
Transport Policy and Regional Development: The Economic Impact of Regional Accessibility on Economic Sectors

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Abstract

Regional accessibility is an important location factor, which enhance the region and, therefore, promote economic growth. It is the virtual aim of transport policy, on European as well as on national level, to strengthen regional accessibility. But available resources to do so are limited. Therefore, new investment and enlargement in transport infrastructure should be based on efficiency considerations. This article focuses on the economic impact of regional accessibility and in different economic sectors in order to prepare a methodology of planning for efficient transport infrastructure investment along the corridor Rotterdam-Genoa. The approach takes into consideration that the output of economic sectors depends differently on logistic services. If we consider different regional concentrations of specific sectorial activity, we can assume different economic impacts of transport infrastructure investment on different regions or, in other words, higher 'costs of non-doing' if bottlenecks in transport infrastructure persist. Therefore, the link between transport costs and regional accessibility in transport infrastructure is analyzed. The results of an empirical study which surveys the correlation between regional accessibility and regional sector output will be described.

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7.1 Introduction

The positive impact of transport infrastructure on the economic development of nations is not a subject of dispute in theory. In macroeconomics, investment in this kind of infrastructure increases the stock of public capital, which is an important input factor in the production of total national output.

On a regional level the correlation between infrastructure investment and economic growth is less evident. In Location Theory, the availability of transport infrastructure and regional accessibility are important location factors which enhance the region and, therefore, promote economic growth. Other models of Regional Science or Economic Geography assume that a high level of transport infrastructure decreases transport costs. In these models, transport costs have a major impact on the agglomeration of economic activity. Public investment in infrastructures can decrease regional economic growth if industries decide to move production to more important agglomerations. Nevertheless, European transport policy aims to enforce regional cohesion by facilitating an above-average increase in economic growth in weaker regions.

The aim of this article is to focus on the economic impact of regional accessibility and in different economic sectors in order to prepare a methodology of planning for efficient transport infrastructure investment along the corridor Rotterdam-Genoa. This approach takes into consideration that the output of economic sectors depends differently on logistic services. If we consider different regional concentrations of specific sectorial activity, we can assume different economic impacts of transport infrastructure investment on different regions or, in other words, higher 'costs of non-doing' if bottlenecks in transport infrastructure persist.

Transport costs are of particular interest. An important issue, therefore, is how economic theories like macro- and microeconomics, international trade theory or geographical economics deal with transport costs. A brief illustration of the Code24 transport model is given, which is based on the cost of freight transport. The model allows for a calculation of regional accessibility in terms of freight transport along the Rotterdam-Genoa corridor from different aspects. A further issue of this article is to analyze the link between transport costs and regional accessibility in transport infrastructure. Finally, the results of an empirical study which surveys the correlation between regional accessibility and regional sector output will be described.

7.2 European Transport Policy on Rail: A Brief Overview

The aim of current European transport policy is to strengthen rail transport by opening up rail markets to greater competition, promoting technical standardization between rail systems and modernizing Europe's rail infrastructure [1]. The new EU infrastructure policy triples EU financing to EUR 26 bn for transport for the period 2014–2020. At the same time it refocuses transport financing on a

tightly defined new core network. It will remove bottlenecks, upgrade infrastructure and streamline cross border transport operations.

This policy is also part of the European cohesion policy (e.g. [2]). Better transport conditions in this sense aims to remove economic, social and territorial disparities across the EU, restructure declining industrial areas and diversify rural areas that have declining agriculture. The title of the European White Paper on transport describes the overall objective of this policy: European transport policy aims at a resource efficient transport system, especially along important transport corridors.

This European transport policy is sometimes in conflict with national policy alignment. In Germany e.g. the federal states and the infrastructure manager Deutsche Bahn Netz propose rail transport projects for each German Federal Transport Infrastructure Plan (German: Bundesverkehrswegeplan; [3]). The choice of those projects is not based on efficiency considerations. Political considerations in the federal states aim at regional balanced investment. Deutsche Bahn Netz is also part of the vertically integrated national incumbent holding of the German railway system. Market power in the infrastructure market can be transferred to potentially competitive markets and used for discrimination of competitors.

The very same problem appears when national transport policy dictates which project of the national plan has to be realized first. Indeed, each national transport project is checked by a cost-benefit-analysis [4]. Projects are only approved if benefits exceed costs.

But this doesn't automatically mean that the evaluated project is efficient. Furthermore, cost-benefit analysis is susceptible to political influence and more importantly, the German planning process doesn't foresee an efficiency-based prioritization of those national transport projects. The new planning process for the period from 2015 until 2030 includes only a level three prioritization which is based especially on considerations of traffic flow [3].

7.3 Economics and Transport Policy

Economics is a study of how people and society end up choosing to employ scarce productive resources that could have alternative uses. It studies the production of various commodities over time and their distribution for consumption, now or in future, among various groups in society in order to maximize social welfare [5]. This definition by the famous economist and Nobel Prize laureate Paul Samuelson fits very well with regard to current problems in European transport development. Transport infrastructure is such a scarce productive resource. The German Federal Transport Infrastructure Plan is a very good example. The Plan has suffered from a chronic shortage of financing right from the start. The current plan, which was published in March 2003, foresees an investment of EUR 150 bn in transport infrastructure in the period from 2001 to 2015. This corresponds roughly to a

yearly spending of EUR 10 bn on rail, road and barge in [6]. On average, EUR 3.5 bn should be spent on rail each year for maintenance and new investment [7].

According to nine important German economic associations, the need for public investment in transport infrastructure exceeds the real investment to a large degree. Every year since 2001, with the exception of 2009 and 2010, public spending has been lower than EUR 10 bn. The associations estimate the need at EUR 14 bn [8]. This is the classic economic dilemma in societies where unlimited needs encounter invariably limited resources.

The mismatch between need and resource becomes clearer when one considers the European Rotterdam-Genoa transport corridor. The project group of Code24 estimates the total costs of all suggested infrastructure projects to be EUR 35 bn. These projects have been highlighted in different workshops and regional round tables along the corridor by regional stakeholders. Even if we refer only to the “most important infrastructure projects,” investments of about EUR 19 bn seem to be necessary [9]. But the total need in Netherlands, Germany, Switzerland and Italy for railway infrastructure is about EUR 210 bn. A planning horizon of at least 40 years seems to be realistic for the realization of the extension of the corridor.

Therefore, it is necessary—from an economic point of view—to realize first those infrastructure projects which lead to highest economic benefit. In general, these will be projects which are able to increase infrastructure capacity in regions where infrastructure bottlenecks lead to higher transport costs due to an increase in transport or travel time and a decrease in reliability. Improvements in transport infrastructure decrease transport costs by shortening transport distances or increasing capacity for transportation.

Economic theory deals differently with transport costs. In macroeconomics, the importance of transportation for a whole economy is analyzed. Transport costs are linked to a level of output, employment, consumption and income within a national economy (e.g. [10]). For example, transport costs are part of the aggregated cost function of a national economy. A decline in transport costs will lead *ceteris paribus* to an increase in output in the economy. But transport investments are supposed to have declining marginal returns. Initial infrastructure investments have a high return since they provide new mobility options and so reduce transport costs. The more the system is developed, the more likely additional investment would result in lower returns.

In microeconomics, the importance of transportation for specific markets of the economy is analyzed. Transport costs are linked to producer, consumer and production costs. The importance of specific transport activities and infrastructure can thus be assessed for each sector of the economy.

There are also significant negative impacts to consider which influence individuals, markets or society in general. Those negative external effects can be congestion in the transport system, accidents, which tend to be proportional to the intensity of the use of transport infrastructures, air pollution and noise, or land usage because transport infrastructure takes up large amounts of space.

In international economics, the impact of transport costs on the volume and nature of international trade is of more interest. Transport costs are one factor, amongst many others, that shapes trade patterns. They are in turn determined by underlying variables such as distance, geography, infrastructure quality, trade facilitation measures, fuel costs and transport technology. Integrated into the classical Ricardian model of comparative advantage, transport costs reduce or prevent trade. Certain goods may not be traded internationally like haircuts or other skilled manual work [11]. Transport costs also influence choice of mode (e.g. [12]), the commodity composition of trade [13] and the organization of production, particularly as ‘just-in-time’ methods, outsourcing and centralized distribution strategies are found all over the world [14].

Furthermore, Hummels and Skiba argue that transport costs lead to the export of higher-quality products [15]. They explain that transport cost per unit *ceteris paribus* falls proportionately as the price of the good rises. Transport costs are not to be considered as absolute costs, but rather in relation to the transported value.

In geographical economics, many of the above-mentioned relationships between transport cost and economic development are singled out. The important role of transport infrastructure for spatial development and, hence, transport cost implies that areas with better access to the locations of input materials and markets will be, *ceteris paribus*, more productive and competitive than more isolated areas. Regional agglomeration theories are early attempts to explain the concentration of economic activity in geographical space. Alfred Weber formulated a theory of industrial location in which an industry is located where the transport costs of raw materials and final product is a minimum [16]. The central place theory of Christaller explains number, size and location of human settlements in urban systems [17]. In this theory, transport cost is proportional to distance. Lösch modified Christaller’s theory by creating an ideal consumer landscape where the need to travel for any good was minimized [18].

The relation between infrastructure endowment (or transport cost) and regional development can be modelled in a regional production function (e.g. [19, 20] or in functions where simple infrastructure impact is substituted by more complex accessibility indicators [21].

7.4 Bottlenecks, Regional Accessibility and Transport Costs

Bottlenecks in the transport system occur particularly in times of transport growth. In public debate, it is sometimes unclear what is meant by a bottleneck in transport infrastructure. In many of these political statements, a lack of capacity is specified, usually combined with the projection of increasing freight transport. Holzhey determines capacity bottlenecks by calculating the potential maximum of freight train paths per day for a corridor and comparing that with future needs [22].

As early as 1996 Rothengatter recognized that technical capacity was not a sufficient measure to identify major deficiencies in railway networks. For him, insufficient service levels of railway companies were at that time more important than technical bottlenecks [23]. Cipolina and Ghiara distinguish four different categories of bottlenecks in freight transportation: infrastructural, organizational, technical and bureaucratic [24].

One important target of the Code24 project is to better understand bottlenecks in logistics and their effects on the freight transport corridor Rotterdam-Genoa. In order to do so, an international and interdisciplinary expert group within the project (planners, architects, engineers, logisticians and economists) developed a common definition in 2011 by means of a structured brainstorming process, called Metaplan.

Bottlenecks always represent additional costs to logistic services by hindering them. They can be observed on a politico-legal, organizational or physical level. Such a bottleneck can be national or transborder [25].

What are the economic effects of these kinds of bottlenecks? They decrease regional accessibility. Good accessibility of regions improves their competitive position. Mobility and accessibility are key prerequisites for economic development of all regions of the EU. Another definition is that “accessibility indicators describe the location of an area with respect to opportunities, activities or assets existing in other areas and in the area itself, where ‘area’ may be a region, a city or a corridor” [26].

Accessibility is the main product of the transport system. It determines the locational advantage of an area relative to other areas. With accessibility indicators, one can measure the benefits for households and firms which profit from the existence and use of transport infrastructure.

To measure regional accessibility, various indicators were developed in the past. The basic principle of these indicators is relatively simple. It refers to Newton’s law of universal gravitation, which states that any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. It was adapted by Stewart for use in regional economics [27]. The idea of those indicators is that the accessibility of a region is directly proportional to the attractiveness or size of the region, and indirectly proportional to distance, travel time or cost. Hence, regional accessibility is a function of regional attractiveness and transport cost

$$A_i = \sum_j g(W_j) \cdot f(c_{ij}) \quad (7.1)$$

where A_i is the accessibility of a region i , W_j the attractiveness or size of a region j , and c_{ij} the general cost to reach region j from region i . $g(W_j)$ is a function of regional attractiveness, e.g. regional GDP, population or employment rate, and $f(c_{ij})$ of space resistance, e.g. transport cost or time between regions [28]: the more

attractions in region j and the more easily reachable from region i , the higher the accessibility of region i .

Various types of accessibility indicators can be created by specifying the functions $g(W_j)$ and $f(c_{ij})$ differently (linear, or non-linear). Wegener et al. describe functions of travel time or weighted travel time, of daily accessibility, potential accessibility, multimodal or intermodal accessibility [28].

Space resistance is measured basically in terms of transport cost, travel time or quality of transport. From an economic point of view, travel time and quality of transport can be included in travel cost, too. A long freight transport time increases transport costs because capital (vehicles and goods) works less efficiently than in shorter transport times. It is the same for passenger transport, where longer transport time creates higher costs because people cannot use the time alternatively. If quality of transport represents punctuality, a bad quality (declining punctuality) in the transport system creates higher costs because of increased uncertainty. The Code24 model contains all this information for regions along the Rotterdam-Genoa corridor (see Sect. 7.3) and includes it in transport cost.

7.5 Accessibility and Regional Sector Economy—a Correlation Analysis

7.5.1 Theoretical Considerations

Microeconomic theory suggests that different markets are differently affected by transport costs. Therefore, certain industries might suffer more from an increase in those costs than others. Available data is not very recent. The US Department of Transportation gives some evidence to this theory [29]. It has developed a set of transportation satellite accounts which seeks to establish the full picture with regard to the scale of transportation costs in the US economy in 1997. The researchers found that the economic sector “construction” was the most intensive user of transport at 14.6 cents transport cost per dollar output. The information and financial services sectors were considerably lower at 1.2 and 1.7 % respectively. For Europe, Meyer-Rühle et al. found further evidence for this theory in a study which covers the EU27 countries in 2000 [29]. The highest share of transport cost in output was found for wholesale and commission trade (21 %). The share of transport inputs in retail trade output was 7 %. Manufacturing varied between 5 % (basic metals) and 2 % (communication).

When a firm relocates, transport issues are not in general a first-order consideration, especially if these costs are only a small part of total production costs. However, these costs may be important in several sectors if the ratio of transportation costs to production costs is high or if accessibility to customers may influence the performance of a company [30].

If companies act in this way, a higher concentration of transportation-sensitive sectors should relocate in regions with well-developed accessibility. A correlation analysis shall test this theoretical assumption for regions along the Rotterdam-Genoa transport corridor.

7.5.2 Data Sources

To carry out the analysis of regional accessibility, a dataset was compiled from Eurostat data which, in addition to information about population, area and gross added value of the corresponding regions, also contains information about the regional gross added value of the individual sectors of the economy. There is also data on the number of employees in the various sectors.

The regions examined are organized in accordance with the NUTS classification system (Nomenclature des unités territoriales statistiques). There is data for Germany, France, Belgium, the Netherlands, Austria, Liechtenstein and Luxemburg at the NUTS 3 level. For Switzerland and Italy, there is only some data at the NUTS 2 level, which however can serve to make a plausible estimate for the NUTS 3 level. The different methods used in the classification systems of the individual countries mean that not all variables are available for each country, especially with regard to the classification of economic sectors according to NACE Rev. 2. As a result, the correlation between the calculated indicator and the added value of the individual sectors cannot be determined for each country and each sector. In particular, for the financial sector as well as for the information and communications sector, there is no specific information about added value for Germany, for these sectors are a subset of a broader category of economic activity and as such are accounted for in the statistics of the latter.

The data necessary for calculating regional space resistance in the accessibility indicators derives from the CODE24 model. This data concerns without exception freight transport. Transport costs between regions are calculated by using the minimum costs of intermodal relations: road, rail and/or barge.

Germany, France, Italy, Switzerland, Luxemburg, Liechtenstein, Belgium and the Netherlands are defined as regions of the corridor or of its direct catchment area. Austria is also viewed in high resolution due to its proximity to the corridor countries. The indicator is calculated for these regions. Geospatial data used to create maps were taken from the geographic information system Eurostat/GISCO.

Data on the non-EU countries, which are needed to calculate the indicator, were taken from the CIA World Factbook[31] and the World Economic Outlook Database of the IMF[32]. Despite their generally high reliability, there are many gaps in the Eurostat data. Thus for practical reasons, only data for the year 2009 are used. They have the least amount of gaps. This simplification is justified because the quality of the transport network over the entire corridor over time varies only slightly. Missing GDP data for regions of the corridor were imputed by multiplying the per capita GDP of the parent NUTS 2 region with the average population of the region, provided this information was included in the dataset. If the population figure was also missing, then the arithmetic mean of the GDP for the rest of the NUTS 3 regions of the same country was used.

7.5.3 The Code24 Transport Model

The CODE24 transport model aims at an assessment of the accessibility of a region with regard to logistics and transport services. The model is built up within VISUM as the software environment [33]. By means of the VISUM software environment, all available information about regions, transport networks, terminals and “schedules” (services), costs as well as transport or monetary flows is integrated into the model. This information is used within routing schemes. The model tries to find the shortest or most efficient path, e.g. with regard to transport costs. The analysis leads to cost matrices (COMAs) containing standardized transport costs for all origin/destination pairs within the CODE24 transport corridor and for selected origins/destinations outside the corridor. These COMAs can be used for further analysis inside (e.g. combination with monetary or transport flows, map-based displays) and outside the VISUM environment in matrix calculations for specific case studies [34].

Within this routing/shortest path calculation, quite different types of information are considered such as: networks, terminals, services, network-based cost as derived by use of specific cost-calculation schemes, waiting and transshipment times, transshipment cost, insurance cost and time losses.

The cost calculation can be done for different transport segments such as containers, bulk goods, mineral oil products or automotive. Different kinds of goods show quite different transport and cost structures. This analysis focuses on transport cost for containers.

7.5.4 Specifications of the Accessibility Indicator

To account for agglomeration effects and thus to take into consideration the stronger pull of very strong economic regions in the model, the additional parameter α is greater than one is introduced into the general equation of regional accessibility (1) as an exponent of the activity function $g(W_j)$ —in this case, gross domestic product. To give more weight to distances, the space resistance function $f(c_{ij})$ is designed with the transport costs as a negative exponential function. A high value for parameter β means that nearby targets are more heavily weighted. The resulting function can also be called a potential function of accessibility [28, 35]. It follows that

$$A_i = \sum_j BIP_j^\alpha \cdot \exp(-\beta \cdot c_{ij}). \quad (7.2)$$

The specifications of parameters α and β in Table 7.1 were chosen to weight regional attractiveness and distance factors of the indicator [36].

Indicators $I_{1,1}$, $I_{2,1}$ and $I_{3,1}$ involve a high weighting for agglomeration effects, and a lower weighting for (cost) distances. Indicators $I_{1,2}$, $I_{2,2}$ and $I_{3,2}$ however, weights agglomeration effects lower while showing just as high a weighting of distance as $I_{1,1}$. Indicators $I_{1,1}$ and $I_{1,2}$ contain only transport cost on road, $I_{2,1}$ and $I_{2,2}$ on road and rail and $I_{3,1}$ and $I_{3,2}$ on road, rail and barge.

Table 7.1 Overview of calculated indicators

Indicator	α	β	Regional attractiveness	Cost function based on mode of transport
I _{1,1}	2	1	GDP	Road
I _{1,2}	1	1	GDP	Road
I _{2,1}	2	1	GDP	Road and rail
I _{2,2}	1	1	GDP	Road and rail
I _{3,1}	2	1	GDP	Road, rail and barge
I _{3,2}	1	1	GDP	Road, rail and barge

7.6 Regional Accessibility Along the Rotterdam-Genoa Corridor

The illustration of the indicator I_{3,1} (Fig. 7.1) shows a clear north-south divide in terms of accessibility. The regions of greater Paris, the Ruhr and the Netherlands are the most accessible, and Italy (with the exception of the area around Rome) and southern France are the least accessible. The Alps are clearly a barrier to the transport of goods. The concentric circular pattern of accessibility intervals around the centers of Rotterdam and Antwerp is very noticeable.

Figure 7.1 illustrates the influence of the river Rhine to the accessibility of regions. Rings of decreasing accessibility centered around the North Sea ports of Rotterdam and Antwerp are still visible. The potential use of barge transportation which is included in the calculation of indicator I_{1,3} increases the accessibility of regions near the river Rhine and illustrates the limitation of the corridor until Basel (Fig. 7.2).

The illustrations of indicators I_{1,1} (road) and I_{2,2} (road and rail) present similar pictures as I_{3,2}, with rings centered around the North Sea ports of Rotterdam and Antwerp (Figs. 7.3 and 7.4). Here again the Alps can be seen as a transport barrier. However, these illustrations clearly show that the Rotterdam-Genoa corridor is in the zone of highest accessibility even if accessibility in the corridor is not homogenous.

7.7 Correlations of Regional GDP with Regional Accessibility

The correlations of the indicators differ significantly between the specifications. The following table shows the relationship between the individual indicator specifications and the added value of the different sectors (Table 7.2).

All accessibility indicators are negatively correlated with the added value of the agricultural sector, but mostly positively with all other variables. The strongest correlations are those with the added value of information, trade, services finance and construction sector.

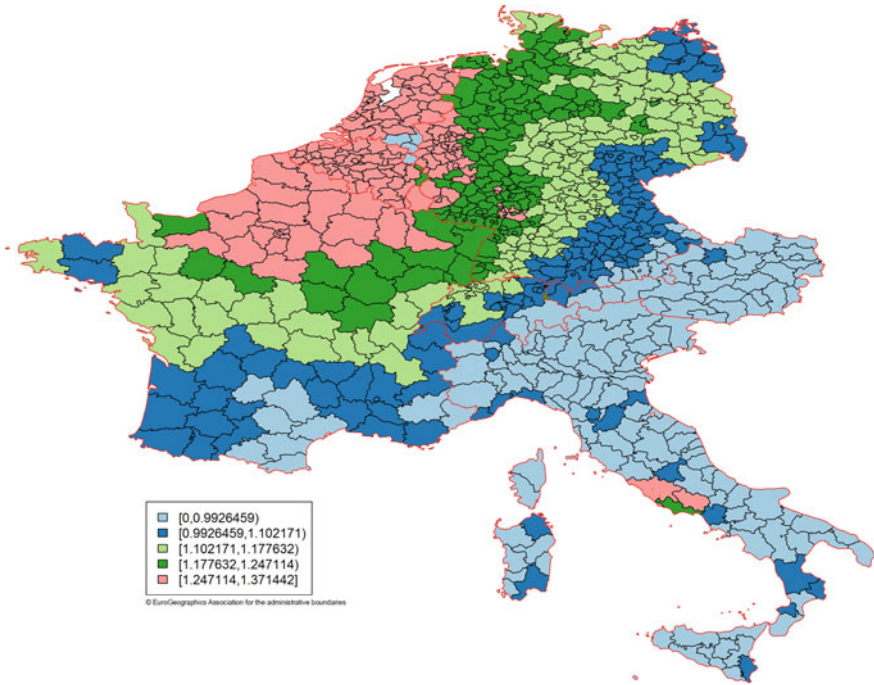


Fig. 7.1 Regional accessibility of Indicator $I_{3,1}$ (data classification in quintile intervals)

Indicators representing road transportation are generally higher correlated with added value of economic sectors than indicators representing rail and road. The two indicators representing all modes of transport ($I_{3,1}$ and $I_{3,2}$) are slightly positively correlated with all sectors except agriculture. Probably this result reflects the relative importance of road transportation for those sectors in relation to rail and barge. Especially the sectors of trade, services and construction seem to be more productive in regions which are well developed in terms of transport infrastructure. The GDP of the sectors of information and finance is highly correlated with the accessibility indicators of road and even of road and rail. Because these sectors do not transport any container, the interpretation is more difficult. Probably a high correlation between regional accessibility and other important location factors exists.

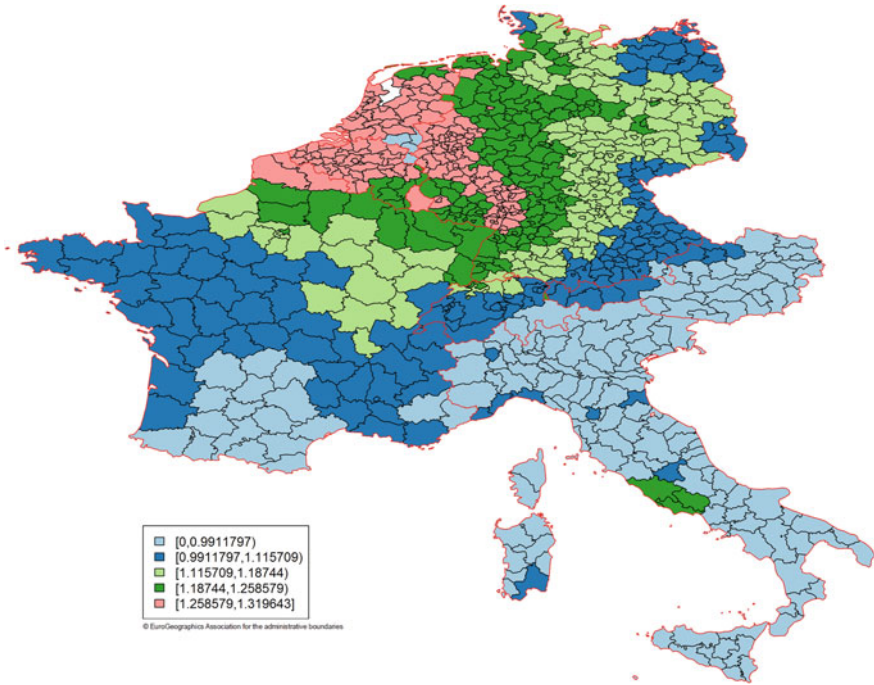


Fig. 7.2 Regional accessibility of Indicator $I_{3,2}$ (data classification in quintile intervals)

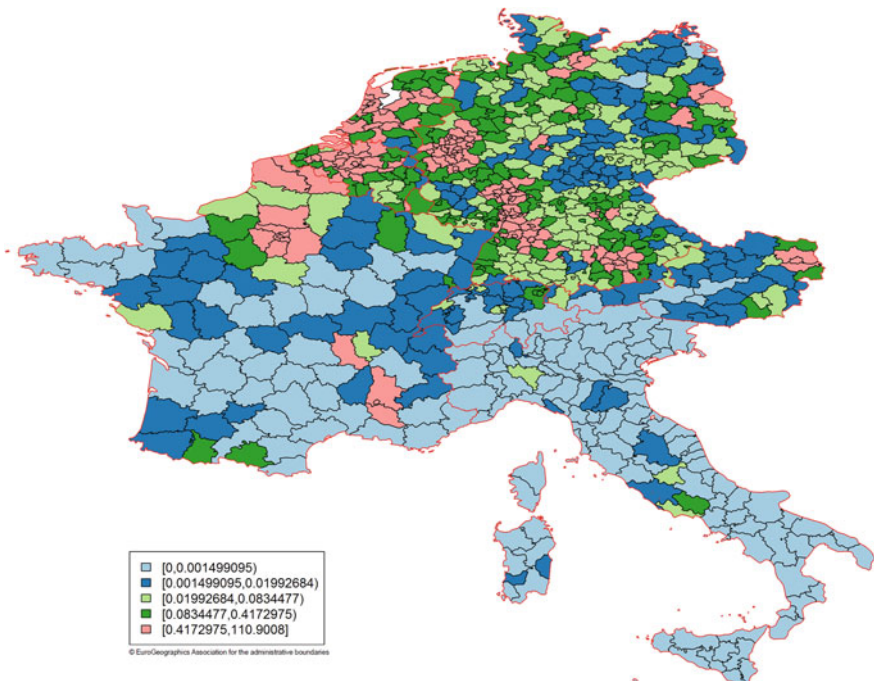


Fig. 7.3 Regional accessibility of Indicator $I_{1,1}$ (data classification in quintile intervals)

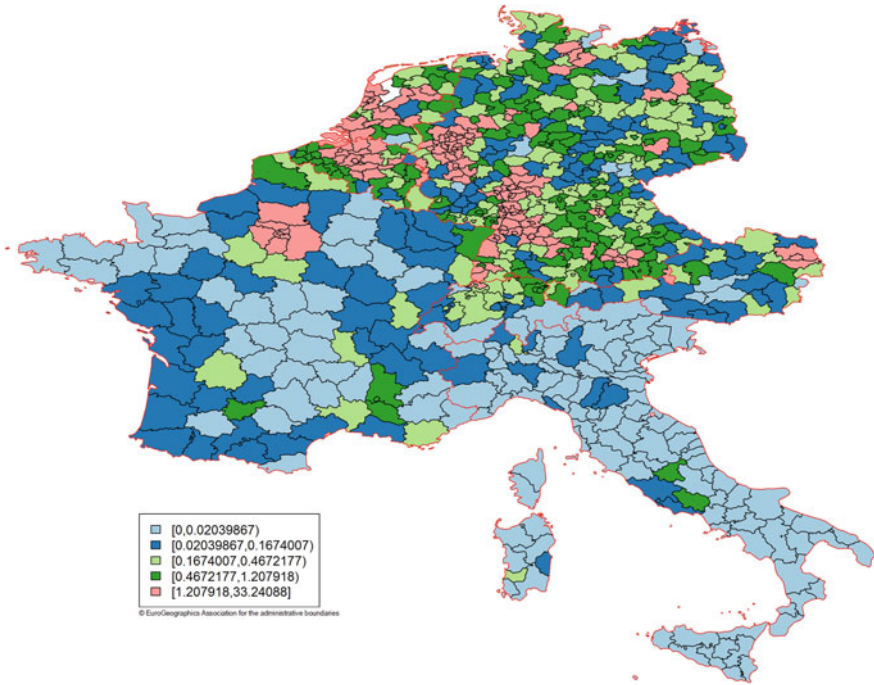


Fig. 7.4 Regional accessibility of Indicator I_{2.2} (data classification in quintile intervals)

Table 7.2 Correlation of accessibility indicators with sector specific GDP

Sector	I _{1.1}	I _{1.2}	I _{2.1}	I _{2.2}	I _{3.1}	I _{3.2}
Agriculture	-0.047	-0.113	-0.048	-0.129	-0.100	-0.176
Industry	0.276	0.290	0.201	0.279	0.181	0.123
Construction	0.441	0.357	0.386	0.340	0.120	-0.047
Trade	0.597	0.565	0.422	0.462	0.157	0.037
Information ^a	0.727	0.715	0.413	0.520	0.122	0.057
Finance ^a	0.503	0.568	0.269	0.388	0.135	0.100
Services ^a	0.508	0.536	0.418	0.487	0.076	0.003
Other services ^b	0.560	0.543	0.377	0.435	0.154	0.050
Manufacturing	0.125	0.182	0.143	0.252	0.087	0.130

^aNot available for Germany

^bCollective variable for services in information, finance, etc

7.8 Conclusions

These indicators reflect the actual structure of the transport network from an economic point of view. Depending on the specification, the indicator values stand for rather short or longer transport destinations. The indicators $I_{1,1}$ and $I_{2,2}$ show very clearly the higher regional accessibility of the Rotterdam-Genoa corridor, which one could also assume.

The correlation analysis shows only weak correlation characteristics for indicators representing all transport modes but high correlations when only road transport is considered. Relatively clear is the negative correlation between the added value of agriculture and accessibility in all three indicators. In rural areas, potential accessibility is generally lower than in urban areas. In relation to the theory, indicator $I_{1,1}$ – $I_{2,2}$ best fulfils the expectations. They show positive correlations of gross added value of the other sectors of the economy with regional accessibility. High correlation between regional GDP of information and finance sectors are in conflict with the expectations. These sectors generally do not depend on freight transport accessibility but more on agglomeration effects. A further regression analysis could illuminate this contradiction.

The choice of suitable values for parameters α and β determines whether the respective indicator shows accessibility rather in terms of local or remote destinations. Future research should already take into account when choosing a model whether the focus of the investigation will be placed on the immediate economic environment or on the accessibility of distant economic zones. It is also important if a consideration of agglomeration effects and the consequent greater emphasis on metropolitan areas is desired—even this question can be included in the analysis by means of an appropriate choice of parameters.

A number of potential future issues come to light against the background of this article. For example, it would make sense to do case studies that relate to urban areas of several NUTS 3 regions. A more detailed consideration of such regions could provide information about accessibility barriers that are only poorly portrayed at the regional level. A classification of such case studies is being developed in the Code24 project.

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