rail infrastructure relatively less impacts convergence regions. Uneven development in terms of infrastructure endowment is more serious among competitiveness regions.

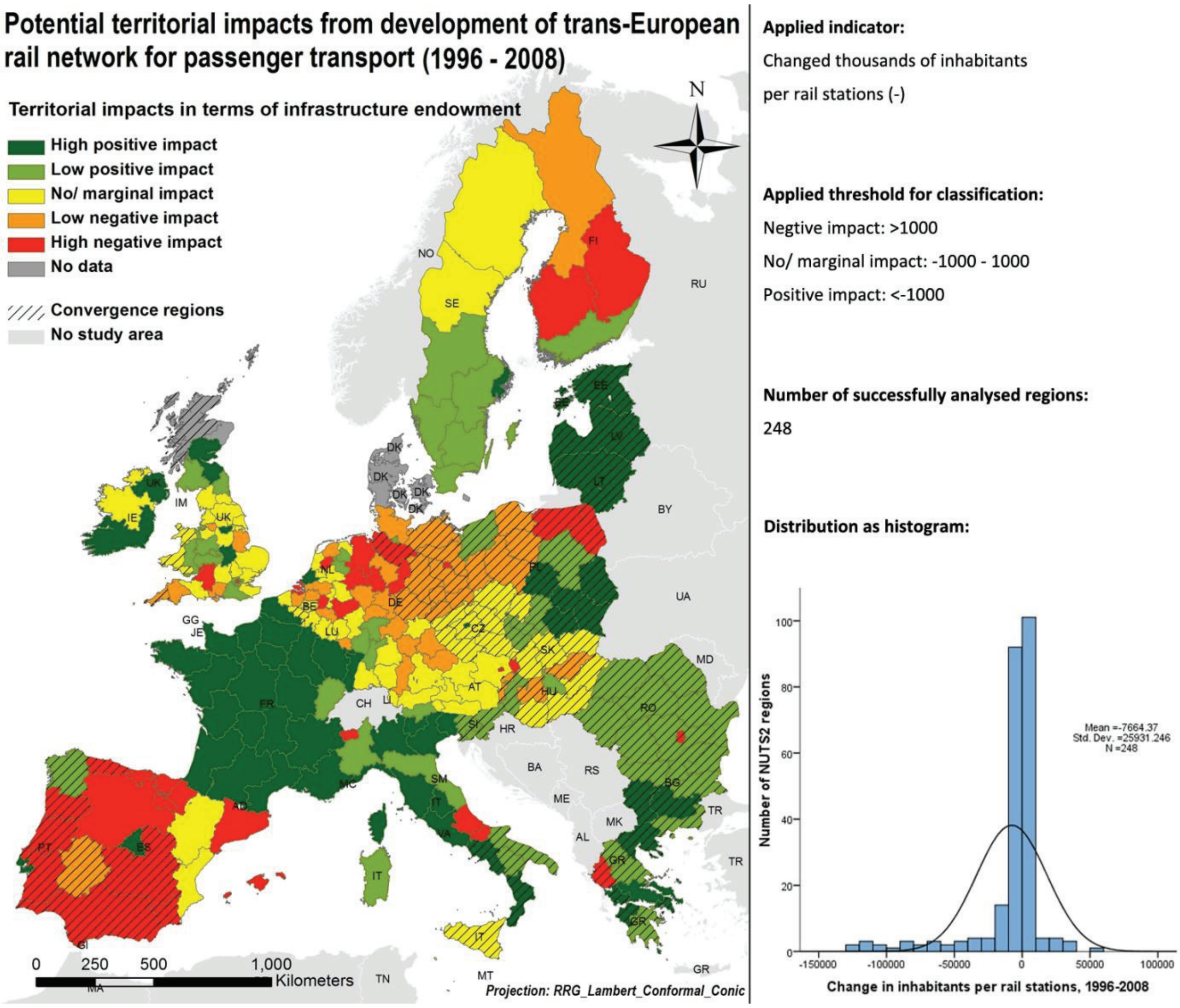


Figure 5-1 Potential territorial impacts from development of TEN rail in passenger transport in terms of infrastructure endowment

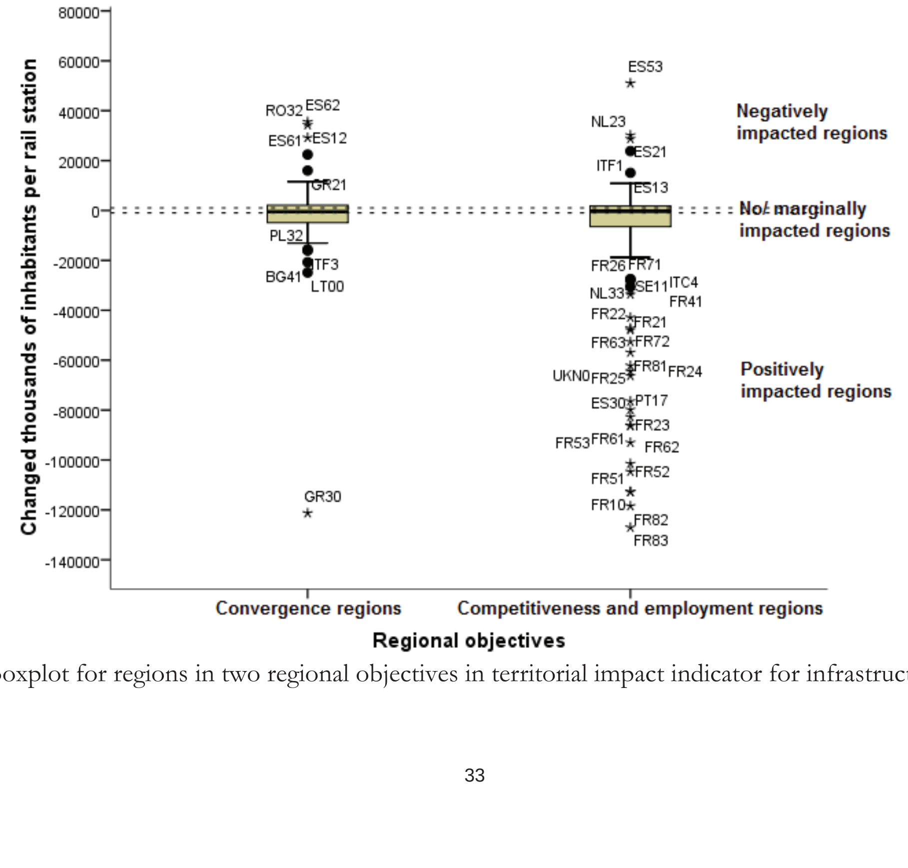


Figure 5-2 Boxplot for regions in two regional objectives in territorial impact indicator for infrastructure endowment

5.2.2. External accessibility

External accessibility is easily understood as the accessibility to external opportunities such as services, markets, human resources, etc. Therefore many different kinds of accessibility indicators can be used for this criterion. For demonstration, this study choose to take the top 10 large metropolitan agglomerations according to GDP rank in the EU (MEGAs) as external opportunities for regions. Because many projects of the trans-European rail network focusing on passenger transport, especially the high speed rail projects, aim largely at connecting core European metropolitans to mostly increase European added-value. While the top 10 MEGAs according to GDP, are the most important metropolitan areas in the EU. As large metropolitan agglomerations, they accommodate large number of population (9 of the 10 MEGAs according to GDP are among the top 10 MEGAs according to population), support significant economic activities and service, generate employment, and promote creativity and cultural development.

The basic territorial indicator is travel time in minutes to the closest top 10 MEGAs, which can indicate the status of external accessibility for each region, and the general distribution of accessibility conditions in the study area. The principal desire is that the faster a region can access to a MEGA, the higher level of external accessibility a region has, the more advantage a region has.

Since enhancing mobility and accessibility is the most important objective of the interested network, territorial impact indicators based on this basic territorial indicator can be convincing proxies of territorial impact in terms of external accessibility. Relative change in travel time from a region to its closest MEGA in Scenario A and C is used as the territorial impact indicator. It is negatively desired because reduction in the basic territorial indicator indicates less cost to access to all service and opportunities the MEGAs offer and increase in potential opportunities and well-being for the region.

Table 5-4 Statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'external accessibility' criterion

Items	Basic territorial indicator: Minutes to the closest top 10 MEGAs through rail		Territorial impact indicator: % Change in travel time to the closest top 10 MEGAs through rail
	Scenario A (1996)	Scenario C (TEN-T completed)	
Number of analysed regions	255	255	255
Number of summarised regions*	249	253	249
Mean	625	349	-0.39
Median	414	211	-0.43
Std. Deviation	588	380	0.5650
Minimum	1	12	-0.97
Maximum	2678	2000	7.67

* The number of summarised regions is smaller than the total number of analysed regions because some regions have no access to any MEGAs in the settle network analysis, so that the value for the basic territorial indicator is NULL. But when classifying regions based on the territorial impact indicator, these regions can also be included considering the real impacts instead of calculated numeric values.

Table 5-4 above shows the basic statistics of the basic territorial indicator in two scenarios and the territorial impact indicator. From statistics of the basic territorial indicator, largely decreased mean and median reflects significant improvement in accessibility among European regions. Consequently, the largely reduced standard deviation witnesses a significant reduction in regional disparity in terms of external accessibility. From the territorial impact indicator, correspondingly, negative values in mean and median, together with a tiny standard deviation convinces the pleased improvement in general sense.

Figure 5-1 is the map of potential territorial impact of external accessibility change showing the result of territorial impact indicator derived from the basic territorial indicator (see the maps in Appendix 4) including a histogram showing the distribution of the territorial impact indicator. Based on the arbitrary regional classification indicated in the map, only a few of regions get non-positive territorial impact in terms of external accessibility, showing the impressive achievement of rail development the EU can enjoy once the TEN-T is completed. Convergence regions also share lots of the big advantage. A couple of regions in Finland, as well as Ipeiros region in Greek suffer from negative impacts due to real accessibility problem. However, results for Madrid region, Brussels region and Paris region should be caused by the network analysis. Actually, it is unnecessary to take a train in reality since the three regions themselves are among the top 10 MEGAs.

Figure 5-4 compares territorial impacts in external accessibility to convergence regions and competitiveness regions. This boxplot shows that the two groups do not significantly differ according to the major T-bar. That means the improvement of external accessibility is relatively even between convergence regions and competitiveness regions.

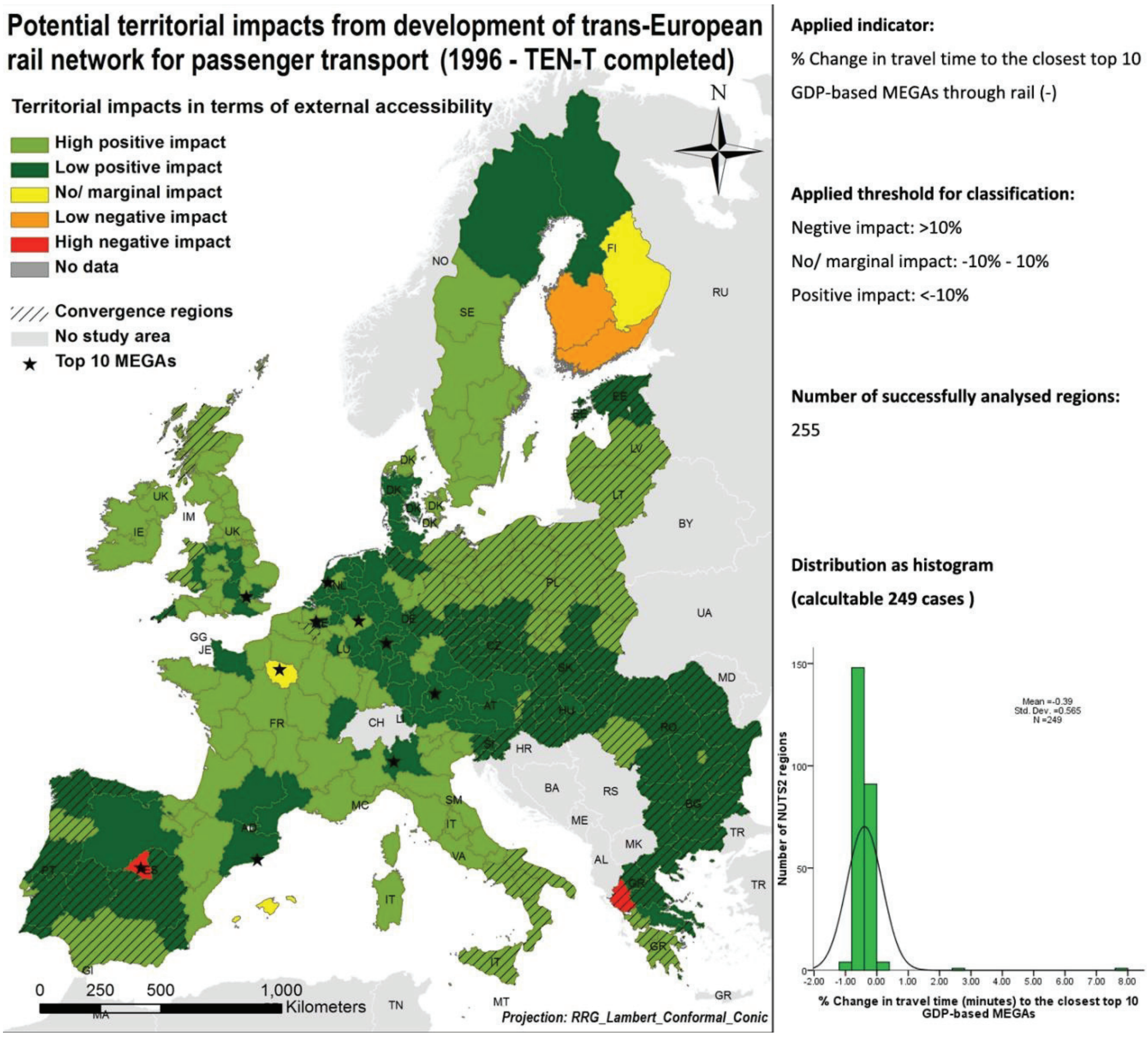


Figure 5-3 Potential territorial impacts from development of TEN rail in passenger transport in terms of external accessibility

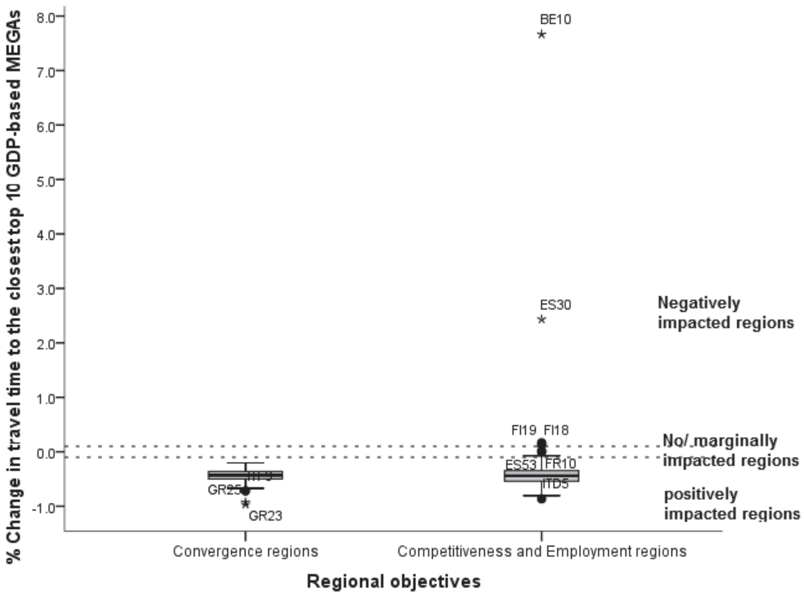


Figure 5-4 Boxplot for regions in two regional objectives in territorial impact indicator for external accessibility

5.2.3. Network efficiency

This criterion checks the general performance of rail networks within a region. The selected indicator is the average travel speed on the network with positive desired direction. Faster travel speed means less time cost, which brings new opportunity by connecting units in a region more efficiently. It will benefit trade, business communication, as well as labour exchange, etc. Increasing network efficiency in a region can also add attractiveness and development potential for this region. The territorial impact indicator is derived from the relative change. The more in speed increase, the better situation is supposed for a region. A more balanced trend in speeding is desired to contribute to territorial cohesion.

Table 5-5 below shows the basic statistics of the basic territorial indicator in two scenarios and the territorial impact indicator. From statistics of the basic territorial indicator, increased mean, median, minimum and maximum indicates overall speeding and network efficiency enhancement. However, the risen standard deviation reflects uneven levels of speeding that relevant regional disparity is enlarged. As to the territorial impact indicator, both mean and median are around 50%, which shows considerably overall improvement in network efficiency due to rail development, especially the trans-European rail network development.

Table 5-5 Statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'network efficiency' criterion

Items	Basic territorial indicator: Average travel speed (km/h) by rail in region		Territorial impact indicator: % Change in average travel speed by rail in region
	Scenario A (1996)	Scenario C (TEN-T completed)	
Number of analysed regions	255	255	255
Mean	42.9	63.6	0.53
Median	42.7	62.8	0.47
Std. Deviation	12.5	16.6	0.3678
Minimum	15.4	28.9	-0.50
Maximum	90.0	127.2	3.67

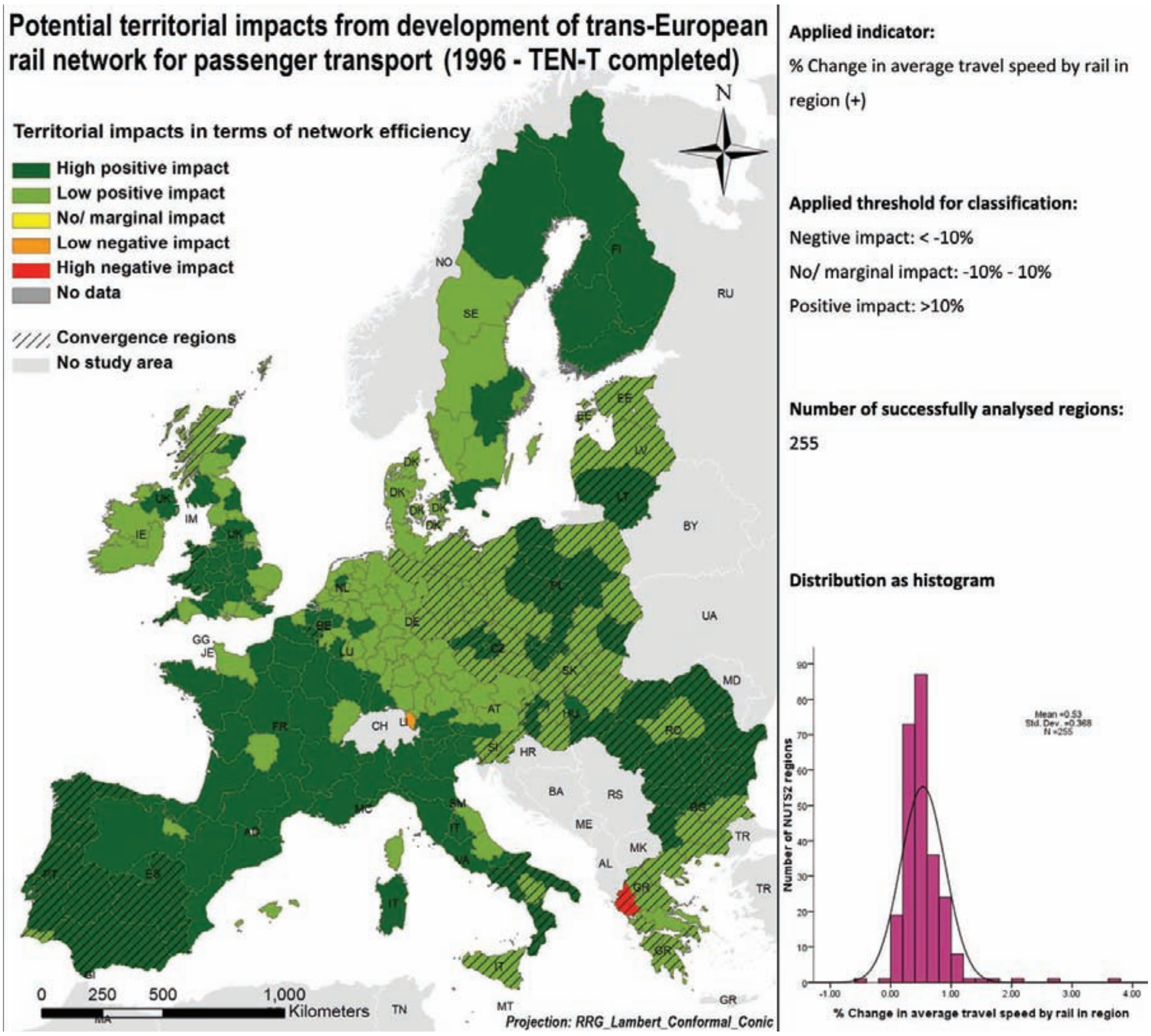


Figure 5-5 Potential territorial impacts from development of TEN rail in passenger transport in terms of network efficiency

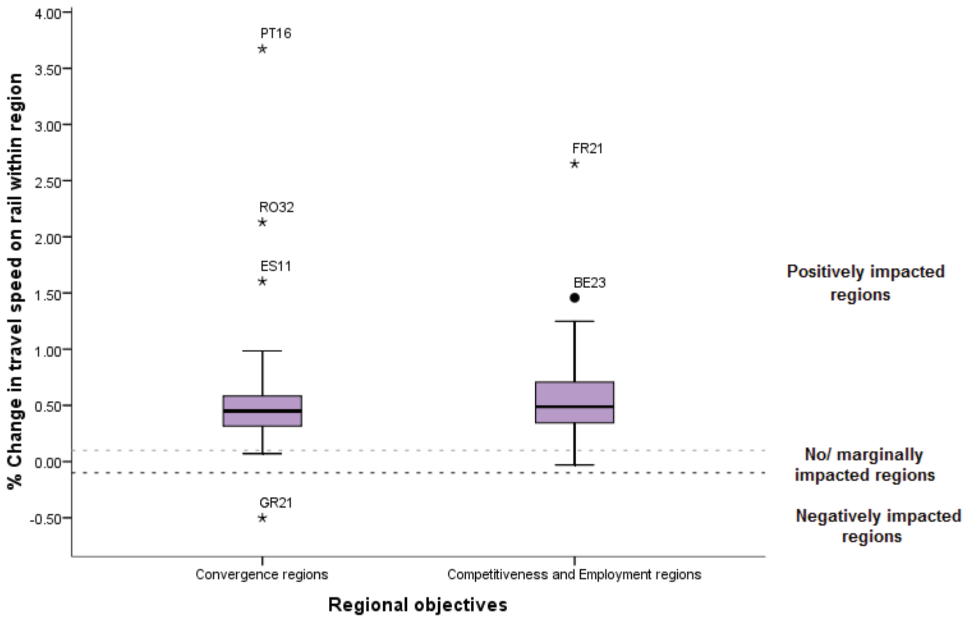


Figure 5-6 Boxplot for regions in two regional objectives in territorial impact indicator for network efficency

Figure 5-5 is the map of potential territorial impact of network efficiency change showing the result of territorial impact indicator derived from the basic territorial indicator (see the maps in Appendix 4) including a histogram showing the distribution of the territorial impact indicator. Based on the arbitrary regional classification indicated in the map, this map shows similar pattern as Figure 5-3 that most regions are positively impacted and very few of regions have marginal impacts, while only one Greek region has negative impact. Figure 5-6 compares territorial impacts in network efficiency to convergence regions and competitiveness regions. This boxplot shows that the convergence group has slower speed in speeding than competitiveness regions. But no big gap exists

5.2.4. Fair accessibility

Fair accessibility is one of the most core concerns for territorial cohesion according to observations during participatory activities in scoping phase of this study. Fair accessibility means fair opportunity for regional development in some extent, which definitely largely contributes to more balanced regional development. Destinations to access can include many aspects in terms of education, health, finance and so forth, as well as transport facilities such as airports. In this criterion, the basic territorial indicator is designed as the disparity in sub-regions' accessibility to main airports in a regions. The rationale is explained as below.

With fast pace of globalization, taking flights becomes a more frequent and common activity in people's life for variant purposes. There is no doubt that good accessibility to airports is urgently required. Rail is often used to reach airport in reality. Thus improving accessibility to airports through rail is necessary for improving both life efficiency and life quality. For different regions, accessibility to airports through rail can be uneven, that internal fairness problem may exist.

Table 5-6 Statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'fair accessibility' criterion

Items	Basic territorial indicator: Internal disparity (SD among NUTS3) of travel time to the nearest main airport		Territorial impact indicator: Change in Internal disparity of travel time to the nearest main airport
	Scenario A (1996)	Scenario C (TEN-T completed)	
Number of analysed regions	227	225	225
Mean	51.54	33.56	-17.56
Median	38.11	25.60	-11.81
Std. Deviation	40.83	27.97	27.70
Minimum	0	0	-140.92
Maximum	212.35	232.05	172.06

Specifically, disparity in accessibility to main airports among NUTS3 regions within a NUTS2 region is indicated by the standard deviation of travel time to the nearest main airport. Absolute change of disparity is taken as the territorial impact indicators, which can reveal whether the disparity is reduced or enlarged. The negative desired direction is preferred for both basic territorial indicator and territorial impact indicator.

Among the interested 255 NUTS2 regions, 26 regions are in small size that only one NUTS3 region belongs to each of them. These regions are excluded in the final summary because they have no meaningful standard deviation. The other excluded regions have no access to a nearest main airport. Table 5-6Table 5-6 shows that along with the overall improvement in accessibility (indicated in sub-

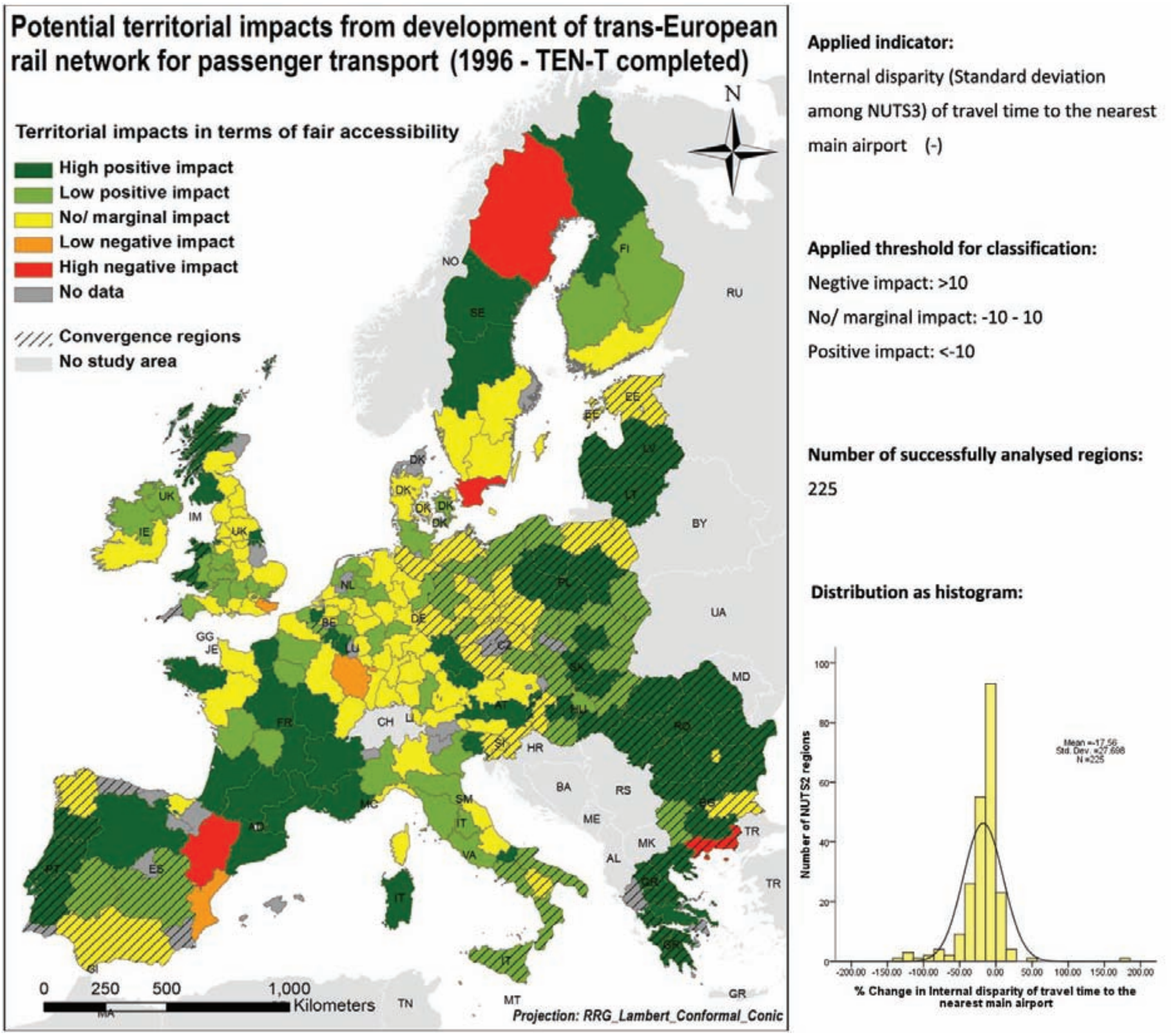


Figure 5-7 Potential territorial impacts from development of TEN rail in passenger transport in terms of fair accessibility

criterion 'external accessibility'), internal disparity in sub-regions' accessibility has also been reduced that mean and median both decrease. Consequently, regional disparity in internal disparity has also been largely reduced according to the decreased standard deviation value. Statistics for the territorial impact indicator can reveal a generally improved situation which has been convinced by . Negative values in the mean and median reflect reduction in internal disparity in terms of accessibility occurs in considerable number of regions. But the situation is still diverse from regions to regions considering the large gap between the maximum and the minimum values.

Figure 5-7 is the map of potential territorial impact of accessibility fairness change showing the result of territorial impact indicator derived from the basic territorial indicator (see the maps in Appendix 4) including a histogram showing the distribution of the territorial impact indicator. Based on the arbitrary regional classification indicated in the map, this map reflects that the major of significantly impacted regions are those peripheral regions in the EU. Among the significantly impacted regions, only a limited number of regions are negatively impacted, while the large portion of regions benefit. This pattern is more obvious when only observing convergence regions. Therefore, in terms of 'fair accessibility', relevant indicators' results hint that TEN rail of passenger transport largely contribute to territorial cohesion.

Figure 5-8 further clarifies the mentioned conclusion about territorial cohesion- most of regions either with convergence objective or competitiveness and employment objective have positive impacts. Moreover the convergence group is almost completely fall in non-negative impact area, which takes explicit advantage over the competitiveness group. From the plotting, we can also see a larger internal disparity in competitiveness group than the convergence group. It means that convergence regions generally have more internally-balanced development.

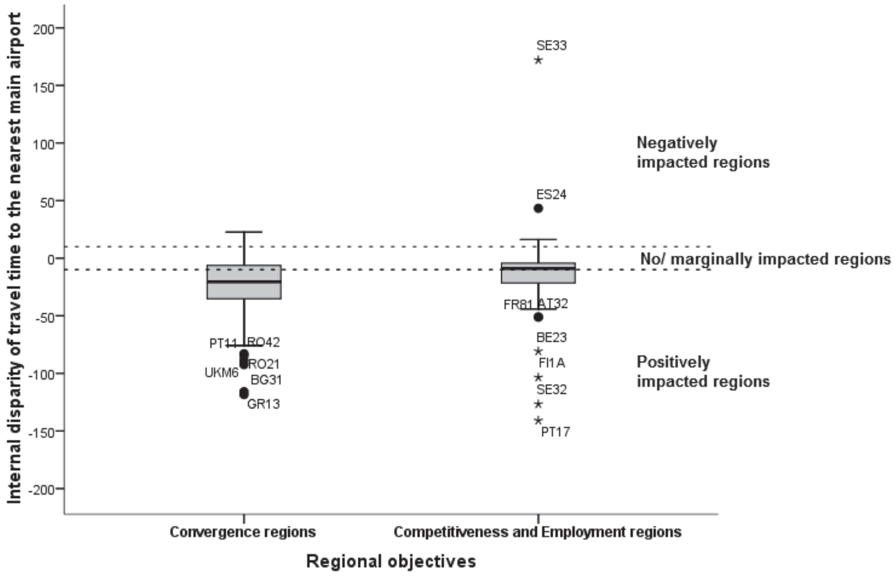


Figure 5-8 Boxplot for regions in two regional objectives in territorial impact indicator for fair accessibility

5.2.5. Environmental risk

Transport development usually has negative impacts on environment as reviewed in section 0. As important capitals for sustainable development and conditions for good life quality, natural assets, e.g. protected natural areas, need to be considered in transport development for minimizing potential environment risk. The basic territorial indicator applied for 'environmental risk' issue is portion of protected natural area (Natural2000 in Europe) within one kilometre from interested network. Potential environmental risk is assumed significant to a certain plot of Natural2000 if it is no further than 1km to any rail infrastructure in the analysed network. For a region, larger portion of its Natural2000 have such environmental risk, the worse situation it has in this issue. Absolute change of the basic territorial indicator is taken as the territorial impact indicator. Negative desired direction is preferred for both basic territorial indicator and territorial impact indicator. Table 5-7 shows statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'fair accessibility' criterion.

Table 5-7 Statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'environmental risk' criterion

Items	Basic territorial indicator: Portion of Natural 2000 within 1 kilometre to rail		Territorial impact indicator: Changed portion of Natural 2000 within 1 kilometre to rail
	Scenario A (1996)	Scenario B (TEN-T completed)	
Number of analysed regions	255	255	255
Mean	0.079	0.108	0.029
Median	0.060	0.071	0.009
Std. Deviation	0.0737	0.1237	0.0565
Minimum	0	0	-0.04
Maximum	0.61	0.99	0.43

Table 5-7 shows that in average, around 8% of Natural 2000 of a region locate within 1 kilometre to the interested network in 1996. But according to evaluation in this study, after the TEN-T projects complete, this number will increase to 10.8%, which indicates the increasing environmental risk for Natural2000 caused by trans-European rail development. The increased median convinces the general worsen situation. In terms of territorial impact, it can be observed that average portion of Natural2000 in risk in a region is increased by about 3%. But the median, which is less than 1%, reveals that quite a number of regions do not have that much change as the mean hints.

Figure 5-9 is the map of potential territorial impact of environmental risk change showing the result of territorial impact indicator derived from the basic territorial indicator (see the maps in Appendix 4), including a histogram showing the distribution of the territorial impact indicator. This map visualises the general worsen situation. It shows that a considerable number of regions, especially most of peripheral regions, have no/marginal territorial impact. Only several relatively small regions including Lisbon and Hamburg appear to have positive territorial impact. Remaining regions are negatively impacted in various scales. Regions with high negative impact distribute mostly in Germany and its neighbour countries, as well as the southern UK. Among convergence regions, Eastern Germany, Western Poland and The Czech Republic are regions with most explicit negative territorial impact due to impressive rail development n these regions probably.

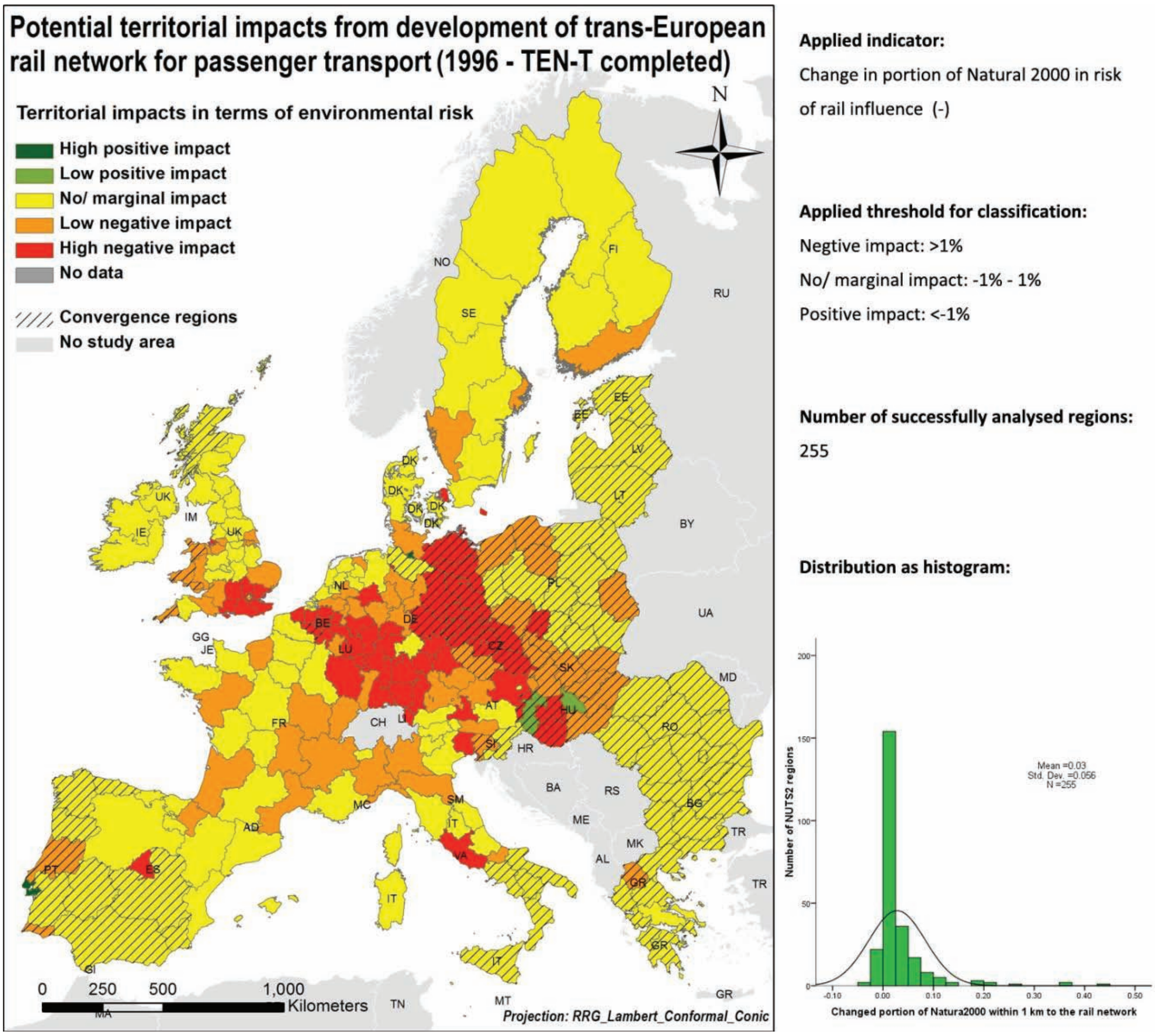


Figure 5-9 Potential territorial impacts from development of TEN rail in passenger transport in terms of environmental risk

Figure 5-10 is the boxplot showing comparison between convergence regions and competitiveness regions. As visualised in Figure 5-9, both groups contain large amount of regions with negative or marginal territorial impacts. Except for the range, there is not too much difference can be found through this figure. Convergence regions are less discrete than competitiveness regions indicated by its narrower range.

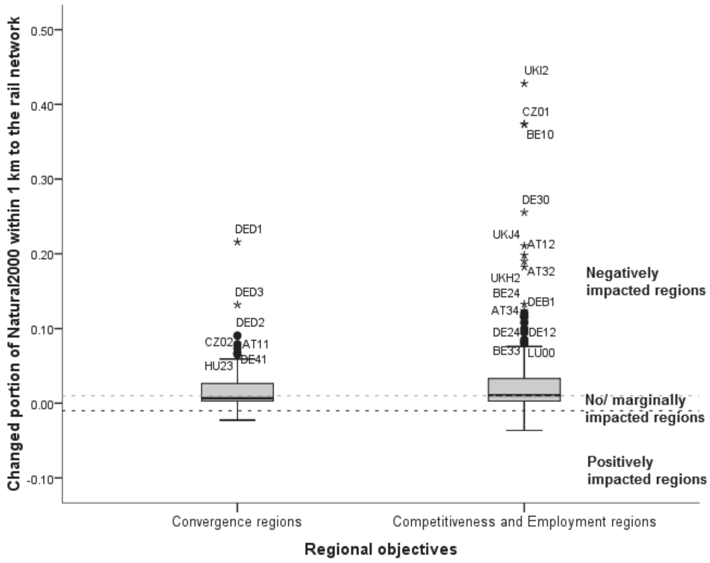


Figure 5-10 Boxplot for regions in two regional objectives in territorial impact indicator for environmental risk

5.2.6. Sustainable transport

Sustainable transport is favoured to contribute to overall sustainability development. For rail transport, electrifying traditional rail plays important role to promote transport sustainability.

The basic territorial indicator thus is selected as the portion of electrified rail out of all rails in a region in terms of length. It is used as proxy to level of sustainability a region achieves in rail transport. Absolute change in this basic territorial indicator becomes the territorial impact indicator. Both basic territorial indicator and territorial impact indicator are desired to have higher positive value.

Table 5-8 Statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'sustainable transport' criterion

Items	Basic territorial indicator: Portion of electrified rail length		Territorial impact indicator: Changed Portion of electrified rail length
	Scenario A (1996)	Scenario B (2008)	
Number of analysed regions	255	255	255
Mean	0.472	0.488	0.016
Median	0.470	0.484	0
Std. Deviation	0.283	0.234	0.1886
Minimum	0	0	-1.00
Maximum	1	1	0.86

Table 5-8 displays statistics of basic territorial indicators for year 1996 and year 2008, together with that of the territorial impact indicator. During the eight year, both mean and median of the basic territorial indicator rise by about 1.5%. Consequently, regional disparity is reduced revealing by the decreased standard deviation. As for the territorial impact indicator, quite small mean and zero median both point out there are large amount of regions have no or marginal territorial impact in this issue. Disparity is quite large considering the large range between the maximum and the minimum.

Figure 5-11 is the map of potential territorial impact of sustainable transport change showing the result of territorial impact indicator derived from the basic territorial indicator (see the maps in Appendix 4) including a histogram showing the real distribution of the territorial impact indicator. This map reflects that the major of all the regions are marginally impacted. Regions with positive territorial impact are distributed by country. that Greece, Denmark and Ireland cover most of regions with high positive territorial impact; while Finland, Romania, Slovakia and Slovenia cover. Most of these countries are within the convergence regional group, indicating convergence regions in this issue take more advantages. Figure 5-12 further convinces this conclusion, in which the box for convergence regions is obviously higher than that of the competitiveness regional group.

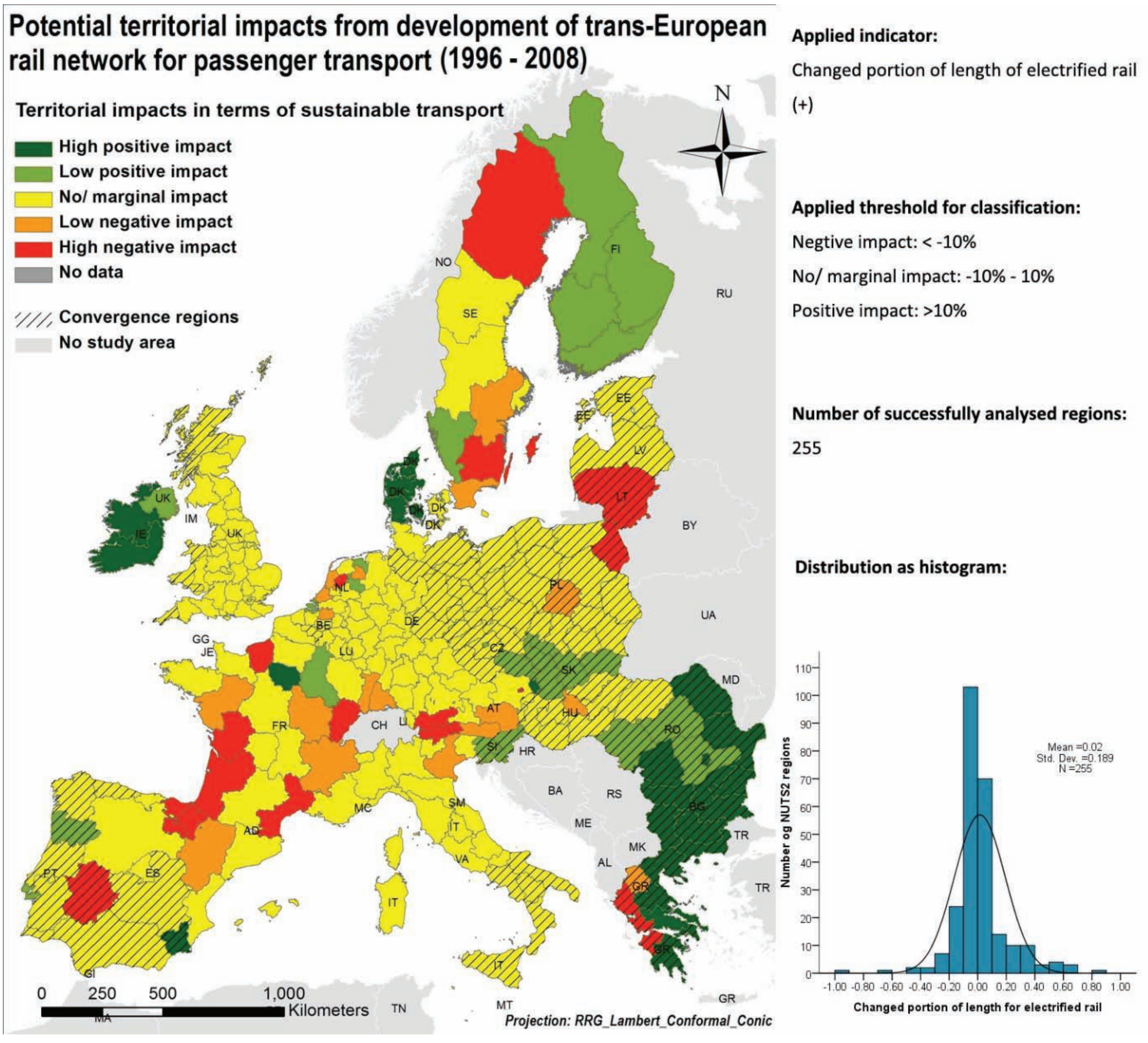


Figure 5-11 Potential territorial impacts from development of TEN rail in passenger transport in terms of sustainable transport

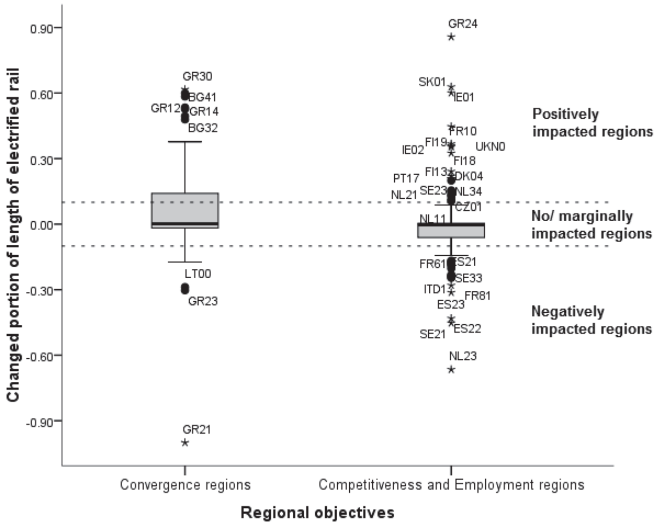


Figure 5-12 Boxplot for regions in two regional objectives in territorial impact indicator for sustainable transport

5.2.7. Land and landscape

Land and unique landscape is among the most important local capitals for a region. Rail development inevitably has impacts to land use and landscape. A most explicit impact is that rails make land fragmented, which is undesired in terms of both land use potential and landscape visualization. Rail density is taken as proxy to extent in land fragmentation. Therefore, the basic territorial indicator, rail density, has a negative desired direction. Absolute change in rail density is used as the territorial impact indicator to measure impacts from rail development to 'land and landscape' during the interested time period.

Table 5-9 statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'land and landscape' criterion

Items	Basic territorial indicator: Rail density (km/ km2)		Territorial impact indicator: Change in rail density (km/ km2)
	Scenario A (1996)	Scenario C (TEN-T completed)	
Number of analysed regions	255	255	255
Mean	0.084	0.085	0.001
Median	0.065	0.066	0
Std. Deviation	0.0807	0.0799	0.0090
Minimum	0.008	0.007	-0.059
Maximum	0.793	0.734	0.052

Table 5-9 shows statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'land and landscape' criterion. Slightly increased mean and median for the basic territorial indicator reflect a general worsen trend in terms of 'land and landscape'. So the decreased standard deviation is possibly due to naturally more rail densification in originally less-rail-dense regions. But from the large range between the minimum and the maximum, it is not hard to imagine the considerable variance in rail density among European regions due to difference in both rail development and territorial area.

Statistics of the territorial impact indicator displayed in the table show that in average level, there is almost no change or only marginal change in rail density. This can also be proved through Figure 5-13. In this map, most regions fall in the category with no/ marginal impacts with no more than 0.005 kilometres per square kilometres change in rail density. Negatively impacted regions, e. g. some regions in Poland, Spain and Portugal, witness impressive development in their rail networks, which may hamper their land capital in terms of landscape and other usages. On the contrary, a few of regions in the Netherlands, Germany, Belgium, Finland and the UK, as well as Slovakia and Hungary in the east, experience considerable decrease in rail density. Regarding the convergence regions, the only explicit information can be extracted is that considerable variance exists within this group.

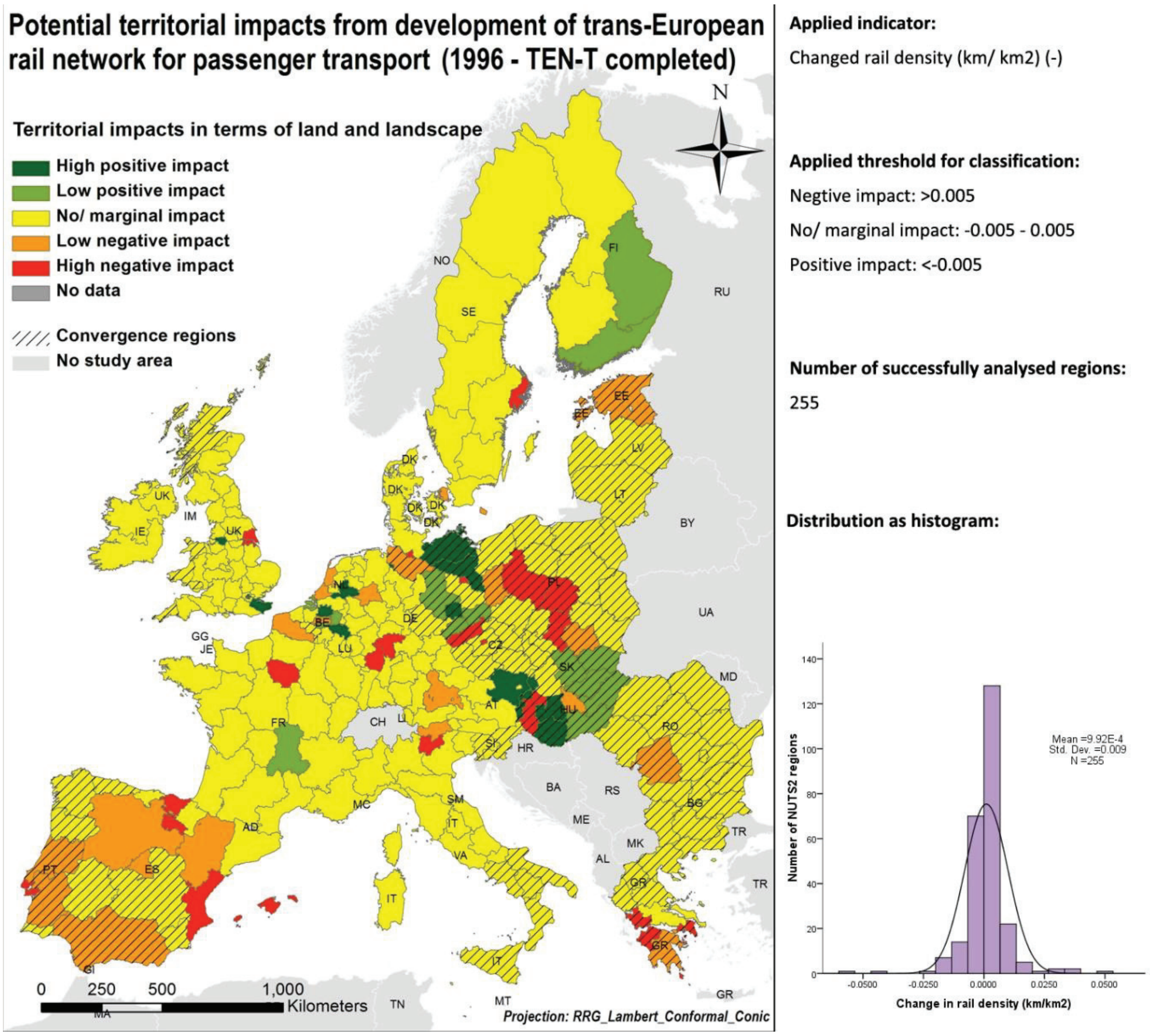


Figure 5-13 Potential territorial impacts from TEN rail in passenger transport development in terms of land and landscape

Figure 5-14 is the boxplot showing comparison between convergence group and competitiveness group in terms of territorial impacts on land and landscape. The two do not significantly differ from each other except for their degree of dispersion. The major of both groups of regions have only been marginally impacted.

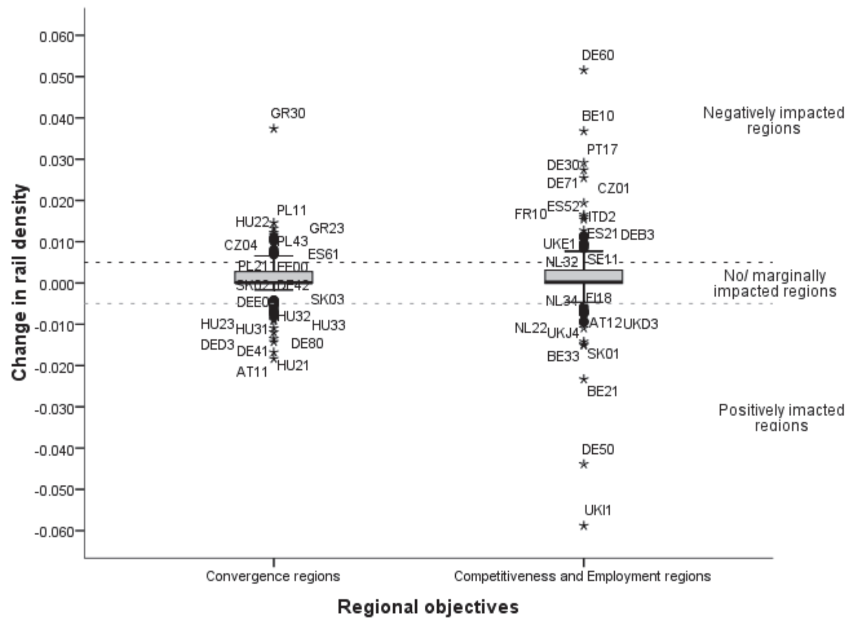


Figure 5-14 Boxplot for regions in two regional objectives in territorial impact indicator for land and landscape

5.2.8. Knowledge and innovation

Knowledge and innovation is quite highlighted in the EU in local development. They are considered offering lasting promotion for development of regions. Human resource is the core of this issue. Considering human capital as a crucial component among local capitals, accessibility to such capitals is no doubt important to promote knowledge and innovation development in a region. The so-called Human resources in science and technology (HRST) are taken as proxy of such human resources that can be relied on to develop innovative economy. On the other hand, potential accessibility measure nowadays is the most popular location-based accessibility measure, and has been widely used in urban and geographical studies, especially in transport network involved studies. So the basic territorial indicator is designed as potential accessibility to HRST. It estimates the accessibility in zone i to all HRST in other zones in such a way that the more distant the HRST, the more diminished the influence. Lower cost in travel time principally adds more possibility for persons among HRST in other regions to contribute to local innovation development through commuting, information exchanging, business and consulting, etc. Obviously this basic territorial indicator has positive desired direction. The derived territorial impact indicator is the absolute change of potential accessibility in HRST with unit of 1000 people.

Since some regions have missing data in HRST in 2000, which is used in analysis for scenario A[11], only 239 regions out of 255 can have basic territorial indicator values in scenario A and the relevant territorial impact indicator values. Table 5-10 shows that EU regions have overall improvement in the basic territorial indicator that the major of them get higher potential accessibility to HRST during the checked years according to the increase in mean, median, Minimum and Maximum. But the increase in standard deviation of potential accessibility to HRST reveals the enlarged regional disparity of developing potential in innovation economy.

11 For Scenario A, time mismatch problem exist in data due to practical data limitation. The rail network dataset applied in Scenario A is based on year 1996. While the HRST statistics is based on 2000, because no earlier data can be accessed to.

Table 5-10 statistics of the basic territorial indicator in two scenarios and the territorial impact indicator in 'knowledge and innovation' criterion

Items	Basic territorial indicator: Potential accessibility to HRST (1000 population)		Territorial impact indicator: Change Potential accessibility to HRST (1000 population)
	Scenario A (1996)	Scenario C (TEN-T completed)	
Number of analysed regions	239	255	239
Mean	61117	83840	24624
Median	42969	61197	16788
Std. Deviation	61303.09	79858.10	25424.34
Minimum	22	47	-6532
Maximum	626589	803194	176605

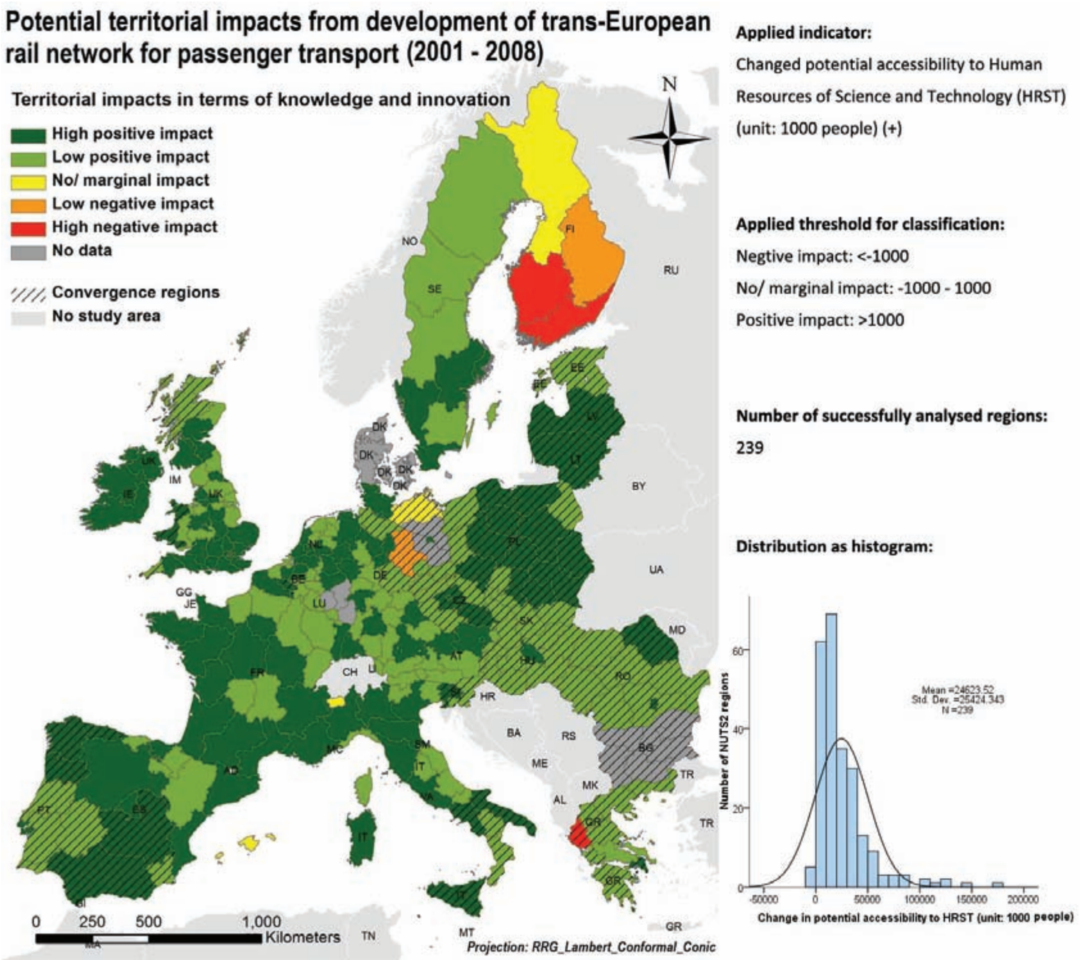


Figure 5-15 Potential territorial impacts from TEN rail in passenger transport development in terms of knowledge and innovation

Figure 5-15 is the map visualising territorial impact in terms of issue 'innovation and knowledge'. It shows a quite pleased picture that over 90% of regions gain positive territorial impacts in various extents. Only five regions have been negatively impacted. Looking at regions with high positive territorial impact, they are found generally even distributed across EU territories. Most impressive agglomerations of such regions include the Baltic regions, Polish regions, French-Balearic coastal-Northern Italian regions, Iberia regions, regions and Ireland. With relatively high increase of potential accessibility in human resources of science and technology, these regions have significantly improved potential for developing knowledge-intensive and innovative economy. Convergence regions, also take considerable advantages in this issue. But referring to Figure 5-16 focusing on comparison between convergence regions and competitiveness regions, explicit gap between the two regional groups can be observed. With higher median and maximum, the competitiveness regional group has clear larger improvement in potential accessibility of high-level human resources on the average level.

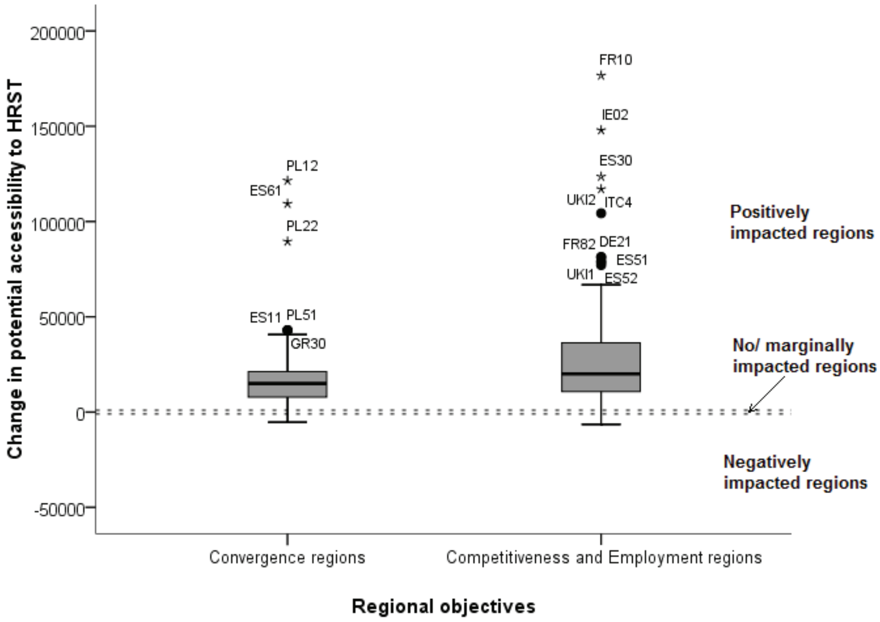


Figure 5-16Boxplot for regions in two regional objectives in territorial impact indicator for knowledge and innovation

5.3. Territorial Cohesion Effect Analysis

Table 5-11 and Table 5-12 summarise results indicating territorial cohesion from analysis described in previous three sections in this chapter. Table 5-11 classifies regions into three groups, including portions of total regions, convergence regions and competitiveness regions with three basic types of territorial impacts, i.e. positive, no/marginal and negative impacts, in terms of the eight sub-criteria. While Table 5-12 classifies regions into five groups based on further subdivided positive and negative impacts. Figures in the two tables are used for generating territorial cohesion effect indicators in terms of positive and negative territorial impacts, as well as high positive and high negative territorial impacts. Table 5-13 displays these TCEIs per issue in terms of the four types of territorial impacts with simple judgement.

Table 5-11 Portions of total/convergence/competitiveness regions with positive, no/marginal, or negative impacts

Sub-criteria	Positive impacts			No/ Marginal impacts			Negative impacts		
	P_{total_p}	P_{conv_p}	P_{comp_p}	P_{total_m}	P_{conv_m}	P_{comp_m}	P_{total_n}	P_{conv_n}	P_{comp_n}
Infrastructure endowment	44.4%	47.1%	42.9%	24.6%	18.4%	28.0%	31.0%	34.5%	29.2%
External accessibility	96.9%	98.9%	95.8%	1.2%	0.0%	1.8%	2.0%	1.1%	2.4%
Network efficiency	99.2%	98.9%	99.4%	0.0%	0.0%	0.0%	0.8%	1.1%	0.6%
Fair accessibility	56.9%	71.3%	49.0%	40.0%	27.5%	46.9%	3.1%	1.3%	4.1%
Environmental risk	1.6%	1.1%	1.8%	49.8%	56.8%	46.1%	48.6%	42.0%	52.1%
Sustainable transport	18.4%	30.7%	12.0%	67.1%	61.4%	70.1%	14.5%	8.0%	18.0%
Land and landscape	11.8%	17.0%	9.0%	71.4%	64.8%	74.9%	16.9%	18.2%	16.2%
Knowledge and innovation	96.2%	96.3%	96.2%	1.7%	1.3%	1.9%	2.1%	2.5%	1.9%

Table 5-12 Portions of total regions, convergence and competitiveness regions with high positive, low positive, no/marginal, low negative or high negative impacts

Sub-criteria	High Positive impacts			Low Positive impacts			No/ Marginal impacts			Low Negative impacts			High Negative impacts		
	P_{total1}	P_{conv1}	P_{comp1}	P_{total2}	P_{conv2}	P_{comp2}	P_{total3}	P_{conv3}	P_{comp3}	P_{total4}	P_{conv4}	P_{comp4}	P_{total5}	P_{conv5}	P_{comp5}
Infrastructure endowment	22.2%	17.2%	24.8%	22.2%	29.9%	18.0%	24.6%	18.4%	28.0%	15.3%	19.5%	13.0%	15.7%	14.9%	16.1%
External accessibility	48.6%	39.8%	53.3%	48.2%	59.1%	42.5%	1.2%	0.0%	1.8%	0.8%	0.0%	1.2%	1.2%	1.1%	1.2%
Network efficiency	49.8%	45.5%	52.1%	49.4%	53.4%	47.3%	0.0%	0.0%	0.0%	0.4%	0.0%	0.6%	0.4%	1.1%	0.0%
Fair accessibility	28.4%	41.3%	21.4%	28.4%	30.0%	27.6%	40.0%	27.5%	46.9%	1.3%	0.0%	2.1%	1.8%	1.3%	2.1%
Environmental risk	0.8%	0.0%	1.2%	0.8%	1.1%	0.6%	49.8%	56.8%	46.1%	24.3%	22.7%	25.1%	24.3%	19.3%	26.9%
Sustainable transport	9.4%	18.2%	4.8%	9.0%	12.5%	7.2%	67.1%	61.4%	70.1%	7.1%	2.3%	9.6%	7.5%	5.7%	8.4%
Land and landscape	5.9%	6.8%	5.4%	5.9%	10.2%	3.6%	71.4%	64.8%	74.9%	8.2%	10.2%	7.2%	8.6%	8.0%	9.0%
Knowledge and innovation	48.1%	37.5%	53.5%	48.1%	58.8%	42.8%	1.7%	1.3%	1.9%	0.8%	1.3%	0.6%	1.3%	1.3%	1.3%

Table 5-13 Results of four territorial cohesion effect indicators respectively in terms of positive, negative, high positive and high negative territorial impacts and with interpretations per sub-criterion

Criteria	Sub-criteria (Issue)	*T*erritorial *C*ohesion *E*ffect *I*ndicators*							
		$TCEI_p$		$TCEI_n$		$TCEI_{hp}$		$TCEI_{hn}$	
Territorial Efficiency	Infrastructure endowment	0.043	Pleased	0.053	Unpleased	-0.076	Unpleased	-0.012	Pleased
	External accessibility	0.031	Pleased	-0.013	Pleased	-0.135	Unpleased	-0.001	Pleased
	Network efficiency	-0.005	Unpleased	0.005	Unpleased	-0.066	Unpleased	0.011	Unpleased
Territorial Quality	Fair accessibility	0.223	Pleased	-0.029	Pleased	0.199	Pleased	-0.008	Pleased
	Environmental risk	-0.007	Unpleased	-0.101	Pleased	-0.012	Unpleased	-0.076	Pleased
	Sustainable transport	0.187	Pleased	-0.100	Pleased	0.134	Pleased	-0.027	Pleased
Territorial Identity	Land and landscape	0.081	Pleased	0.020	Unpleased	0.014	Pleased	-0.010	Pleased
	Knowledge and innovation	0.000	Pleased	0.006	Unpleased	-0.160	Unpleased	0.000	Fair

For an individual issue (sub-criteria in the method), territorial cohesion effects is mixed if lagging regions gain more (or less) but also lose more (or less).

As Table 5-13 displays, there exists diversity in territorial cohesion effects in terms of different issues. Considering the basic positive and negative territorial impacts, the interested network brings overall positive territorial cohesion effects to three issues (external accessibility, fair accessibility and sustainable transport), overall negative territorial cohesion effects to two issue (network efficiency and knowledge and innovation), and mixed territorial cohesion effects to the other three (infrastructure endowment, environmental risk and land and landscape).

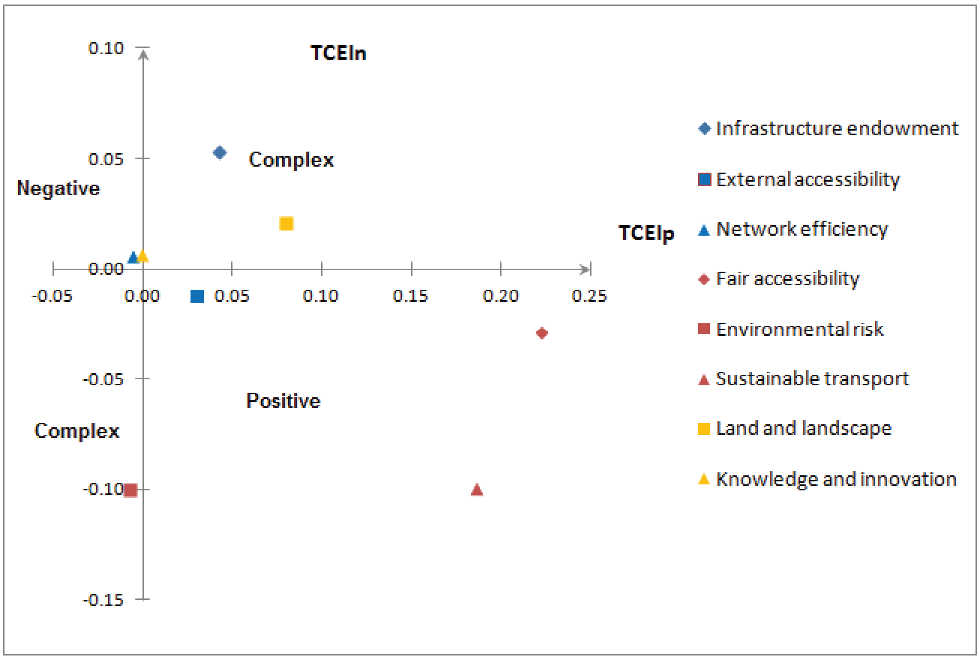


Figure 5-17 Combinations of TCEIs in terms of positive and negative impacts for all sub-criteria

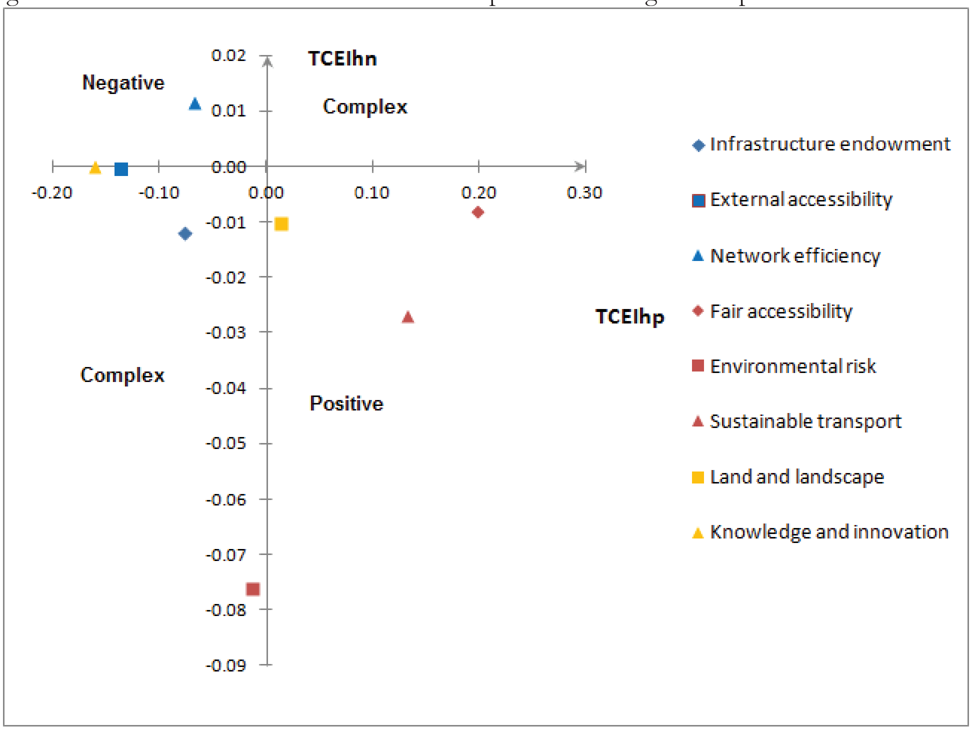


Figure 5-18 Combinations of TCEIs in terms of high positive and high negative impacts for all sub-criteria

While considering territorial cohesion effect indicators in terms of the extracted high positive/ negative impact instead of the mentioned basic positive and negative territorial impacts, results significantly change. The interested network still brings overall positive territorial cohesion effects to three issues, but relevant issues change to fair accessibility, sustainable transport and land and landscape, among which land and landscape replaces external accessibility. Overall negative territorial cohesion effect only occurs in network efficiency. While regarding the other four issues, we witness mixed territorial cohesion effects in various scales.

It is interesting that the overall territorial cohesion effects are different 1) in terms of basic positive and negative territorial impacts ($TCEI_p$ and $TCEI_n$) and that 2) in terms of relatively high positive and high negative territorial impacts ($TCEI_{hp}$ and $TCEI_{hn}$) for half of the issues. This phenomenon reveals that different norms determine judgement, that they need to be set based on needs and purposes.

Figure 5-17 combines $TCEI_p$ and $TCEI_n$, while Figure 5-18 combines $TCEI_{hp}$ and $TCEI_{hn}$ in terms of the eight issues to have an overall and picture of territorial cohesion effects from the interested network. As the two shows, a pair of positive and negative TCEIs (or a pair of high positive and high negative TCEIs) must belong to one of the nine types of overall territorial cohesion effects (refer to Table 4-4). Both figures reveal the diversity in territorial cohesion effects in terms of different issues (also see Table 5-14).

Table 5-14 Overall territorial cohesion effects

Dimensions (Criteria)	Issue (Sub-criteria)	Overall Territorial Cohesion Effects	
		In terms of basic positive and negative territorial impacts ($TCEI_p$ and $TCEI_n$)	In terms of relative high positive and high negative territorial impacts ($TCEI_{hp}$ and $TCEI_{hn}$)
Territorial Efficiency	Infrastructure endowment	Strong and complex	Weak and complex
	External accessibility	Positive	Weak and complex
	Network efficiency	Negative	Negative
Territorial Quality	Fair accessibility	Positive	Positive
	Environmental risk	Weak and complex	Weak and complex
	Sustainable transport	Positive	Positive
Territorial Identity	Land and landscape	Strong and complex	Positive
	Knowledge and innovation	Negative	Weak and complex

Based on the results shown in tables and figures above, we can have an overall conclusion that the trans-European rail network for passenger transport has explicit but quite complex effects on territorial cohesion.

6. CONCLUSIONS AND REFLECTIONS

This chapter closes this thesis with two sections. The first section contains some overall conclusions about the developed method and results revealed from the testing method application. The second section rethinks the current research ending with recommendations and suggests in further study.

6.1. Conclusions

This study successfully proves that territorial cohesion effects from TEN-T at the EU scale can be measured, evaluated and judged through the shown method. The three phases in the method, i.e. basic territorial indicator analysis, territorial impact analysis and territorial cohesion effects evaluation and judgement, have global value, which can be also adapted in territorial cohesion appraisal for other major policies other than TEN-T. But since the core concept territorial cohesion is hard to have fixed definition, before any serious evaluation, setting judgement and identifying relevant issues to be measured according to contexts should be always the first priority before all real operations.

By testing the developed method with available datasets for year 1996 and 2008 on 255 NUTS2 regions covering most territories in the EU, it is shown that the trans-European rail network for passenger transport has explicit but complex effects on territorial cohesion. At the general EU scale, territorial cohesion is either promoted or hampered in various extents in terms of different dimensions. In other words, the on-going TEN-T does not always stand in line with the territorial cohesion objective, which should be paid attention in decision making processes.

These facts well support indications in some existing studies that the trans-European network may bring complex impacts in territorial development (e.g. Camagni, 2009; ESPON, 2005a; R. W. Vickerman, 1995). So far, the on-going trans-European rail network for passenger transport is not always standing in line with the general territorial cohesion objective in the EU. Careful decision making based on scientific method is always recommended. Plan and implementation of new projects in the trans-European rail network should seriously have concerns in relevant territorial impacts and the following territorial cohesion effects. It is expected that they do not explicitly harm the general territorial cohesion objective at least. As to those happened or inevitable negative effects, remedial or compensatory policies should be considered. Only in this way, we can expect policy consistency and implement territorial cohesion in practice.

6.2. Reflections

As a core concept in the method, territorial cohesion is studied theoretically from literatures and empirically from workshops and communication with experts. Although it is generally agreed that territorial cohesion has close links to reducing regional disparity, sustainable development, territorial cooperation and territorial integration, etc. This concept is found vague in its definition and specific contents based on both existing literature and empirical observations. Moreover, as an explicit EU policy objective, related political debates involving various wide stakeholders and interests make it even more debatable in practice. This situation makes territorial cohesion quite difficult to be measured and assessed by any standardized methodology.

Existing empirical evidence and results shown in this study actually can be for or against territorial cohesion based on measurement and interpretation, just depending on what we are looking for. So clarifying specific aspects according to corresponding purpose(s) should be the first step for any similar serious attempts as this study, including fixing a favoured definition of territorial cohesion and setting a limited number of core issues based on specific context.

The method shown in this study has revealed the complex concept of territorial cohesion in terms of its multiple dimensions and their tangled relationships. It is developed base on virtues of existing methods, including the well developed Multi-criteria Assessment and the Territorial Impact Assessment model 'TEQUILA' of Camagni (2009). It also takes advantages of advanced geo-information technologies and tools for spatial analysis and statistics tools (e.g. SPSS and EXCEL) for non-spatial analysis.

Some innovations are doubtlessly valuable. Firstly, this study conducts a method in a specific context – trans-European rail network on passenger transport, which provides more straightforward and practical information. Secondly, this method ends with simple judgement (e.g. positive, negative and complex) about territorial cohesion at the EU scale based on territorial impact evaluation, which takes a further step than the TEQUILA model. Lastly, instead of weighing and simply aggregating different dimensions into a global result as traditional MCA does, this method makes efforts to keeping concerned issues independent in all quantitative operations but connecting them through qualitative approaches in the last phase of territorial cohesion analysis. In this way, the evaluation process becomes as transparent as possible for easier understanding. It also contributes to combining quantitative and qualitative approaches in evaluations.

Unfortunately, the proposed method is not all about the good.

First of all, this method relies on indicator analysis so that its results largely depend on selected indicators. Since all the proposed issues can be indicated by different indicators, there is flexibility for real application according to available data conditions. Limited number of indicators for practical application may lead to questionable results and judgements. As demonstrated, each selected core issue has only one basic territorial indicator, which may lead to partial results. For instance, external accessibility can be indicated by many accessibility indicators considering different destinations, services and types of accessibility indicators, they may have different outcomes. A more ideal way is to assess each issue by multiple indicators to have more comprehensive and convincing measurement. Availability and quality of data are also crucial to well operationalize the method. There should be a minimum dataset and scientific tools as foundations for method implementation. The minimum dataset should include transport network(s) with attributes about infrastructure such as type and usage in relatively good quality, spatial data of interested regions, and corresponding social-economic statistics. However, in reality, data limitation is so common that it takes efforts to fulfil the minimum dataset. It is quite possible that even one indicator for each of the selected issues is difficult to realise. Just as the situation in this study, there is no accessible data for issue 'local identification'. Moreover, data from different sources is probably mismatched in terms of time, reference, definition, etc., which definitely brings extra errors to results. This study meets all mentioned difficulties. Although conducting a scientific progress properly, there is still question mark in factuality of the results from the testing method application. In a word, data limitation may be the largest bottleneck for realising the proposed method.

Consequently, similar as TIA, the results are supposed to offer information for practical use, e.g. planning strategically, justification or in favour of different opinions, or symbolically as replacement of the decision-making procedure. However, it shows in this study that, even with sufficient data, the process can be quite time-consuming and spirit-consuming due to large amount of involved elements and data objectives, which leads to time and budget problems in reality. Besides, considering it is typical that the major decision has already been made before conducting evaluation, the method can be completely meaningless with considerable resources waste.

Objectively speaking, the developed method is only an initial attempt in approaching to the set goal of this study. There is huge space for improvement from multiple aspects. Further study can consider these possible directions:

1) Have more discussion about indicators for each of the issues including relevant assumptions, thresholds, norms and classification;
2) Analyse results with deeper discussion in reasons resulting certain territorial impacts with sufficient consideration in local context;
3) Realize easy method application by developing packaged toolbox or model;
4) Conduct sensitivity analysis and noise analysis to increase method reliability and stability;
5) Operationalize the method at regional scale as well.

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APPENDICES

APPENDIX 1 NETWORK PROCESSING AS PREPARATION FOR NECESSARY NETWORK ANALYSIS

1. Flowchart Of Preparation For Network Analysis

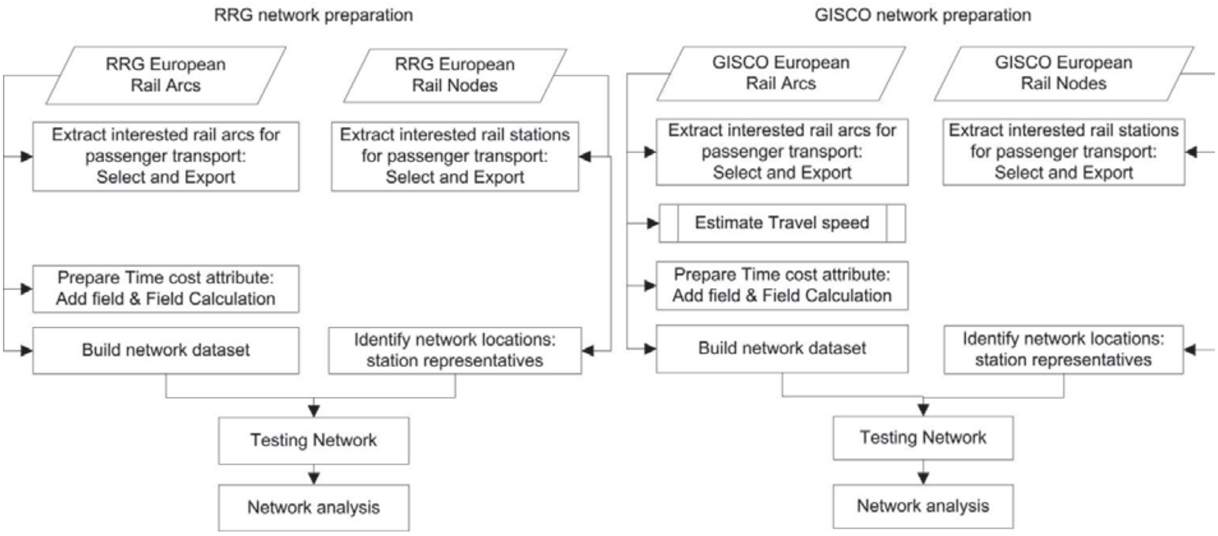

Figure A 1. Main operations in network analysis preparation based on the two available networks

2. Preparation For Network Analysis Based On RRG Data

Preparation for network analysis based on dataset from RRG included:

1) Extract interested rail arcs (polylines) from the original arc feature class;
2) Prepare attributes for network analysis;
3) Build the network dataset;
4) Identify network locations for further network analysis.

Extract Interested Rail Arcs

Rail segments for passenger use and in operation were extracted from the available original polyline feature class based on its attributes indicating rail properties. In ArcMap, spatial analysis tool "Select" could manage the work easily. An optional two-step method to achieve the same purpose was using "attribute selection" firstly and exporting selected objectives.

Prepare Time Attribute

The most important attribute for network datasets in this study was time cost. For each rail arc in a network, a specific value was calculated and stored in attribute field "Minute_T" as time cost to travel through this rail segment. This field would be applied as impedance in further network analysis. Three fields in attribute table of the feature class containing rail arcs offered elements to calculate "Minute_T", namely fields called "SPEED_TT", "Shape_Length" and "MARITIME". Detailed information could be found in the table below.

Table A 1 Relevant attributes for preparing time attribute for the network dataset

Relevant Fields	Units	Value Description
Minute_T	Minute	Travel time through specific segments of the network. For segments with no data, the value would be -99
SPEED_TT	Kilometres per hour	Travel time according to real train time table in 2008. For segments with no data or out of operation in 2008, the value would be -99
Shape_Length	Metre	Length of rail segments according to geospatial calculation
MARITIME	Minute	Maritime for travelling through specific ferry segments. Only train ferry segments had valid positive value in this field, while other segments had NULL value.

For non-ferry rail segments with valid positive speed value, time cost (field "Minute_T") could be obtained from field calculation: dividing rail length (field "Shape_Length") by travel speed (field "SPEED_TT") with unit conversion. While for ferry rail segments, time cost "Minute_T" equalled the maritime to travel through relevant ferry segments (field "MARITIME"). All other non-ferry rail segments (with invalid speed value) had time cost "Minute_T" valued -99, which indicated no data in original database or out of operation in 2008.

In order to have an advanced view on the completed trans-European rail network, all rail segments in RRG dataset have been assigned another estimated future speed as well. For those segments with valid speed in 2008, the estimated speed equalled the existing speed. While for segments with invalid speed in 2008, estimated speed were assigned following rules as below:

Table A 2 Estimated future speed per rail type assumed for rail network from RRG source

Rail type	Estimated future speed
Main line, Double track, Electrified	90 km/h
Main line, Double track	75 km/h
Main line, Single track, Electrified	70 km/h
Main line, Single track	60 km/h
Branch line, Double track, Electrified	40 km/h
Branch line, Double track	40 km/h
Branch line, Single track, Electrified	45 km/h
Branch line, Single track	40 km/h
Narrow Gauge line	25 km/h
Train Ferry	35 km/h
No link type information, HSR (including planned, upgraded)	300 km/h
No link type information, conventional lines (including planned, upgraded)	65 km/h

Build the Network Dataset

A geodatabase-based network dataset has been built in ArcCatalog. It contained 99180 edges and 46522 junctions covering larger areas than the study area to keep the completeness of the network. Global turns, end point connectivity policy, no elevation and no direction have been defined as the default. The only attribute with usage of cost was the time cost evaluated as pre-prepared field "Minute_T".

Identify Network Locations

Rail stations would be the applied network locations. The reason was that, in reality, passengers could only get into or get out of the rail network from train stations/ stops. Therefore, interested rail stations for passenger use in operation, which were within a distance of 100 metres to the rail arcs in the study area, were extracted from the original node dataset to be the basic "pool". Then, for different network analysis purpose, different groups of rail station representatives in need were further extracted from the basic pool to be real applied network locations.

For instance, in order to find the closest MEGA among the top 10 MEGAs based on GDP for each NUTS2 region, two groups of rail station representatives were extracted. One was a group of 255 rail stations presenting the 255 NUTS2 regions, and another one was a group of 10 rail stations presenting the 10 top MEGAs. To identify a specific rail station for a NUTS2 or a MEGA, following steps were followed:

1) Applied spatial analysis tool "Near" to relate one rail station being closest to each NUTS2 centroid12;
2) Joined the updated attribute table of the NUTS2 centroid feature class to the feature class containing all the interested rail stations;
3) Extracted those matched rail stations by using either spatial analysis tool "Select" or a two-step method of attribute selection and data export;
4) Loaded extracted rail stations as network locations either as "Facilities" or "Incidents"
5) Operated a testing Closest Facility analysis to identify those rail stations unlocated or on a non-traversable network element and zoomed in to check each questionable objective;
6) Identified and extracted a nearby alternative station with better linkage in the network for each NUTS2 centroid (or MEGA) manually, when such an objective existed; otherwise, kept the original closest rail station as representative;
7) Updated network locations based on last round of adjust and redid a testing Closest Facility analysis until no optimization could be conducted.

3. Preparation for network analysis based on GISCO data

Steps in preparation for the network analysis based on GISCO dataset was exactly the same as that based on RRG dataset – extracted interested rail arcs; prepared attributes for the network dataset; build the network dataset and identified network locations for further analysis. However, there was no existing field indicating real travel speed in attribute table of the feature class for rail arcs. Thus evaluation of real travel speed for segments in the rail network from GISCO has been conducted based on available information and some assumptions.

Evaluate travel speed

Since the rail network from GISCO presenting the European rail network in year 1996, while the rail network from RRG presenting the European rail network in year 2008, the latter was considered a developing and more advanced version. Based on this consideration, three core assumptions were used in the speed evaluation:

i. Rail arcs in the same type supported similar travel speed
ii. Ferry speed was 35 kilometres per hour
iii. For the same rail segment, travel speed in 2008 was always larger than that in 1996

Among the three assumptions, iii overrode the other two.

To initial the evaluation based on assumption i and assumption ii, a simple descriptive statistic analysis has been conducted (in SPSS) for real travel speed in 2008. All rail segments in 2008 were classified by types as indicated in the following table. For non-ferry rail segments, considering the ease of processing and understanding, median of real travel speed in 2008 per link type were rounded to be the initial evaluators for real travel speed in 1996. For ferry segments, initial real speed in 1996 was assumed as 35 km/h. For the very small group of segments with null value in the field of type, similar value was assigned as the assumed speed in 1996 manually compared to the corresponding objectives in dataset from RRG.

12 Two fields will be added to the attribute table of NUTS2 centroid feature class (input features). Field "NEAR_FID" would store the feature ID of the nearest train station; while field "NEAR_DIST" would store the distance from an NUTS2 centroid to its nearest rail station.

Table A 3 Different types of rail segments with their median speed in 2008 and initial assumed speed in 1996

Link Type	Description	Travel speed 2008 Median (km/h)	Initial real speed 1996 Assumed value (km/h)
MDE	Main line, Double track, Electrified	91	90
MD	Main line, Double track	74	75
MSE	Main line, Single track, Electrified	70	70
MS	Main line, Single track	60	60
BDE	Branch line, Double track, Electrified	38	40
BD	Branch line, Double track	38	40
BSE	Branch line, Single track, Electrified	45	45
BS	Branch line, Single track	40	40
NG	Narrow Gauge line	25	25
TF*	Train Ferry		35

* As assumption iii indicated, train ferry's speed was assumed as 35 km/ h according to external information rather than deriving from 2008 data.

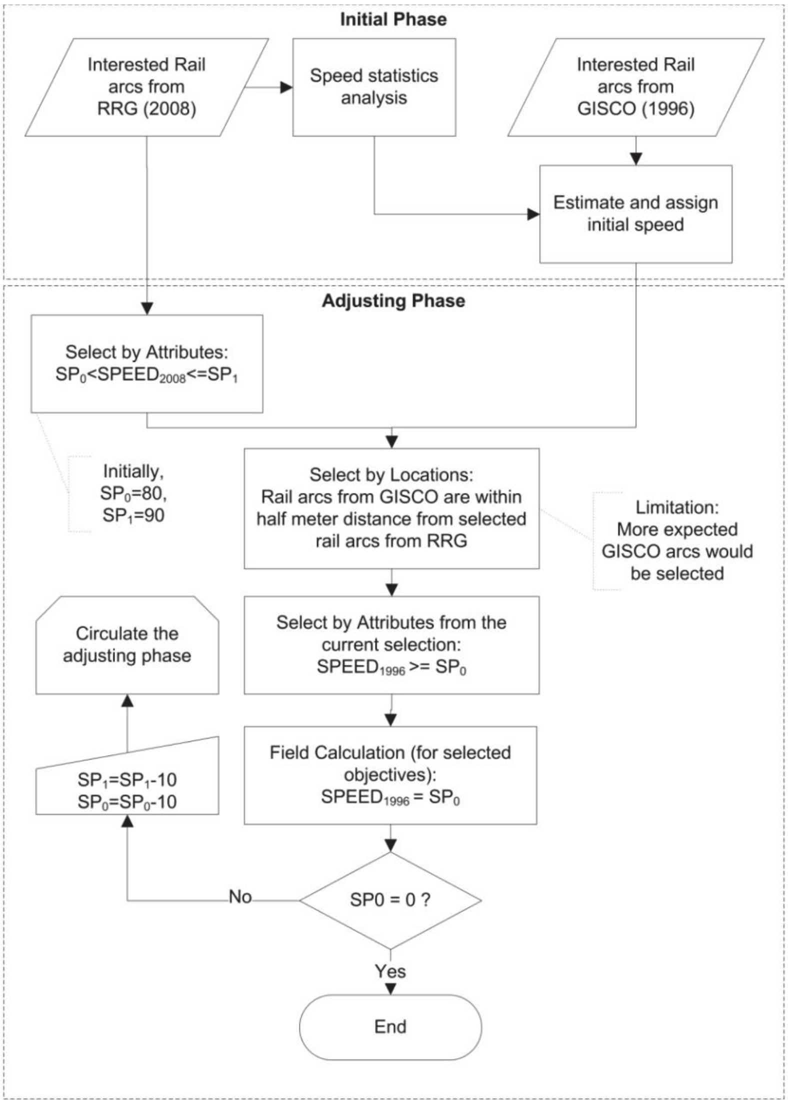

Figure A 2 Flowchart for network processing

To keep these initial assumed speed values for 1996 was not against assumption iii, a series of operations in flow and circulation have been done as showed below in the "Adjusting Phase".

From different sources, the two datasets could not be seamlessly related spatially or based on a set of sharing code. In this case, if a GISCO arcs located within 0.5 meters distance to a RRG arc, it was considered to be one objective in reality. The limitation was GISCO arcs intersecting with the RRG arc would also be counted in. So there would be error came from this limitation. This study could not find a good solution to solve this problem so far. Considering not too many such cases happened, the operation was still acceptable.

Assumption iii requested each arc in GISCO dataset had a lower speed than that of the corresponding rail arc in RRG dataset. However, in operation, a simplified process considering time limitation and ease of operation has been designed; so not every single speed value in 2008 has been compared to. Instead, speed values in 2008 have been grouped with an interval of 10; then a group of RRG arcs would be compared to. Those GISCO arcs with speed higher than the low threshold would be identified and re-assign value. For example, RRG rail arcs with speed value higher than 80km/h but lower than or equal with 90km/h would be a group. All related GISCO rail arcs with initial assumed speed higher than 80km/h would be assigned new assumed speed of 80 km/h.

A circulation of speed comparison from high value to low value was run to finalize the adjusting phase. Because the maximum initial assumed speed in 1996 was 90 km/h for type-identified segments, the circulation started from comparing GISCO arcs to RRG arcs grouped with the high threshold of 90 km/h. It is clearer to check this process from the flowchart (Figure A 2). Table below displayed detailed parameters applied in the 9-round circulation.

Table A 4 detailed parameters applied in the 9-round circulation in the adjusting phase

Circle	Rail arcs from RRG dataset as references			Corresponding rail arcs from GISCO dataset		
	Speed Range: SP0~SP1	SP0	SP1	Arcs with questionable initial assumed speed value		Initial assumed speed was OK and kept
				Initial speed	Adjusted speed	Initial speed
1	(80, 90]	80	90	>80	80	<=80
2	(70, 80]	70	80	>70	70	<=70
3	(60, 70]	60	70	>60	60	<=60
4	(50, 60]	50	60	>50	50	<=50
5	(40, 50]	40	50	>40	40	<=40
6	(30, 40]	30	40	>30	30	<=30
7	(20, 30]	20	30	>20	20	<=20
8	(10, 20]	10	20	>10	10	<=10
9	(0, 10]	0	10	>3*	3	<=3

* In RRG database, the minimum travel speed on a rail arc was 3km/h

Again, after completing speed estimation for GISCO rail network, travel time can be obtained through dividing “Shape_Length” by “SPEED” to be further applied as network attribute in terms of time cost.

The final built network dataset based on GISCO rail data contained 71566 edge elements and 33038 junction elements. All network settings were the same as those to build network dataset based on RRG rail data.

APPENDIX 2 DEIGN OF THE BASIC TERRITORIAL INDICATORS

Name & Code	Inhabitants per train station 1
Relevant dimension	Territorial efficiency – Infrastructure endowment
Definition	1000s inhabitants per train stations
Spatial Resolution	NUTS 2
Applied Data	GISCO Railway network database 1996; RRG Railway network database 2008; NUTS2 2006; Demography statistics from Eurostat 2000/2008;
Assumptions	1. All rail stations can provide sufficient capacity to server passengers in need as basic entrance/ exit of interested rail network, no hierarchy issue considered. 2. Inhabitants in a region have similar and stable need in train stations even in different time points
Unit	1000 inhabitants
Possible value range and classification of regions	Range: 0 ~ +∞ Classification: 5 levels according to quantile classification method. 1-5 relatively represent classes from low value to high value: 1 - Most sufficient infrastructure endowment 2 - Sufficient infrastructure endowment 3 - Medium infrastructure endowment 4 - Less sufficient infrastructure endowment 5 - Least sufficient infrastructure endowment
Calculation	Firstly summarize number of train stations in a region according to available spatial dataset. Then use relevant regional population divide the number.

Name & Code	Travel time to the closest top 10 MEGAs 2
Relevant dimension	Territorial efficiency – External accessibility
Definition	Travel time to the closest top 10 MEGAs according to GDP rank through related rail networks
Spatial Resolution	NUTS 2
Applied Data	GISCO Railway network database 1996
Assumptions	RRG Railway network database 2008
Unit	Minutes
Possible value range and classification of regions	Range: 0 ~ +∞ Classification: 5 levels manually according to quantile classification method and special values. 1-5 relatively represent value from low to high with meaning of: 1 - Best accessibility 2 - Good accessibility 3 - Medium accessibility 4 - Unsatisfied accessibility 5 - No access to any MEGA
Calculation	Through GIS Network Analysis – Closest Facility function, travel time to the closest MEGA (as facility) from each NUTS2 (as incidence) can be accumulated by searching the route and stored in route table. Principally, for each NUTS2, the expected indicator value was generated after running model as accumulated time. However, since not every NUTS2 must have access to a MEGA (facility) due to the distribution of applied networks, some NUTS2 may have no route to a closest MEGA, so no travel time value will be available. Generated route tables of the two years were exported to SPSS for further processing.

Name & Code	Average travel speed by rail within a region 3
Relevant dimension	Territorial efficiency – Network efficiency
Definition	Average travel speed by rail within a region
Spatial Resolution	NUTS 2
Applied Data	GISCO Railway network database 1996 RRG Railway network database 2008 NUTS2 2006
Assumptions	1. Basic rail network assumptions about speed; 2. Travel speed is the main factor in rail transport efficiency, other factors, such as operation and management, have been assumed to have insignificant impact or equal level among interested regions;
Unit	Kilometres per hour
Possible value range and classification of regions	Range: 0 ~ 320 Classification: 5 levels according to quantile classification method. 1-5 relatively represent value from low to high: 1 - Very Low level 2 - Low level 3 - Medium level 4 - High level 5 - Very high level
Calculation	Average travel speed (ATS) in a NUTS2 region was calculated through dividing total length of rails in a region by total travel time to go through these rail segments in this region. In both rail network databases of 1996 and 2008, each rail segment has its unique travel speed and length, and derived unique travel time. Based on these values, total rail length and total travel time in the two years have been summarized and in SPSS. Simple calculation can further generate the value of this indicator.

Name & Code	Internal regional disparity in travel time to the closest main international airports 4
Relevant dimension	Territorial Quality – Fair accessibility
Definition	Standard deviation of travel time to the closest main international airports among sub-regions within an interested region through related rail networks.
Spatial Resolution	NUTS 3
Applied Data	GISCO Railway network database 1996 RRG Railway network database 2008 Airport data 2006 NUTS 2006
Assumptions	1. All selected main airports were equal in functions, that people prefer to use the closest one 2. Basic network analysis assumptions1
Unit	None
Possible value range and classification of regions	Range: 0 ~ +∞ Classification: 5 levels according to quantile classification method. 1-5 relatively represent region classes with indicator value from low to high: 1 - Most fair 2 - Fair 3 - Medium 4 - Unfair 5 - Most unfair
Calculation	Through GIS Network Analysis – Closest Facility function, travel time to the closest airport (as facility) from each NUTS3 (as incidence) can be accumulated by searching the route and stored in route table. Principally, for each NUTS3, travel time to the closest facility could be generated as accumulated time after running "close facilities" models based on the networks. For NUTS3 regions with no accessibility to a closest main airport, the time value will be considered as ∞. Tables containing time values were exported to SPSS to calculate the final value for each NUTS2 region in this indicator. Standard deviation of travel time was summarized based on NUTS2 region, which contains at least two NUTS3 regions. Those small-size NUTS2 regions coving only single NUTS3 regions were excluded in this indicator since no standard deviation existed.

Name & Code	Percentage area of Natural 2000 within 1km distance to rail infrastructure 5
Relevant dimension	Territorial Quality – Environmental risk
Definition	Area share in percentage of Natural 2000 within 1km distance to rail infrastructure, which were supposed to be in environmental risk
Spatial Resolution	NUTS 2
Applied Data	GISCO Railway network database 1996 RRG Railway network database 2008 Natural 2000 NUTS 2006
Assumptions	1. 1 kilometre is the distance that rail infrastructure may have negative effects to surrounding environment by making noise, emission, attracting economic activities
Unit	%
Possible value range and classification of regions	Range: 0 ~ 100 Classification: 5 levels according to quantile classification method. 1-5 classes relatively represent region classes with indicator value ranges from low to high: 1 - Slight risk 2 - Low risk 3 - Medium risk 4 - Considerable risk 5 - High risk
Calculation	Natural2000 polygons were first intersected with NUTS2 polygons to get Natural2000 for each NUTS2. Area of Natural2000 per region can be easily summarised in ArcMap and stored in a table. Then the 1 km buffer has been generated for rail infrastructure in ArcMap by applying "Buffer" spatial analysis tool as first step. Spatial data of Natural2000 within 1 km distance to rail per NUTS2 could be gained by intersecting Natural2000 polygons within NUTS2 with the generated buffer polygon. Again applying "summarise" tool can calculate the area of Natural2000 in environmental risk for each region. Simple dividing operation based on the two summarised area values led to the final value in this indicator.

Name & Code	Share of electrified rail length out of the total rail length 6
Relevant dimension	Territorial Quality – Sustainable transport
Definition	Share of electrified rail length out of the total rail length within a region
Spatial Resolution	NUTS 2
Applied Data	GISCO Railway network database 1996 RRG Railway network database 2008 NUTS 2006
Assumptions	1. Electrified rail were considered as relatively sustainable
Unit	%
Possible value range and classification of regions	Range: 0 ~ 100 Classification: 5 levels according to interval classification method. 1-5 classed relatively represent regional classed with indicator value ranges from low to high: 1 - Very low level (0-20) 2 - Low level (21-40) 3 - Medium (41-60) 4 - High level (61-80) 5 - Very high level (81-100)
Calculation	Since there were fields indicating whether a rail segment in the dataset was electrified, it was easy to select those electrified rail segments and summarise their total length per NUTS2. This indicator was calculated by dividing total length of electrified rail by total length of all rail within a region for each NUTS2.

Name & Code	Rail density as proxy as land fragmentation measure	8
Relevant dimension	Territorial identity – Land and landscape	
Definition	Rail density (kilometres per square kilometres) within a region	
Spatial Resolution	NUTS 2	
Applied Data	GISCO Railway network database 1996 RRG Railway network database 2008 NUTS2 2006	
Assumptions	GISCO and RRG rail databases cover all existing rail infrastructure in study area;	
Unit	km/ km²	
Possible value range and classification of regions	Range: 0 ~ +∞ Classification: 5 levels according to 0 quantile classification method. 1-5 classes relatively represent regional classed with indicator value ranges from low to high: 1 - Least fragmented 2 - Low fragmented 3 - Medium fragmented 4 - High fragmented 5 - Most fragmented	
Calculation	Summarize rail length for each NUTS2 in the two interested year, and then calculate rail density through dividing the length value by region's area.	

Name & Code	Potential accessibility to human resources in science and technology (HRST)	9
Relevant dimension	Territorial identity – Knowledge and innovation	
Definition	Potential accessibility in terms of Human resources in science and technology (HRST). HRST are defined by Eurostat as persons fulfilling at least one of the following two conditions: 1) Human resources in terms of education: individuals who have successfully completed a university level education; 2) Human resources in terms of occupation: individuals who are employed in a science and technology occupation as 'Professionals' or 'Technicians and associate professionals'. 1	
Spatial Resolution	NUTS 2	
Applied Data	GISCO Railway network database 1996 RRG Railway network database 2008 NUTS2 2006 HRST statistics 2001/ 2009 from Eurostat	
Assumptions	1. Potential accessibility is assumed as a negative exponential cost function: $Ai = \sum_j HRST_j * \exp(-\beta * T_{ij})$, where Ai is the Potential accessibility for region i, HRSTj is human resource in science and technology in region j, Tij is the time cost from region i to region j through rail network, and β equal the reciprocal of maximum among all Tij.	
Unit	1000 people	
Possible value range and classification of regions	Range: 0 ~ +∞ Classification: 5 levels according to 0 quantile classification method. 1-5 classes relatively represent regional classed with indicator value ranges from low to high: 1 - Lowest potential 2 - Low potential 3 - Medium potential 4 - High potential 5 - Highest potential	
Calculation	Applying network analysis- OD cost matrix, a table based on Origin-Destination was generated containing time cost values to travel from origins to destinations. Origins and destinations were both representative points for NUTS2 regions. Simple ranking could find the maximum time cost among all the values, which was used to get β. Then the potential accessibility measure was calculated based on its function $Ai = \sum_j HRST_j * \exp(-\beta * T_{ij})$ for each NUTS2 region.	

APPENDIX 3 MAP OUTPUTS OF BASIC TERRITORIAL INDICATORS

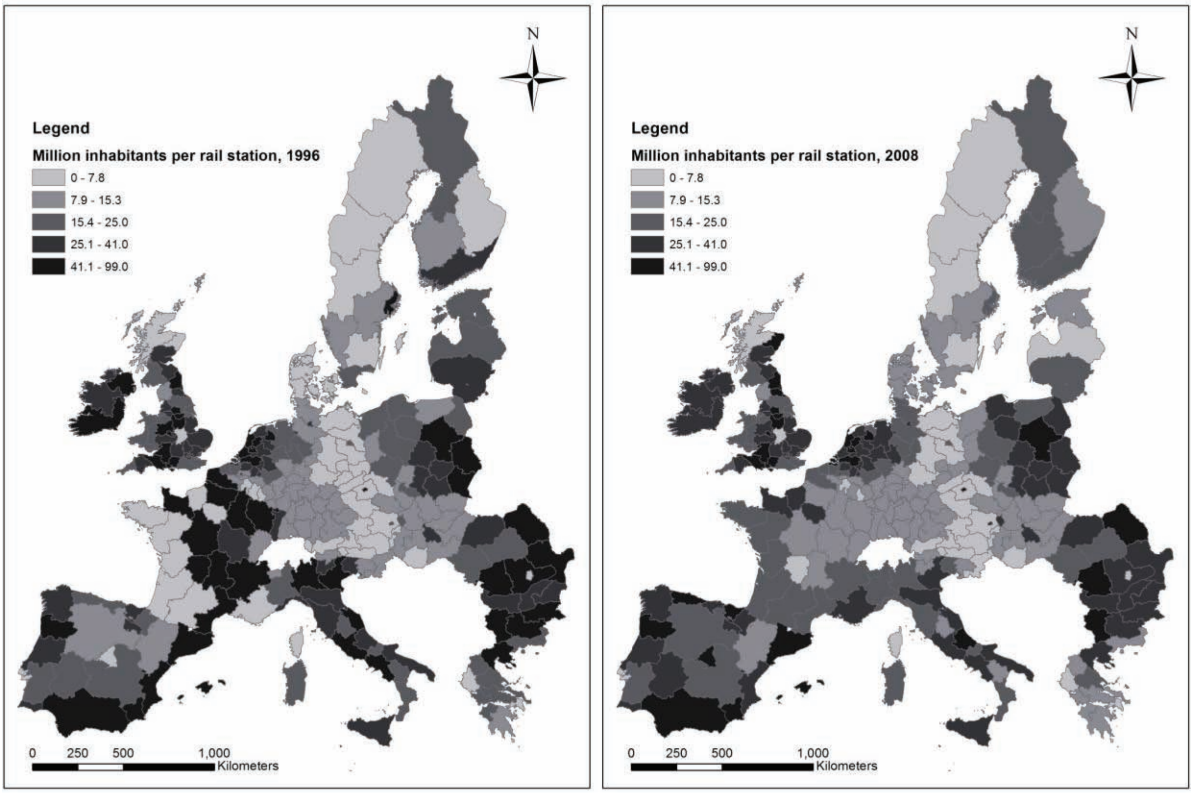

Figure A 4 Basic territorial indicators for Infrastructure endowment, 1996-2008

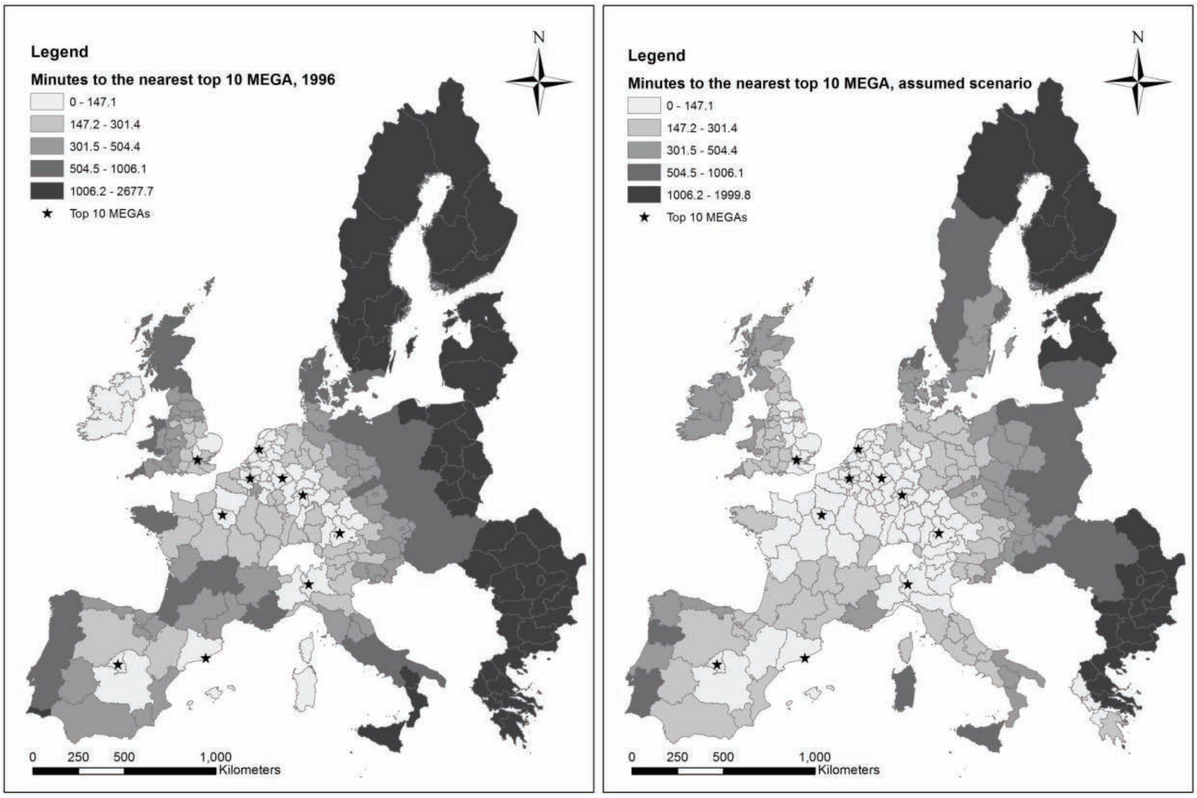

Figure A 3 Basic territorial indicators for External accessibility, TEN-T completed year

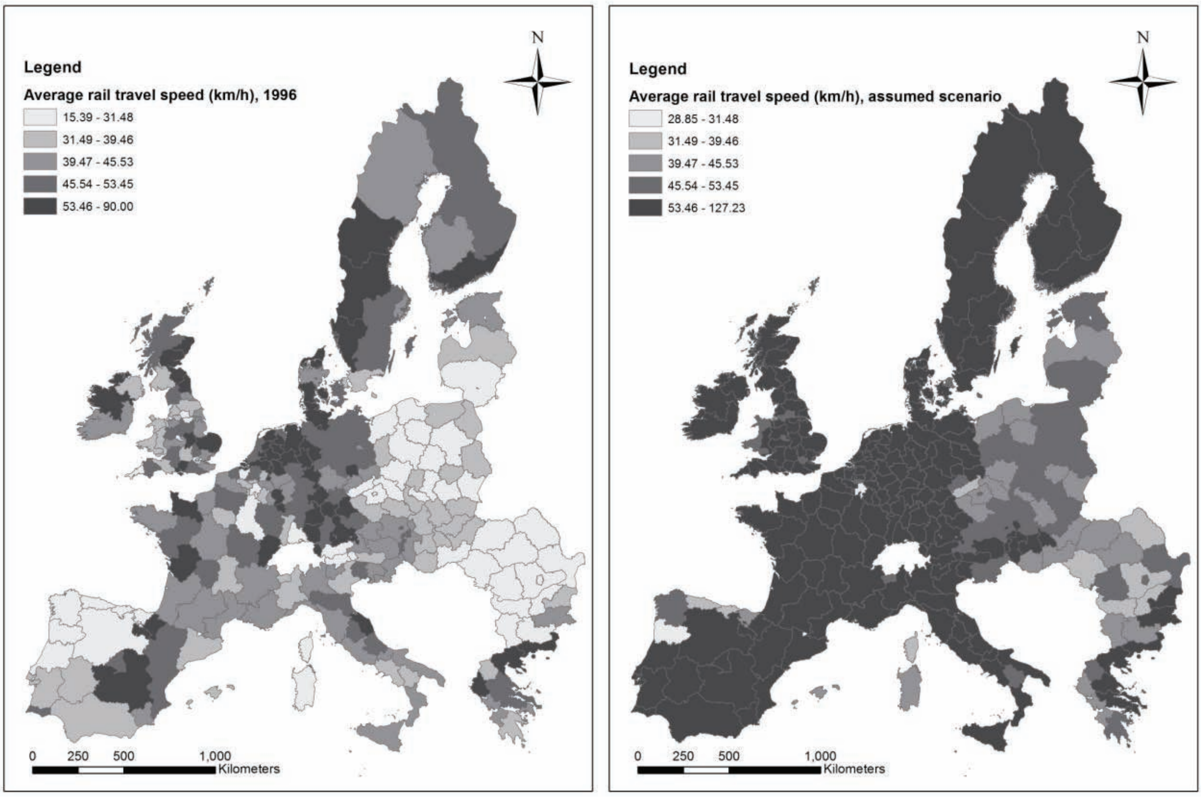

Figure A 5 Basic territorial indicators for Network efficiency, 1996-TEN-T completed year

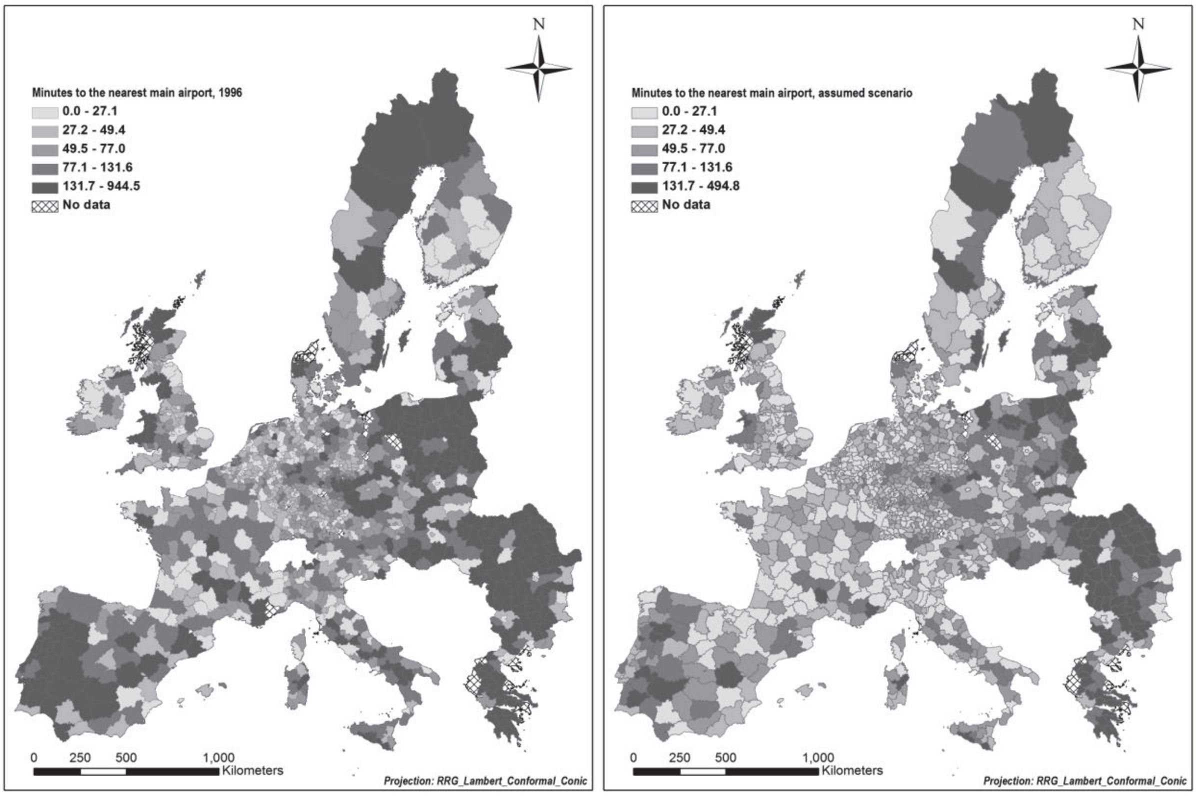

Figure A 6 Minutes to the nearest main airport at NUTS3 level, 1996-TEN-T completed year

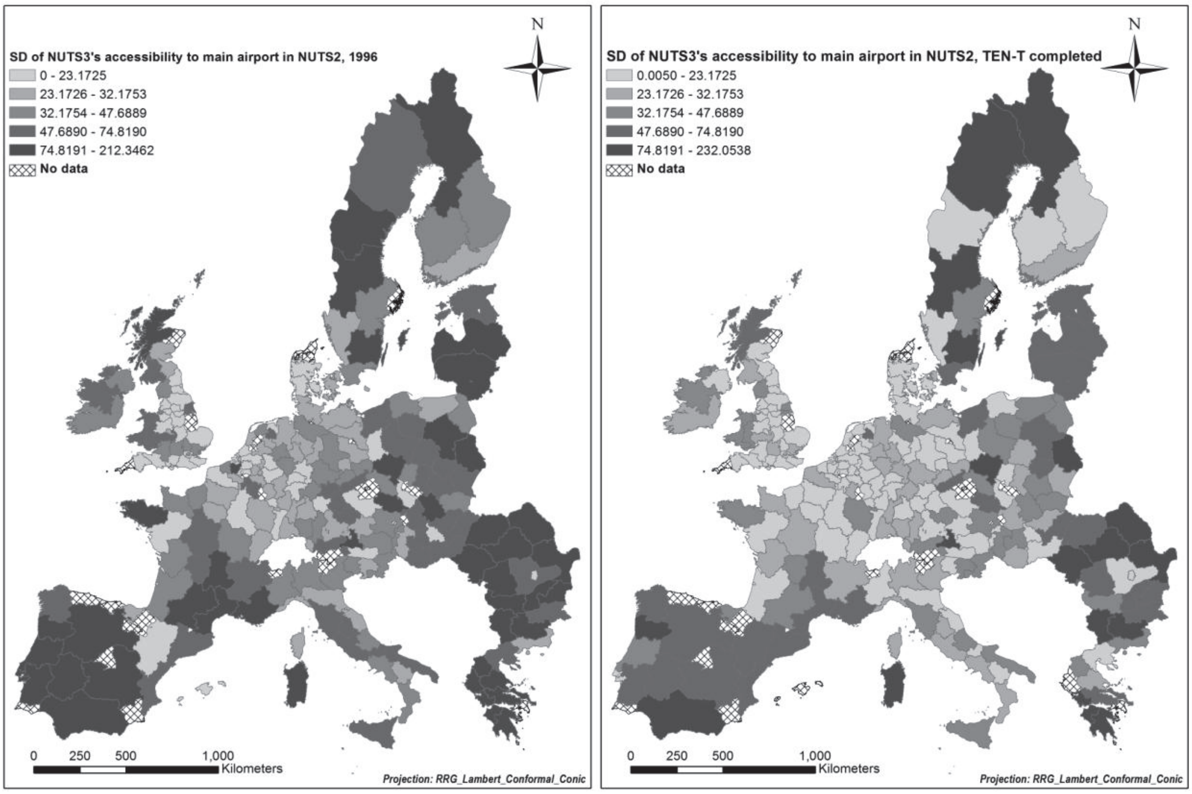

Figure A 7 Basic territorial indicators for Fair accessibility, 1996-TEN-T completed year

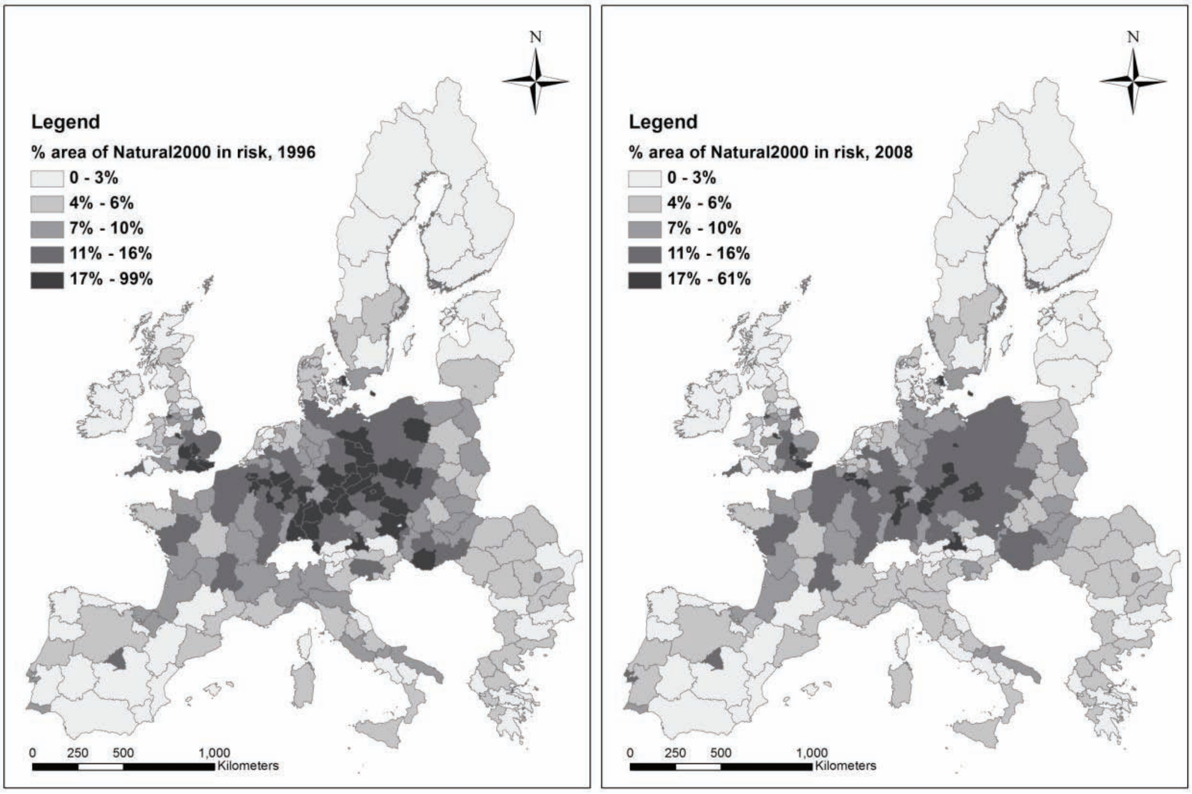

Figure A 8 Basic territorial indicators for Environmental risk, 1996-TEN-T completed year

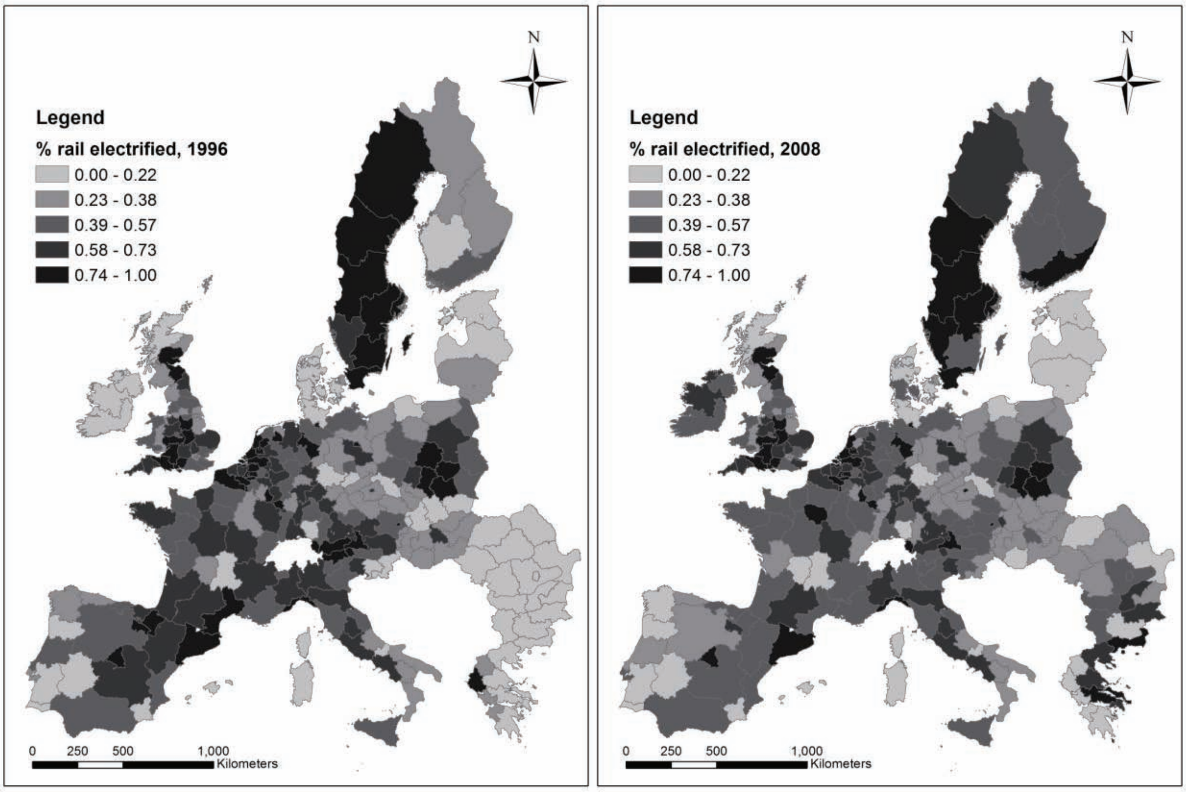

Figure A 9 Basic territorial indicators for Sustainable transport, 1996-TEN-T completed year

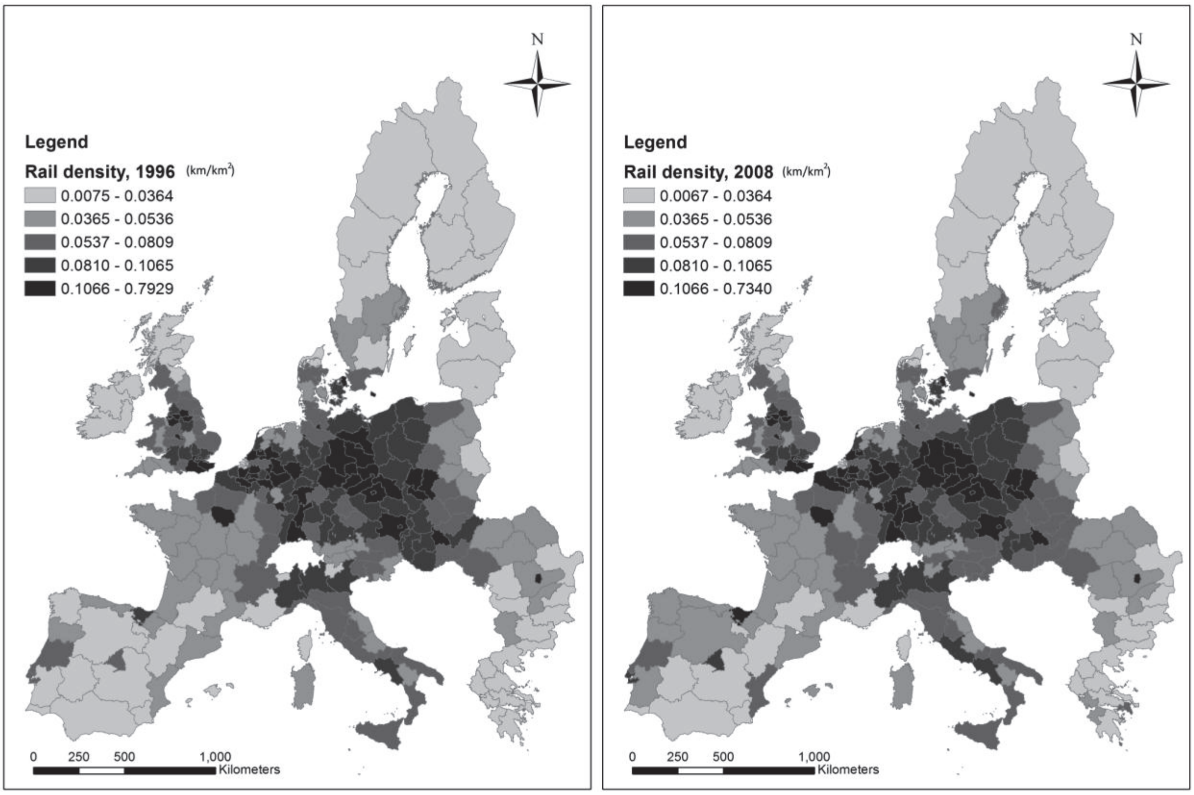

Figure A 10 Basic territorial indicators for Land and landscape, 1996-TEN-T completed year

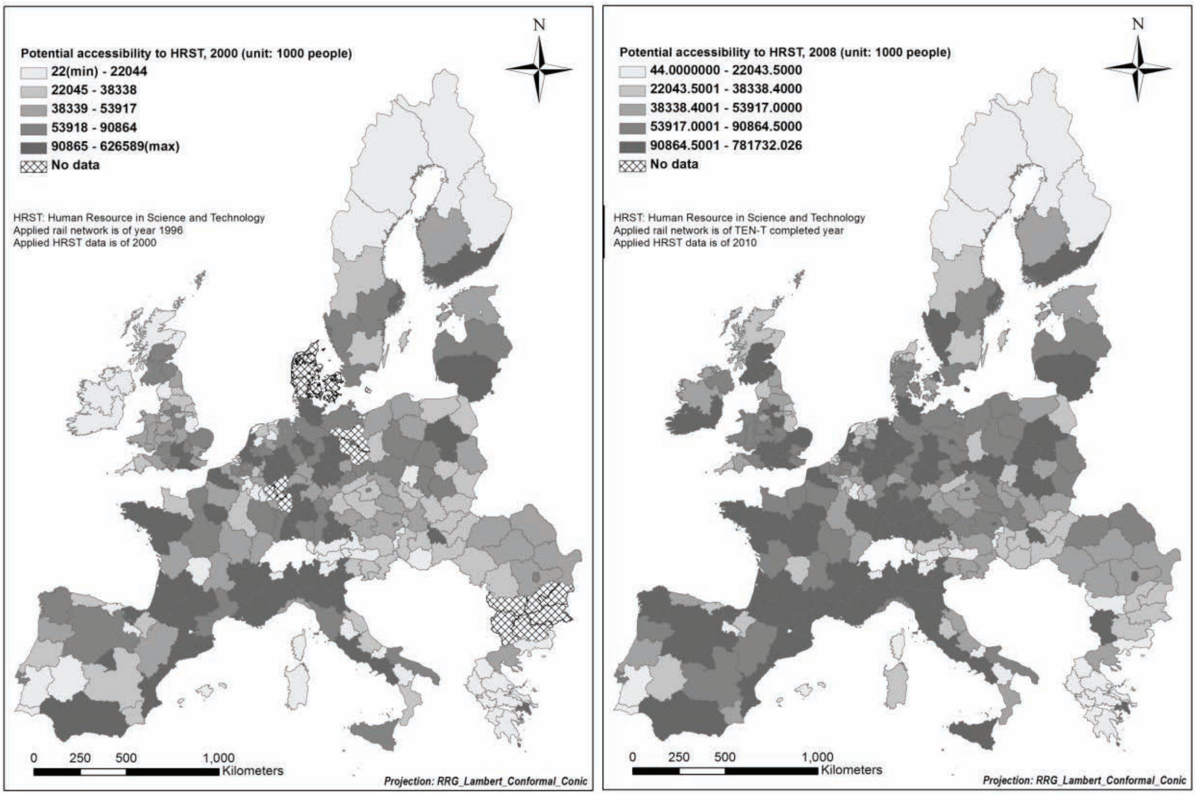

Figure A 11 Preparation for Basic territorial indicators for Knowledge and innovation, 1996-TEN-T

APPENDIX 4 REVIEW OF PARTICIPATORY ACTIVITIES

OPEN DAYS: Chao's Review, 17-10-2011

During the four days events, I participated in different workshops, in which three were relatively highly-relevant to my thesis, but even the 'non-relevant' ones also brought ideas to my mind about the thesis. These workshops mainly covered fields of impact evaluation methods, territorial cohesion views, regional project practice and regional studies involving territorial indicators. Most of the presentations are or will be available on-line. Here are some notes and rethinking.

Workshops	Interesting presentations	Views and Notes
11C02 - How to capture the effects of EU funding? Bringing together qualitative and quantitative methods	1) Mouque D.- The best of both worlds; 2) Picciotto R. - Capturing the Impact of EU Funding: The potential and limits of experimental methods. **Potential contacts**: Picciotto R., European evaluation society	Quantitative methods need qualitative methods to complement in evaluation especially in regional/ urban studies involving in soft impacts such as life quality, governance and environment aspects. There should be consideration about both qualitative and quantitative indicators in the developing framework. "Not everything counts can be measured, not everything measured, counts". There should be deeper and critical discussion about quantitative results from modelling because "Number should be the starting point, not the end". Evaluation quality: credibility(accuracy), dependability(reliability), transferability(external validity), conformability(verifiability) A rigorous methodology study needs quality analysis to analyse its limitations and potential. "Impact means different things to different people." Territorial impact has two dimensions, one is time (change between two years), and another one is regional disparity / disparity between region groups. No "before-after", but "with-without" Before I equate these two concepts. The results should be observed estimated outcomes with those of a counterfactual (without scenario).
11C06 - How to use major investments for the benefit of the whole region?	Dam A. - The Fehmarnbelt Fixed Link: Creating permanent value from infrastructure investments	Money measures (such as GDP) need to be standardized when multiple years are involved in Traffic flow could be proxy of attractiveness

12B19 - Territorial programming in cohesion policy: What does territorial cohesion mean in practice?	Baliński D. - Territorial programming in cohesion policy: What does territorial cohesion mean in practice? Potential contacts: Baliński D. daniel.balinski@mrr.gov.pl	There is no uniform definition for Territorial Cohesion, but in practice, achieving Territorial Cohesion objective “greatly emphasizes on the concentration of public intervention to conditions of various territories, by tailoring policy measures to **specific problems of developed and less developed places**” ... Regional disparity reduction is the most important issue in territorial cohesion practice. From Polish view, balance is the answer to objective confliction problem in terms of competitiveness and cohesion in HSR development, which means enhancing competitiveness of the country and consequently paying attention to “problem areas” in danger of exclusion. But the first priority is to connect big cities. Territorial cohesion in TEN-T development will have totally different effects in different regional scale, for higher scale such as national or provincial scales, cohesion effect might be consistent with competitiveness improvement, while in lower local scales, it’s more possible to have negative results. This can be a hypothesis to prove. Pay special attention to those “problem areas” (rural areas, border areas) in analysis. When talk about territorial cohesion in practice, detailed measures are needed, not only from GDP. Multi-level institution coordination and cooperation is important in any projects, because they make decisions. Institution-related factors and measures need some integration in the evaluation.
13B27 - Regional and Local Economies in a Changing Global Context, Performance Monitoring and Territorial Indicators	1) Hy Dao. – INTERCO: Indicators on territorial cohesion 2) Lennert M. - Territorial Performance Monitoring 3) Stefan Greiving- Territorial impacts of climate change on European Regions	In CLIMATE project, focus is on the response from regions to climate change (cc). Cultural/ institutional factors influencing climate change effects are considered. Sensitivity to CC, regional adaptive capacity (including awareness), vulnerability (function of reality, sensitivity and adaptive capacity) are checked in sequence with sets of maps. This conceptual framework showed a good way to deal with environmental measures in regional scale with doubt in the sense to check “global” issue in regional scale. Territorial Performance Monitoring project emphases again the need to integrate qualitative information to complement limits of quantitative methods in data availability, information absence and ambiguity from numbers. Qualitative information’s application in the study INTERCO gives general guide in indicators on territorial cohesions. Main dimensions including 1) territorial structure, 2) connection, 3) competitiveness, 4) innovation, 5) inclusion, 6) environmental quality, 7) energy and 8) cooperation/ governance. Indicators are calculated at sub-national level and analysed between types of areas, showing context, trends and performance. Top indicators are proposed and will be discussed in ESPON’s workshop.

REVIEW: ESPON Workshop "Assessing Indicators for Territorial Cohesion" organized in cooperation with the ESPON INTERCO project, European Commission - DG Regio, Brussels, 20 October, 2011

1. Workshop Brief

This workshop is organized by ESPON to have public discussion and consultancy for the ESPON INTERCO project, which set out to develop a set of comparable and reliable indicators and indices that can be used to measure territorial cohesion, complex territorial development, structural issues, territorial challenges and opportunities as well as territorial effects at different geographical levels and types of regions in a general sense. The focus of this workshop is indicators' usefulness, relevance and meaningfulness based on a manageable short list of indicators proposed by the project team after studying, discussing and testing a wide range of indicators and indices. More than 30 participants from diverse institutions and organizations, who are working on or interested in territorial relevant issues, presented in the workshop. Through presentations, group discussions, debates, panel discussion and conclusion, this workshop delivered impressive comments, remarks, proposals and suggestions for INTERCO team to better complete the project. Moreover, this workshop enhanced the understanding of territorial cohesion both in its connotation and operationalization, which has provided a guiding framework for developing specific studies in contexts, such as the thesis I am conducting, saying in the specific context of Trans-European rail network development in passenger transport.

During the workshop, the INTERCO team presented their most important output up to this moment, saying the **five facets** and **a series of top and supplementary indicators and indices** relevant to the facets. These were the starting point of discussions and debates among participants.

2. Facets

The five facets illustrating the main dimensions of territorial cohesion and interest for various interpretations of territorial cohesion were extracted through a series of workshops running from November 2010 to January 2011:

Smart growth in a competitive and polycentric Europe

Inclusive, balanced development and fair **access to services**

Local development conditions and geographical specificities

Environmental dimension and sustainable development

Governance, **coordination** of policies and territorial impacts

Each of the facets stresses different aspects of territorial cohesion and the different facets are by no means mutually exclusive and some of them can in parts also contradict each other. By considering all the five facets, the INTERCO team intent to develop indicators covering the full spectrum of what territorial cohesion can mean and that all relevant stakeholders can relate to some of the indicators.

3. Remarks referring to my own study

As stated by the INTERCO team, these facets were not exclusive mutually but partially overlapping or even contradict. They structured INTERCO's framework to develop indicators. These facets to INTERCO are similar to the three dimensions - territorial efficiency, territorial quality and territorial identity (shortly indicated in TE-TQ-TI in this report) to my study. Some comparison:

INTERCO's facets and my dimensions share the aim to cover the full spectrum of territorial cohesion and a generally consistent extension of territorial cohesion (covering socio-economic, environmental, geographical and institutional aspects). Although in different classification, they can be correlated.

TE-TQ-TI has a more general sense in territorial cohesion; while INTERCO's facets has explicit consideration of current policy (European 2020 & TA 2020), such as smart growth and polycentric development.

As discussed in the final session in this workshop, should such study refer more to current policy (TA 2020), or it should generate longer-term value in general sense to be adaptable even policy changes? For my study, I prefer the later, to develop a more general method. In my perspective, TE-TQ-TI components for territorial cohesion are more favored in this sense. However, INTERCO's facets could be priorities to consider or minimum set of aspects to cover in my study. They provide sharpened understanding of territorial cohesion merging emphasis of multiple stakeholders and a reasonable framework for the final top indicators.

4. Indicators

Proposed indicators were presented by INTERCO team facet by facet following by group discussions. During the discussion, participants discussed, rethought and then either rejected/modified existing indicators or proposed new indicators in terms of usefulness, relevance, meaningfulness, data availability, time and spatial resolution, desired direction of change, as well as use in practice.

The original list of indicators was challenged and complemented by participants. Impressive remarks include:
1. There should be explicit territorial dimension in the indicators
2. Context indicators should be distinguished from the favoured outcome indicators
3. Better to have indicators in NUTS 3, or at least NUTS 2 level, or they are meaningless in indicating territorial cohesion
4. It is preferred to largely consider lagging areas, rural areas
5. Indicators need to be linked and read in context

New issues or indicators to be consider, desired ways to modify some valuable but improvable indicators, and suggested context indicators are briefly listed as below. **In all, access to service, population in poverty, employment (especially for youth), tertiary education, cooperation between regions are the most emphasized core issues about territorial cohesion.**

New: high growth firms, corruption , ESPON climate index, noise pollution, access to health/ university/ clean water/ drinking surface/ broadband/ ICT/ pubs/ large cities/ culture/ sport/ public transport (NUTS 3), relevant presence of integrated territorial strategies, energy consumption by households, stability of energy supply (access to grids), NATURA 2000 areas, water use efficiency (urban-rural compensation/ hydro-electricity), accessibility in commuting in functional areas, e-business, increase in public transport, trust in police, crime rate, tertiary education/ long life learning, youth employment, demand for jobs and job create, connectivity, flows of innovations between regions, biodiversity, energy efficiency (more useful than intensity), commuting distance/ time,

Keep/ useful: employment (NUTS3, especially high unemployment regions), air pollution (NUTS 2), regional governance (detail work), water resource, access to service (school), labour productivity, population at risk of poverty and social exclusion, life expectancy in NUTS 3, hazards NUTS 2, Natural assets, soil sealing (per GDP), renewable energy intensity, workless households (used in cohesion policy),

Context: population aged with education, polycentricity index, disposable household income, population potential in 50 km, net migration, population density,

Useless: quality of governance, disposable household income

5. Remarks referring to my own study

Most of the indicators proposed either by INTERCO team or participants are more as guide but too general to use directly in my study, such as GDP per capita, employment rates/ unemployment rates and life expectancy. However, the discussion about them offers me the way to re-think and re-define my indicators, as well as much opener horizon combining with data information to either reduce or add my indicators.

Considering the Trans-European rail network context, the most relevant issue is still accessibility. Accessibility to all kinds of services was highlighted by almost all the participants. But through TEN-T, local services mentioned such as health, primary school, pubs, broadband should not be used since Trans-European rail network does not serve passengers in this way. Noting the main function of Trans-European rail network is connecting important functional areas, I prefer to use **accessibility to large** cities/ international airports and hubs/ natural assets (Nature 2000 areas, UNESCO sites, etc.)/ markets and jobs/ innovation centres through the network and proximity to train stations.

Relating indicators with population, population in risk of poverty, more vulnerable population are necessary to enhance common indicators' territorial property in line of focusing on outcome indicators (measuring regional well-being, difference, and change). Much attention is needed to distinguish context indicators from outcome indicators. Net Migration is a contentious indicator in discussions, since it is hard to tell which direction of change is desirable. But from the view that it can be a proxy for attractiveness of a region, this indicator becomes more meaningful than a simple context indicator.

Besides, the way to read indicators is important. For example, proximity to university for a region seems less reasonable an advantage if taking universities only as educational institutions for students. However, taking universities as innovation centres and development engines makes sense.

Finally, about data availability, it is true there is more expectation than reality. Although data is a key condition to reach a "result", it shouldn't be the first criterion to select indicators. Ideal indicators might be unable to present completely in maps or graphs in this moment; however, they have value in recommending relevant data collection in the future. Therefore, I don't expect all indicators I finally selected can be implemented, but all of them should be clear and meaningful, as well as reasonable and possible to collect data.

6. Lewis' conclusion: Five headline targets related to territorial cohesion

a. Access to services
b. High quality natural environment
c. At risk of poverty or exclusion
d. Territorial innovation
e. Territorial governance

Under each heading, one could include multiple dimensions.

For services, one could include compulsory education, primary health care, hospitals, universities and broadband. It could be measured by degree of urbanization and/or based on a GIS layer

For high quality natural environment, one could include data on soil, water, air and noise pollution by degree of urbanization or grid based data.

At risk of poverty or exclusion would be by degree of urbanisation and one could add the three sub-dimensions separately.

Territorial innovation could look at the % of high growth firms in a NUTS 3 region, it could also include labour productivity in industry and services, birth rates and survival rates of firms

Territorial governance could cover the use of integrated place based strategies, the use of functional regions, use of territorial impact assessments and the variation in corruption and discrimination by degree of urbanization.

7. External materials

Workshop webpage:

http://www.espon.eu/main/Menu_Events/Menu_Workshops/workshop111020after.html

Workshop background document:

http://www.espon.eu/export/sites/default/Documents/Events/Workshops/IndicatorsTerritorialCohesionOctober2011/Assessing_Indicators_for_Territorial_Cohesion_-_Background.pdf

INTERCO project webpage

http://www.espon.eu/main/Menu_Projects/Menu_ScientificPlatform/interco.html