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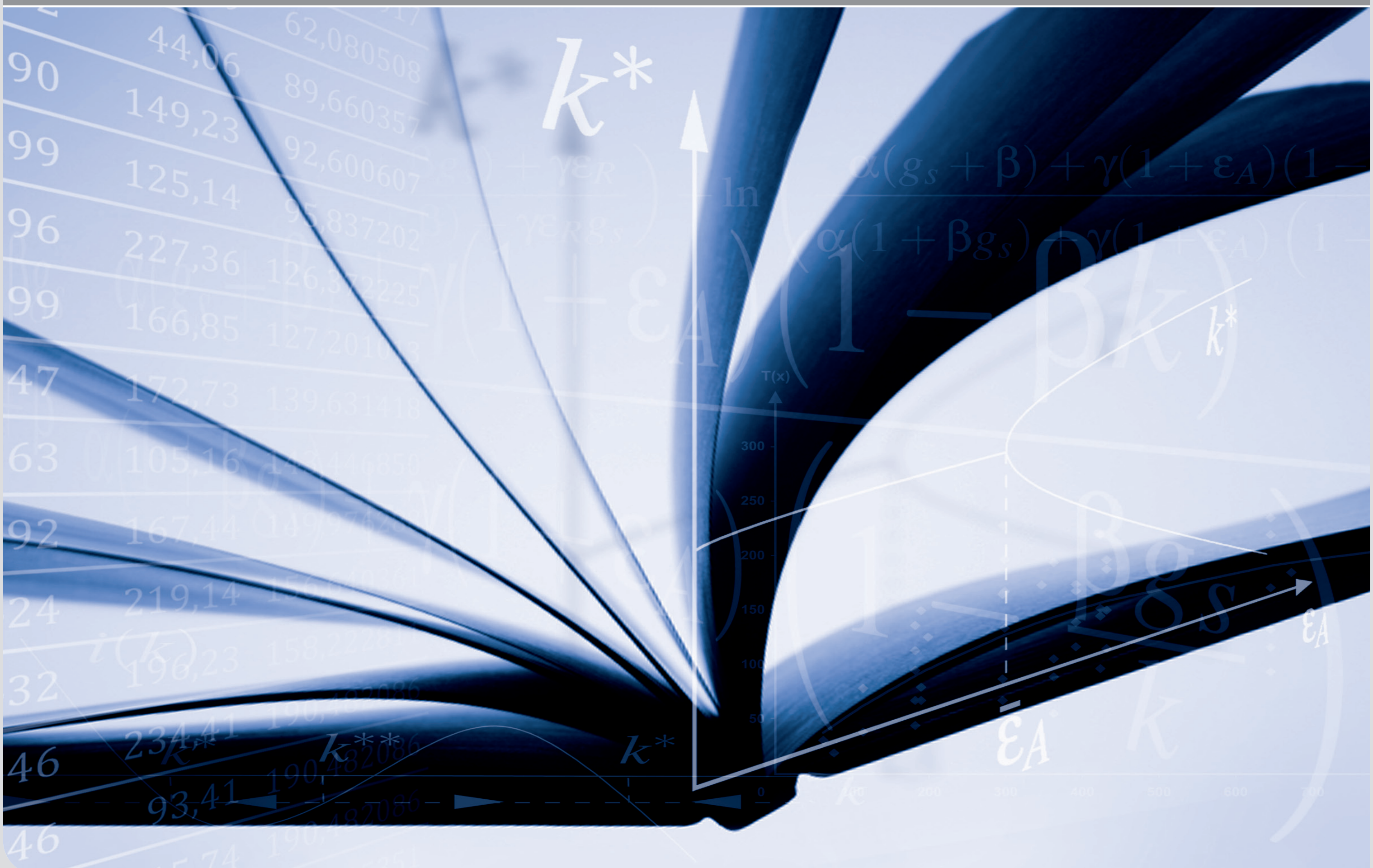

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The Structure of Freight Flows in Europe and its Implications for EU Railway Freight Policy*

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Abstract

We analyse the potential for shifting freight transports to the railways in Western and Central Europe. This potential arises for large and concentrated freight flows over long distances of about 300 km or more. However, we show that there are only few such freight flows in Europe, and that they are concentrated or connected to the central European population centers, sometimes called the "Blue Banana". As a consequence, the European railway freight corridors according to EU Regulation 913/2010 should be divided into two distinct groups: first tier and second tier corridors. Substantial innovations should be introduced on the first tier corridors first, in order to increase efficiency and reduce noise. This refers to core innovations for rolling stock like the introduction of automatic couplings, electronic or electro-pneumatic brakes, and modern bogies.

Keywords: freight transport, railways, corridors, rolling stock, innovation policy

JEL-classification:

R48 Government Pricing and Policy

L92 Railroads and Other Surface Transportation

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1 Introduction

How can railway freight transport be revived in Europe? In view of congested motorways, lower negative ecological impacts of railway transports compared to truck transports (primary energy inputs, CO_2-emissions, other emissions), and the significant financial deficits of many railways, this question is often raised by many people, by the media, and by many national as well as EU policy makers. Policy measures which aimed at shifting transports from road to railways and at increasing the attractiveness of railway transports have a long history. Facts and figures, however, show, that the revitalization of railways progresses only slowly. This discrepancy raises some questions about the effectiveness and efficiency of the existing policies. Against this background, the present article provides a closer look at actual freight flows within Europe in order to identify the potential market size for railway transports. Based on this, some policy recommendations aimed mainly at EU policy makers are developed.

It is well known that railway freight transport tends to become more and more economically viable the longer transport distances are. Railways are practically irrelevant for container transports of less than 200 km, while for distances above 400 km, they could become the dominant mode of transport.[2] Consequently, the EU 2011 White Paper on transport envisions that a large part of freight transports of more than 300 km distance should be shifted away from the roads to rail or waterways.[3]

However, in fragmented Western and Central Europe, many countries are relatively small compared to such distances, so that *national* railway freight transport is on the edge of profitability in several countries. Thus, it appears to be a perfect idea to dedicate railways particularly for the *international* freight transports. That is why the EU has covered Western and Central Europe with a grid of international rail freight corridors to be further developed which also serve as a starting point for a future multimodal core freight transport network. The implementation of these freight corridors is a further step forward in a long history of policy measures to foster inter- and multimodality such as, for instance, the Second Railway Package of 2004 which aimed at opening all European railway networks to freight trains from other countries. This is underpinned by EU's TSI policy (TSI = Technical Specifications for Interoperability) for a better interoperability of freight rolling stock and infrastructure.

However, international trains still face a bunch of problems in Europe. Electrical power supply as well as command and control systems are not harmonized across Europe, driving up the costs of locomotives (either by the necessity to change locomotives or by the additional costs of deploying multi-system locomotives). It is still not always easy to get an at-

[2] It should be acknowledged that railways are in use for short-distance transports as well in some countries. Even in these countries, the growth potential of railways is on the long distances. We come back to this point in the next section.

[3] White Paper on Transport of 2011: „30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors." (p.9)

tractive train path for an international train, since this requires coordination of two or more infrastructure managers. Moreover, there are deficiencies in parts of the infrastructure (like bottlenecks or temporary downgrades), and particularly within big network nodes such as in large cities or agglomeration zones. The same holds especially for the freight wagons, which remain frozen in a technological state of a hundred years ago (manual couplings, unfavorable bogies and brake systems; the latter ones also causing substantial troubles of noise).

In this article we want to investigate some potential causes for the stagnation of railway freight in several EU countries which is sometimes connected with a stagnation of policy's involvement. Some obvious causes for the stagnation of freight traffic on the railways have been discussed intensively elsewhere: Lack of money for infrastructure investments with the result of local bottlenecks and resulting quality problems, lack of political thrust in the Member States to conduct effective railway reforms, in some countries the interests of the trucking industry (including unions), and possibly the influence of the dominant national railway companies which are not so enticed by the idea of a European super-structure network that would take away competencies from them and would invite competitors into their "own" country networks.

In our view, all these causes contribute significantly to the explanation of the stagnation of EU rail freight, and we will have a closer look at them later when discussing the situation in different countries. But in this article we want to highlight another aspect – the sheer market potential and connected economic reasons that might give rise to the political impasses just mentioned. With this end in view we will take a look at the actual flows of goods in Europe. We will find that – even on the continental scale – the market of economically viable railway transports is highly concentrated on a well-defined region and some related corridors. Based on this analysis one might put into question the concept of a "homogeneous" network of railway freight corridors in Western and Central Europe. Another way to look at it is the following: In a few central parts of the European continent there is real and dear need for an upgrade of rail freight technology (infrastructure and rolling stock); the EU should take this "regional" need as the starting point to initiate and promote such an upgrade. Starting from there, upgrade is likely to spread around to other (even less needful) parts of the continent.

The article is structured as follows: In the next section we will have a closer look at the comparative advantages of railways in freight. In Section 3 we will analyze the potential "markets" for railway freight in Western and Central Europe. That is, we will have a look at streams of freight transports – summed over all modes – on distances over 200 km, since these aggregate quantities are potential candidates for being shifted to the railways. Section 4 describes the situations of freight railways and the policy stances in the EU and some major member states. Section 5 begins with a recapitulation of our observations and then draws recommendations for EU railway policy.

2 On the comparative advantages of railways in freight transport: focus on the long distances

In freight transport, railways have a competitive advantage compared to the roads under two conditions: Firstly, the longer the transport distances, the better for the railways. This effect results from the low variable cost for running a freight wagon in a given train compared to high costs for auxiliary operations such as intermodal transfer, loading and unloading, empty wagon provision, and shunting. Secondly, the larger the shipment quantities, the better the railways are suited to carry the commodities. This advantage results from economies of scale in traction, wagon handling, and consolidation activities.

The examples from the U.S. and Russia show that railways are really advantageous on very long distances. This advantage is also reflected in the high share of *international* freight in total railway freight transport in Germany, which amounts in 2012 to about 50% if measured in tkm (according to Destatis, German Statistical Office).

For intermodal transports starting at an international gateway – such as a port – and for dedicated logistics full-trains, railways are an economically viable option on transport relations of more than about 200 km. On distances of more than 400 km, railways are competitive in various market segments including intermodal transports, full trains and single wagon transports. At this point, the transshipment costs are more than made up by savings in the distance-dependent costs. The 400 km mark is also relevant for another reason: Beyond 400 km, railway transport can even be substantially *faster* than road transport, due to the regulation of the truck drivers' working and behind-the-wheel times.

Of course, there is a lot of *short* distance railway freight transport in Europe as well. Traditional heavy mass goods like coal and iron ore are very unsuitable for the roads due to their sheer weight. A similar reasoning holds for more "modern" heavy mass goods like construction material or waste. Furthermore, some industries like the automotive or chemical industry use railways even on short distances to connect different factories (or firms) in the vertical production chain. An extreme case is the German Rhine area, where short distance transports (less than 200 km distance) make up about 85 % of railway transport volume, measured in tons.[4] But in terms of transport performance measured in tkm, this share is much smaller.

In this article we will focus on long-distance transports as the main potential for railways, for the following reasons:

- Although short distance transports make up a large proportion of total transport volume of the railways (in tons), their portion of transport performance (in ton-km) is much smaller. This implies that the impact of these short distance transports on the

[4] The 85% share is calculated based on a special inspection of the ETISPlus data. See Appendix on Data.

earnings of railway companies, on relieving congested motorways, and on reducing total CO_2-emissions are limited.

- The potential to achieve further modal shifts of short and middle-distance transports is limited, since these are often last-mile transports and irregular bulk transports of construction materials.
- Short distance railway transports are rarely a concern for EU transport policy. Particularly the railway freight corridor concept and the Commission's aim to shift transports of more than 300 km distance from road to rail (besides inland water ways) are based on the idea that railways have a particular comparative advantage in the long distances.
- Empirical evidence shows that transport volumes on short distances tend to stagnate whereas long-distance transports have experienced – and are expected to experience – substantial growth in the future.

3 An empirical analysis of the potential for railway freight in Central and Western Europe

We start with the general idea that the regional patterns of economic activity follow the distribution of population or, more generally, that the two are closely related. Moreover, flows of physical goods – i.e. freight transport – will most likely take place between the centers of economic activity respectively agglomerations of population. Thus, we will look at the distribution of population in Europe.

Figure 1 shows a map of population densities in Europe (the zones correspond to NUTS 3 regions). The central region highlighted by a blue contour is the so-called "Blue Banana".[5] It starts in the North with the main industrial cities in central England, includes the London area, then crosses the Channel, contains the major cities of The Netherlands and Belgium as well as the region around Lille in France, then continues in Germany with the metropolitan regions Rhine-Ruhr, Rhine-Main, Rhine-Neckar, and Stuttgart, as well as the French regions of Alsace and Lorraine, then contains Switzerland, and then finally the North-Western industrial region of Italy. Altogether some 148 Million people live in the Blue Banana. This corresponds to 28 % of the population of all those European regions which are shown as colored in Figure 2. At the same time the Blue Banana produces some 36 % of the BIP of all these regions.[6]

[5] There seem to be several origins of the concept and term "Blue Banana": (i) a work by the French geographer Roger Brunet of 1989, (ii) the press using the term since the 1990s, or, for that matter, (iii) related pictures and maps appearing in the Internet. The color "blue" is traditionally the color of the European continent; it also appears in the EU flag.

[6] On population and BIP figures see Appendix on Data, Table 5.

Inspired by the idea that the Blue Banana constitutes a natural cluster of regional economic activities, we defined 10 regions in Western and Central Europe which are shown in Figure 2. The central region is the Blue Banana (region 1). The adjacent region at the left-hand-side will be called "Western Adjacency of the Blue Banana" (region 4). It encompasses the three largest metropolitan areas of France (Paris, Lyon, and Marseille) and has about 31 Million inhabitants, corresponding to 6 % of the population of all these regions, and produces 9 % of the BIP. On the other side of the Blue Banana is the "Eastern Adjacency" (region 7), encompassing the remainder of Germany (i.e. the parts of Germany which are not part of the Blue Banana), Austria, and the Eastern part of North Italy.[7] It has about 64 Million inhabitants, or 12 % of the population, and produces about 15 % of the BIP. Thus, the Blue Banana plus its Western and Eastern Adjacencies together have a population of some 243 Million people, or 45 % of the population, and produce 60 % of the BIP. In contrast, the territories of these three regions make up only 21 % of the territory of all ten regions.

The seven remaining regions of Figure 2 are easily explained: Spain and Portugal (region 2), Western France (region 3); Great Britain and Ireland, except the parts belonging to the Blue Banana (region 5); Central and Southern Italy (region 6); Scandinavia (region 8); East Central Europe to the North of Hungary (region 9); Hungary and Balkan Peninsula (region 10).[8]

Freight quantities between and within these ten European regions can now be analyzed. We use data from the ETISplus open source freight matrix for the year 2010. The data of the ETISplus project and the way we processed them are explained in detail in the Appendix. In essence, we summed up over all goods and all transport modes. Moreover, we aggregated all these transports by OD (origin-destination) relations from the NUTS 3 level of the ETISplus data set to the level of the ten European regions described before. Finally, we summed up all antidirectional flows. Thus, for example, the amount of tons shipped from Constanza (Romania) to Duisburg (Germany), and those vice versa, are added to the bidirectional flow volume from the region "Balkan" to / from the region "Blue Banana". Note that the Constanza-Duisburg OD quantities do not affect any flow of the region "Eastern Adjacency" in our data (to either "Balkan" or "Blue Banana"), although it is clear that these transports are passing through that region.

[7] Sometimes the Eastern parts of Northern Italy (Trentino, Friuli, and Veneto) are counted as parts of the Blue Banana. We have chosen not to do so. We will see that the Eastern Adjacency and the Blue Banana are tightly interwoven also in Germany.

[8] One might shift Hungary from region 10 to 9. However, the long distance railway corridor connecting Hungary with regions 1 and 7 goes further down to Romania. In any case, shifting Hungary would not make much difference for our analysis of freight flows put forth below. Similar holds for the possible inclusion of Turkey to region 10 which we have experimented with. This would make a big effect on the distribution of population, but only a small effect on long-distance freight flows of Europe.

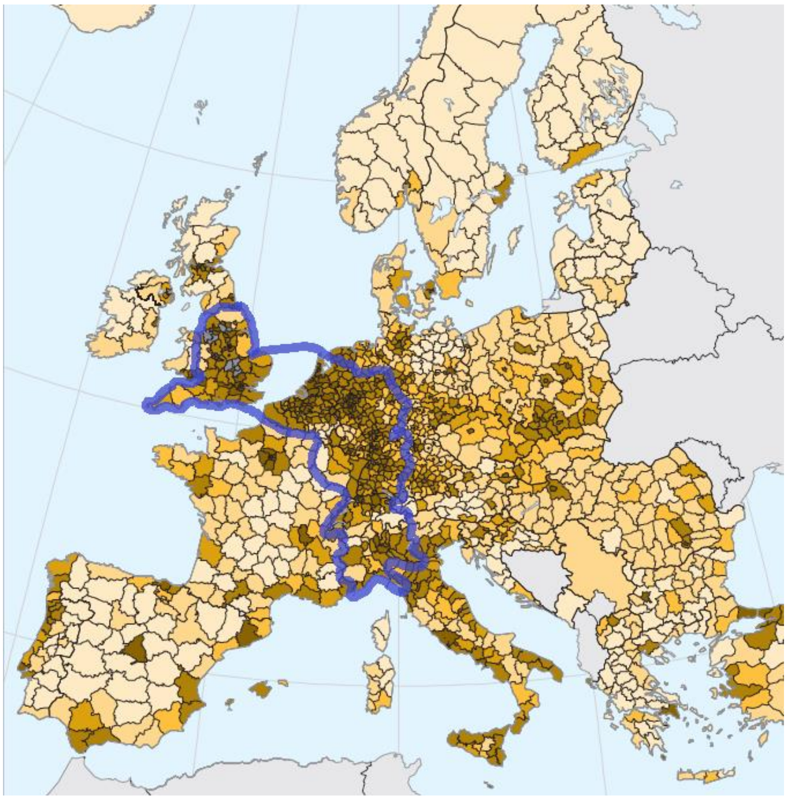

Figure 1: Population densities in Europe

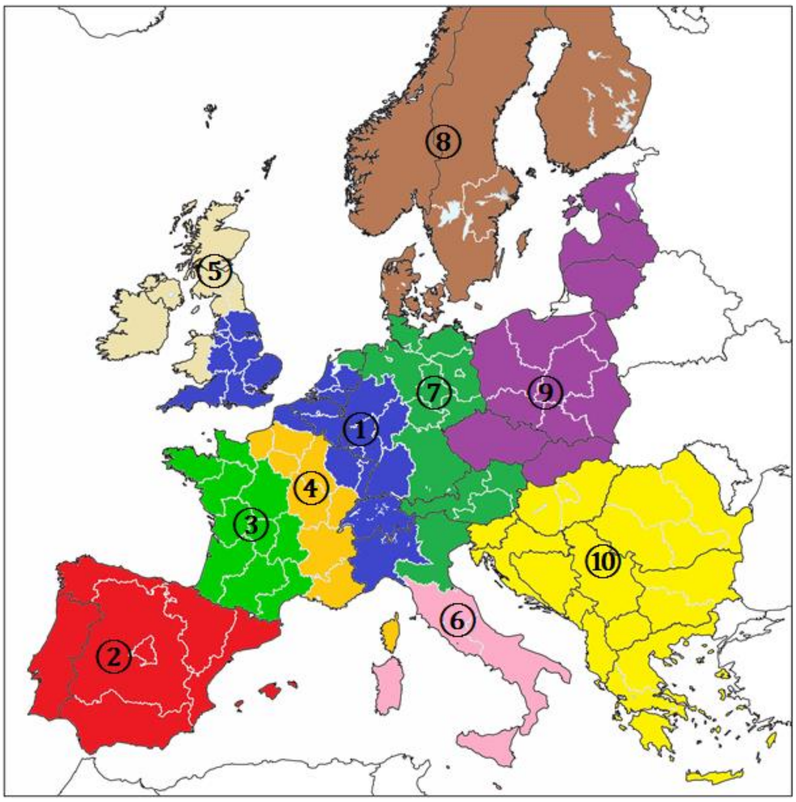

Figure 2: European regions

The results are shown in Figure 3. The freight flows *between* regions are depicted as double arrows where the width of an arrow (between the arrowheads) is proportionately correlated to the transport volume. Flows of less than 40 million t. p.a. are not shown.[9] Freight flows *within* the regions are shown as vertical bars, where the length increases proportionately to the freight volume. However, the scale of the bars is one third of that of the arrows. This is illustrated for the case of Spain & Portugal: The gray long bar, three times as long as the black one, would be directly comparable to the width of the arrows.[10]

Keeping this in mind it becomes clear that the amounts of freight within the regions are much larger than those between the regions. The by far largest quantity is the internal freight volume within the Blue Banana.

The most significant *interregional* freight flows of Europe are connected to the Blue Banana or to the Eastern Adjacency. It is amazing and noteworthy that three prominent Western European regions – Spain & Portugal, Western France, and Western Adjacency – are almost not connected to each other by significant freight flows. This can partly be explained by the collapse of transports on these relations after the financial crisis of 2008. But even when abstracting from such special effects, the order of magnitude of these flows is small compared to the other ones.

We show Figure 3 only for sake of completeness. Our main interest is on long-distance freight flows since these are potentially relevant for the railways, particularly in their shifting potential. For that purpose we have filtered from the ETISplus data those transports of more than 200 km distance (thus reducing total freight quantities to almost one fifth). Then, in a next step, we filtered out transports of more than 300 km distance (leaving about 15%; recall that 300 km is the threshold identified by the EU for shifting transports on the railways). In a final step, we filtered out transports of more than 400 km distance (leaving about 12%). The results are shown in Figures 4 to 6. Here, freight quantities – within or between the regions – are expressed as double arrows and measured in the same unit. For the Blue Banana we show two arrows interlaced: the inner one excludes freight flows to, from, or within the English part of the Blue Banana (since these freight flows are to a large extent either dedicated to short sea shipping or isolated from the remainder of the continent).

[9] The thickness of the line surrounding an arrow has no meaning by itself.

[10] The statistics underlying this and the following maps is given in the Appendix on Data.

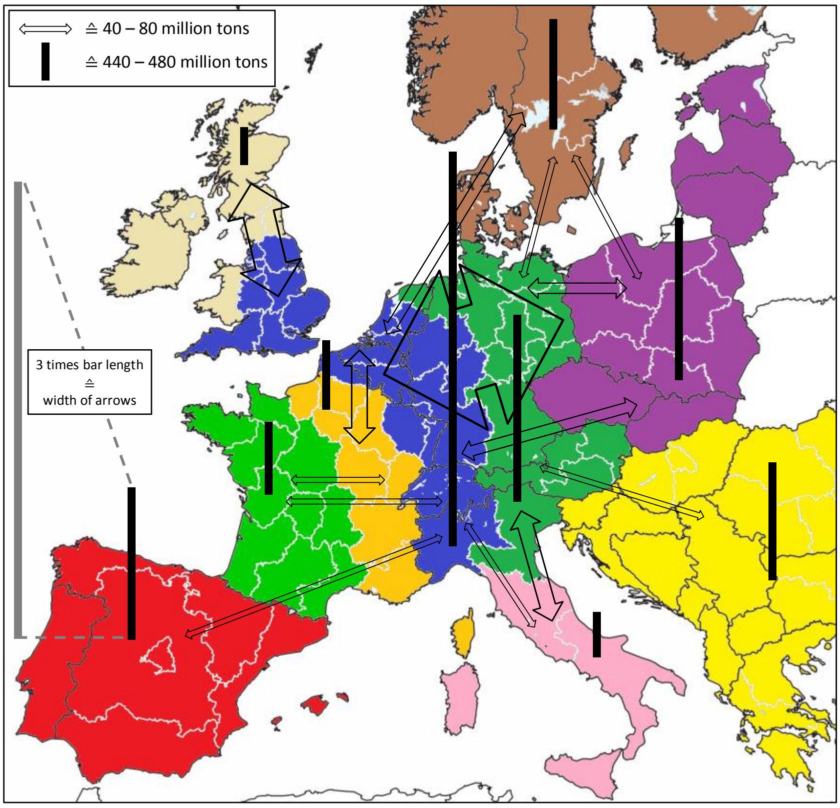

Figure 3: Freight flows within Europe

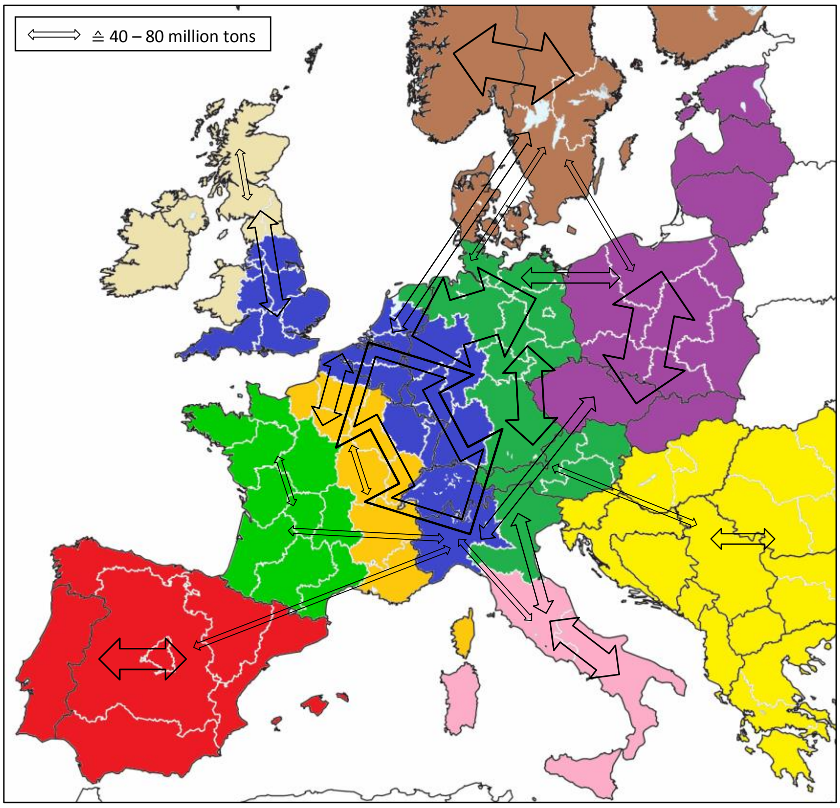

Figure 4: Freight flows of more than 200 km distance

From inspection of Figures 4 to 6 – and evoking some additional knowledge about the European regions and the freight corridors – it becomes clear that there are only a few candidates for high-performance railway freight corridors in Europe which are particularly suitable to the use of freight trains. Firstly, there should be at least one North-South corridor within the continental part of the Blue Banana. Secondly, another North-South corridor should go through the Eastern Adjacency. The dominance of these North-South relations is of course underpinned by the central role of the large North Range ports (Antwerp, Rotterdam, Amsterdam, Bremen, Hamburg) for intercontinental trade and transport. Still, at least one East-West corridor will also be needed connecting the Blue Banana and the Eastern Adjacency, and possibly extendable to some parts of East Central Europe (region 9).[11]

These observations can directly be related to the nine EU Rail Freight corridors established by the Appendix of EU Regulation 913/2010. We obtain the following **"tier one" railway freight corridors** among the nine EU corridors:

1. EU railway freight corridor No. 1 along the river Rhine (particularly Rotterdam-Milano) should really be called the **"central corridor"**.[12]
2. EU railway freight corridor No. 2 (particularly Antwerp-Metz within the Blue Banana) is also relevant, but of less importance. It also constitutes a bypass for traffic to the central corridor. However, the same corridor goes further South to connect Lyon and Marseille in the Western Adjacency as well.
3. EU railway freight corridor No. 3 (particularly Hamburg-Verona) is the other route parallel to the central corridor, going through the Eastern Adjacency (and probably also taking away some load from the central corridor).[13]
4. EU railway freight corridor No. 8 (particularly Aachen-Berlin) connecting the Eastern Adjacency to the Blue Banana.[14]

Having identified the central corridor and the other tier one railway freight corridors of Europe, let's go back to Figures 4 to 6 and try to make out some potential **"tier two" railway freight corridors**.

[11] For our quantitative considerations we added up antidirectional freight flows. As a consequence the problem of the imbalances of freight flows does not show up. Almost all freight flows have this problem in one way or the other, increasing the difficulties for railways to handle these flows efficiently.

[12] It is well-known that the Rhine ships alone cannot handle the huge amounts going from Rotterdam to the Rhine regions or vice versa. Currently the share of Rhine ships is about 40 to 50% of this freight volume according to rough estimations based on Eurostat data.

[13] This corridor is supplemented by the so-called SCANDRIA Scandinavia-Adria (multimodal) corridor project, slightly to the East of railway corridor No. 3.

[14] We might add from EU railway freight corridor No. 6 the small section Turin-Milano-Verona-Padua making the East-West connection in the North of Italy.

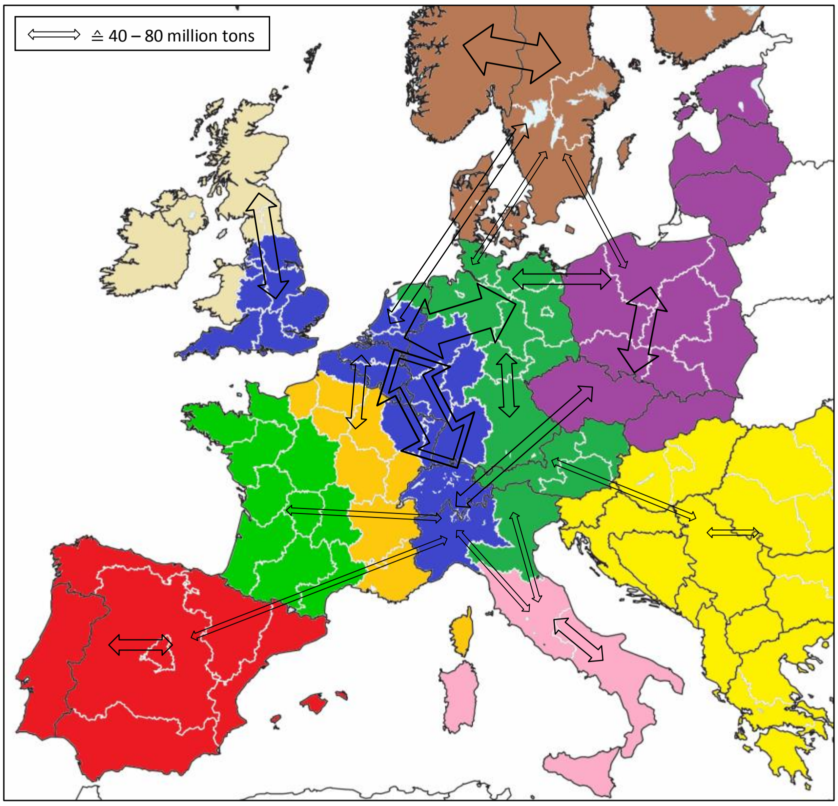

Figure 5: Freight flows of more than 300 km distance

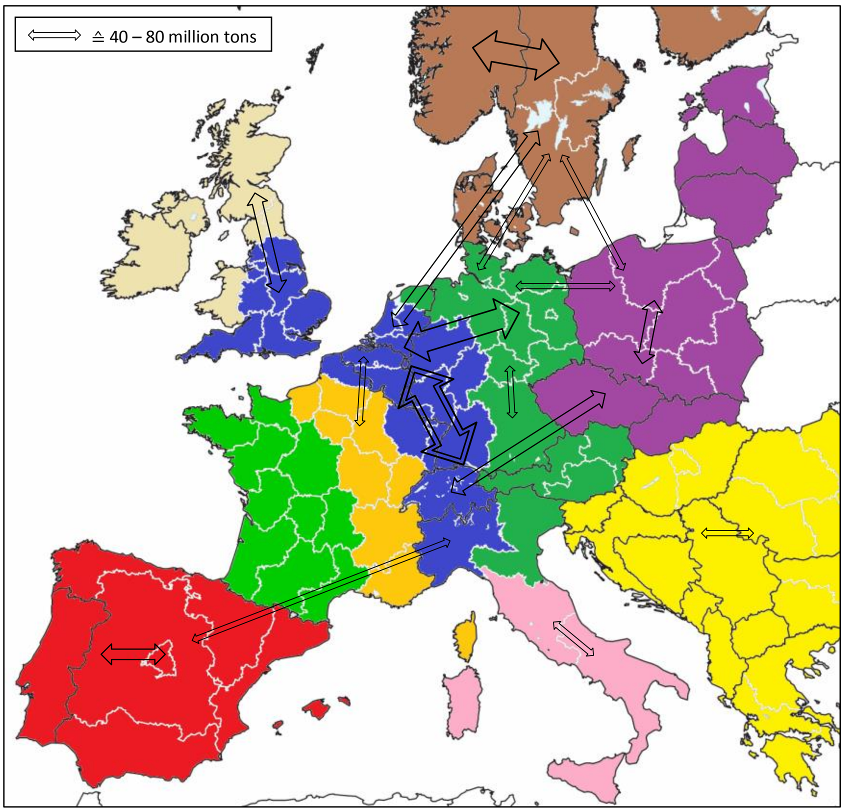

Figure 6: Freight flows of more than 400 km distance

As shown in Figures 4 and 5, there is a rather big arrow within region 9, i.e. within East Central Europe (North of Hungary). A closer look at these flows reveals that these are mainly internal flows within Poland, particularly of coal and other bulk commodities. Similar holds for the flows within Scandinavia, within Spain and Portugal, within Great Britain (connecting with the Blue Banana part and the remainder of Great Britain), or within Central and South Italy. In some of these cases, there exist potentials of national long-distance railway transports. The question is, however, whether these freight streams are really concentrated and big enough to be suited for railways.[15] If freight streams are not very concentrated and/or not very long-distance, one might even think about abandoning railway freight transport. If the comparative (dis-)advantage of railways is not so clear, it will depend on the political decision of the respective nation whether railway freight is to be developed or not. Possible arguments for a further development of railway freight transports can be found in ecological, historical and strategic considerations. This kind of policy choice is relevant for many of the second tier EU railway corridors.

4 A look at freight railway policies in the EU and some member states

In this section we will have a look at the situation of railway freight and railway policies in selected member states of the EU and at the European Level. A focus is put on the states that make up the continental part of the Blue Banana: the Netherlands, Belgium and Luxemburg, France, Germany, Switzerland, and Italy. As demonstrated above, these regions have the most favorable economic conditions for further developing freight railways. At the same time, they also encompass regions that appear less favorable for freight railways (like the center of France or Italy South of Naples).

4.1 Some general observations about the state of railway freight in the EU

At the moment, the outlook of the European rail freight corridor network seems to be overshadowed by signs of stagnation. On a European scale the commodity transport performance on the railways stagnates since more than 20 years, whilst its market share has continuously declined. Behind this stagnation, there are dynamic trends in several submarkets: On the one hand, the transport volume of bulk is stagnating or even declining; the same holds for dispersed single wagon transports. But on the other hand, intermodal transports have experienced a dynamic growth during the last two decades. Also, logistics block trains operated by order of one or a couple of companies can more and more be observed. But the installation respectively the modernization of the freight railway corridors is progressing only slowly.

[15] There is also an intermodal project called SoNorA, South-North Axis, which covers the SCANDRIA connections, but also includes Poland (except its most Eastern parts) and the Czech Republic.

Interoperability, too, advances only slowly. This is a problem for locomotives operating across borders, which have to be supplied with expensive multi-system equipment regarding traction current as well as command and control systems. However, in recent times, more and more multi-system locomotives are now available for sale or leasing.

In contrast to the locomotives, the European freight wagons are already perfectly interoperable. And even more so: A fifty year old wagon for bulk cargo from one country and a modern carrying wagon from a different country can be coupled. In fact, there exists a homogenous mass of wagons that can be rearranged to build freight trains in almost any combination in any country (as long as the country has the normal gauge).

This homogeneity of wagons comes, however, at a horrendous price: wagon technology is based on standards and knowledge from a hundred years ago. Striking examples are the manual couplings. They do not only put severe limits on the attractive force that can be exerted on a wagon, and thus, on the weight and length of freight trains. They also induce the need of increased deployment of personnel and time and/or technology for production processes like shunting and train composition.

Another problem of increasing importance is noise. Railway freight transport concentrates more and more on corridors through densely populated areas. The population living close to the railway lines increasingly suffers from the noise produced by freight trains – and in particular by the old rolling stock. Here, the old cast iron block brakes that cause most of the trouble. But once they will be replaced by other block brakes, many other sources of noise of the old rolling stock (and track) will remain. In Germany and other countries political resistance by the people against freight railways has become a major problem for railway investments. Attempts to initiate an upgrade of the outdated fleet of wagons have so far been quite unsuccessful.

4.2 The Netherlands, Switzerland, Germany, and Italy

The Netherlands have a dense railway network with a heavy basis charge from local, regional and inter-city trains. The national government and the regions are eager to promote the leading role of Rotterdam as major European port (but also of Amsterdam) by providing hinterland transport capacities at high quality for all modes, including railways. In particular the Betuwe route, a pure rail freight line, connects Rotterdam to the German border, thus constituting the Northern part of the central corridor (EU corridor No. 1, Rotterdam-Milano). The Betuwe line should bundle practically all noisy and dangerous goods transports between Rotterdam and Germany.

Switzerland is very active in investing and upgrading its railway infrastructure, and into noise abatement measures. Passenger transport has the top priority in Swiss railway policy – and this creates some problems here and there – but the Swiss are determined to keep their railway freight systems in a good shape and to shift more freight transports from the roads to the rails. There is a long tradition of experimenting with new innovative technological solutions aiming at strengthening railway freight transports. This shifting policy is particularly pronounced for the Alp transit freight traffic through Switzerland that connects the North Range ports and Germany with Northern Italy. In connection with the implementation of the “Neue Eisenbahn-Alpentransversale (NEAT)” or “Alp Transit” Switzerland takes major steps to enable a substantial shift of Alp transit freight traffic from the roads to the rails. Cornerstones of this policy are the construction of the new Gotthard base tunnel to be opened in 2016 and the already operating Lötschberg base tunnel. They will render railways even more attractive on the central corridor. At the same time, the Swiss have sworn (by at least two referenda) to reduce road freight over the Gotthard road once the base tunnel opens. At the moment, about two thirds of the transit freight traffic over the Gotthard is already on the rails. Once the new Gotthard tunnel opens, new attractive long-distance intermodal services can be expected to be developed.

Germany can be called the “country of the corridors” as it hosts the longest parts of many international first tier railway corridors: (i) the central corridor from the borders of the Netherlands to those of Switzerland, (ii) the parallel North-South corridor No. 3 with its main parts running from Hamburg to Munich and to the Austrian border (heading for the Brenner to reach the Eastern part of Northern Italy), and (iii) the East-West corridor No. 8 from the Belgian border at Aachen to Cologne and Duisburg, and further to Berlin and the Polish border. Moreover, departing or extending from corridors No. 3 and 8, there are some other interesting connections to East Central Europe (like to Czech Republic or to Austria with the aim of going further East or South-East from there), as well as some other important cross-connections within Germany.

The growth of traffic on these lines was a consequence of several factors. First, the changing international division of labor (“globalization”) connected with the rise of the East Asian economies: Many successful German industries export machinery and, in reverse, consumption goods are imported from abroad. Moreover, the downfall of the Berlin Wall led to a re-integration of the Central European economy with Germany in its center. Second, the massive spread of globalization in the past two decades was connected to a further fragmentation of supply chains, which means that intermediate industrial products are to an even larger extent sourced from abroad. This development affected particularly the traditional German industrial sectors. Finally, the intercontinental trade was facilitated by the rise of the “box”, i.e. containers which are fed into the land-based traffic networks in the North Range ports. All in all, total railway freight volume in Germany is with 110 billion ton-km in 2012 the largest in all Western and Central Europe (the second largest being France with only 32.6 billion ton-km).

In this environment, German incumbent’s subsidiary DB Schenker Rail has grown out as the largest rail freight company of Western and Central Europe with branches in almost all countries (sometimes resulting from acquisitions). At the same time, a considerable degree of on-track competition between different European railway undertakings has developed. The rise of on-track competition is a result of several factors, the most important ones being: (i) a long-standing open access policy in Germany since 1994, (ii) the fact that many transports on these corridors can be organized by fairly easy shuttle trains from the ports to the industrial clients, implying that newcomers could realize most of the (limited) economies of scale for these transport and at the same time ripe the benefits of greenfield operations, (iii) the fact that many big customers – like large companies or branches (Chemistry, Automotive) or the ports – were fearful of being monopolized by DB in their core businesses and for some period actively supported the emergence of competitors.

However, once sparse network capacities are used up and more heavy investments are needed to increase capacities, the German government turns out to be much less generous for railway freight than its neighbor countries, Netherlands and Switzerland. In particular, the connecting investments on the central corridor to (i) the Betuwe route of the Netherlands and (ii) the Swiss Gotthard route have been initiated far too late and (in the Northern case) at a smaller scale (for instance, the 3-track line connecting the Betuwe line to the Ruhr area). In spite of many realized high-speed projects, there seem to be many local bottlenecks which inhibit a further increase of railway transports. The most serious bottlenecks are in the nodes of Cologne, Frankfurt, Hamburg and Mannheim/Ludwigshafen.

In meantime, the central corridor is almost bursting from traffic. Recall that this corridor runs straight through the Blue Banana, i.e. through the most densely populated regions of the continent. This has two consequences. First, these tracks are heavily used by passenger trains, both regional and long-distance, and passenger trains are generally given a priority over freight trains. Second, there are many people living side by side to the central corridor who are much annoyed by the noise of freight trains. Since the corridor capacity is claimed by passenger trains during the day, most of the freight trains have to put up with night slots. However, during the night time, the negative effects of noise on health are even worse.

Recall that, after the opening of the Gotthard base tunnel in Switzerland in 2016, rail freight traffic is expected to grow particularly on the Southern and middle part of the central corridor, which will create even more noise problem and bring capacity definitively to its limits.

One way to alleviate these problems is the development of alternative routes that would take some pressure from the central corridor away. There is, of course, the inland waterway shipping on the river Rhine – but for many transport purposes this alternative would require the construction of tri-modal transport chains and increase transport times significantly. An important and fairly well developed alternative is the railway line to the East of the central corridor, going from Hamburg to Munich and then further to the Brenner in Austria and to North Eastern Italy (EU railway corridor No. 3). But its capacity in the Northern section is almost used up as well. The railway lines still further to the East may come to help: Rostock-Berlin is currently enhanced and the Erfurt-Nuremberg project is nearly completed. However, the Brenner base tunnel is expected to open not until 2025, and some local bottlenecks around Nuremberg and Munich remain. These more Eastern connections have an interesting perspective since more and more suppliers for the automotive industry are moving into that area. However, it is already too far in the East to relieve the central corridor substantially. It also lacks big zones of freight attraction and generation as they are agglomerated in the Blue Banana.

Another alternative to the central corridor goes through France (EU railway corridor No. 2), from Antwerp to either Metz and then to Ludwigshafen / Germany, or to Basil and then to Northern Italy via the Gotthard, or directly via Lyon to North West Italy. This corridor could also take up intermodal transports from and to the Ports of the North-Range. Thereby, the French route would also open up "Pitman-style" of railway competition within the Blue Banana, i.e. competition between different railway infrastructure lines run by different infrastructure managers, equally capable of connecting economically important regions to sea ports.[16] But for the moment, the further development of this route progresses only slowly (see below on Belgium, France, and Italy).

Apart from these potential alternatives, the central corridor – plus the German parts of the other tier one corridors – dearly need modernization with respect to (i) more efficient use of capacity and (ii) noise abatement. Both goals require upgrades of the rolling stock used on these corridors and of the infrastructure of the corridors. On the side of wagons, the use of the current block brakes, purely pneumatic brake systems and hand couplings need to be overcome. On the side of the infrastructure, several bottlenecks need to be removed, more passing loops provided, tracks must be held in a better shape (particularly in view of their heavy use), and more noise barriers need to be installed.

Italy has recently built up an impressive network for HGV passenger trains. In contrast to that, its freight railway policy is rather disappointing. Similar to France (see below), total rail freight volume in ton-km has dropped dramatically by more than 40% during the last decades and is now at only 11 billion ton-km in 2012. The reasons for this dramatic decrease are to be seen in the economic crisis after 2008 and the catastrophic railway accident at Viareggio in June 2009. In the aftermath of this accident EU-wide safety requirements were increased for railway freight – and the cost increases or investment requirements to meet these safety requirements can be seen as another reason for the decrease of railway freight in several countries.

The industrial centers of North-Western Italy around Milano and Torino are of course connected to the central corridor coming from Switzerland. There are also some connections of these centers to the industrial parts in the central and Eastern parts of North Italy. That's about it.

[16] See Russell Pittman (2001): "Railway Competition: Options for the Russian Federation" who shows that this type of competition between vertically integrated railway companies worked well in Mexico and Russia in the 19th century. Pittman holds the view that this type of competition might be more preferable for the railway sector than access competition. However, we would like to emphasize that access competition has strong beneficial effects on the Central and Eastern corridors.

Most notable, Italy is even far behind in adapting the railway connections of its industrial centers to the required capacities of the new Gotthard line to be opened at 2016. There is a risk that its industrial centers will be disconnected from the other parts of the Blue Banana once Switzerland reduces the truck volumes over the Alps after 2016 or 2019 (expected opening of the Ceneri tunnel).

Similarly, Italy has never made an effort to connect Genoa to the central corridor effectively. Improving and modernizing that connection – and the port handling itself – might have the effect that some share of the maritime freight to Northern Italy, Switzerland or Southern Germany might be re-routed from the North Range ports to the port of Genoa from where it would be shipped northwards by train (compare again footnote 12).

At first sight, Italy is a long and rather thin country, thus appearing to be very suitable for railways. The investments in new HGV lines from Milano to Rome have left the old lines with a lot of free slots for freight trains. However, in central and Southern Italy, there is no industrial base demand for freight transports on a large scale. Most transports in North-South direction are logistics goods with dispersed destinations, and even the total sum is not very impressive (see the transport maps above); in addition, it is difficult to find any significant quantities going the way back, from the South to the North. For these reasons, the North-South transports are mainly done by trucks – even though the distance Milano-Rome is more than 500 km, Milano-Naples almost 800 km.

In principle, Italy would be a good candidate for the establishment of a multi-modal concept: Large modern distribution centers could be set up in the vicinities of Rome and Naples where rail transports coming from the North (done by different railway undertakings in competition) would be put on trucks for further distribution. But up to now, there are no signs for such a policy shift in Italy. Neither does Trenitalia or any other railway undertaking make an attempt to develop such business on its own.

4.3 Belgium and France

Belgium has two main railway connections to its neighbor countries: First, a route from Antwerp to Aachen in Germany and, second, a route from Antwerp to the South leading to Metz, Nancy, Strasbourg and Dijon in France (EU corridor No. 2). On the route to Germany there are capacity shortages and noise problems, so that Belgium contemplates the reactivation of the old "Iron Rhine" from Antwerp to Germany North of Aachen, which cuts through a narrow strip of the Netherlands. In contrast, the Belgian part of corridor No. 2 (to France) has no substantial problems of noise or capacity shortage. Thus, in Belgium, just as in the Netherlands, there are not so many problems for international railway freight.

However, seen from a vision of one single European railway network, there are still some drawbacks in Belgium and the Netherlands as well. Interestingly, there are only few connections between Belgium and the Netherlands. In principle, the Dutch Betuwe line could be used by transports going from Antwerp to Germany, relieving the overused Belgian line to Aachen. Similarly, transports could go from Rotterdam to the area of Metz (France) using the corridor No. 2 through Belgium. Both does not happen. Although there is an existing railway line between Antwerp and Rotterdam, this line is practically not used by freight trains, leaving in particular many night slots unused.

In **France**, freight flows are concentrated in a rectangle with the four corners Paris, border to Belgium Dijon, and Metz. Furthermore, there is significant freight traffic from this rectangular area to Belgium and towards to Lyon and to La Rochelle, with some flows continuing to Spain. In addition, there is some transit traffic through France connecting the Hispanic peninsular and the non-French parts of the Blue Banana resp. its Eastern Adjacency. Remarkably, our data analysis has shown that there are only small freight streams between the three regions Hispanic peninsular, Western France, and the Western Adjacency of the Blue Banana (i.e. Eastern France).

At the moment, even the most utilized railway lines don't carry more than about hundred freight trains per day. As a major proportion of long-distance passenger transport is now guided by a dense and Paris-centered network of dedicated high-speed lines, many slots on the conventional network are freed. For freight transport, there are only a few capacity bottlenecks in the areas of Lyon and Paris caused by an intensive traffic of regional passenger trains. Also some capacity and delay issues remain caused by ongoing maintenance works on the network. There are strong operational incompatibilities between rapid passenger trains and slow freight trains on the some parts of the network.[17]

In the past couple of years, French railway transport volume has dropped dramatically by about -40 % (measured in in ton-km) between 2000 and 2011, and reaches 32.6 billion ton-km in 2012.[18] Despite large subsidies and recovery plans, Fret SNCF, the historical operator, has abandoned single wagon services (80 % of all single wagon operations based on SNCF's cost structure was not profitable) and is still losing market shares. It is widely accepted that this decline is mainly caused by endogenous reasons like a lack of innovation, lack of productivity gains, cost based pricing, or frequent worker strikes.[19] There are, however, also some exogenous reasons like the lack of economic growth in France.

In the past, newcomers had difficulties operating in a centrally regulated rail environment with the strong market power of SNCF and its more than 700 subsidiaries. It is noteworthy,

[17] Rail freight transport makes up about 15 % of train-km on the national French network, but contributes only 3 % of track access revenues of the network (7 % of total revenues if one includes the "Compensation Fret", a subsidy from the government). Rail freight covers then ¼ of its total costs. Without the subsidies, it covers only 10% of its total cost and less than 40% of its variable cost. Source: RFF.

[18] The conventional freight transport of the SNCF in ton-km was divided by two between 2002 and 2012 (from 37 billion tkm in 2002 to 16.5 billion tkm in 2012). The share of combined transport of the SNCF was also divided by two (from 12.4 billion tkm in 2002 to 5.6 billion tkm in 2012). In a more global perspective, the freight transport of SNCF was divided by two (from 50 billion tkm in 2002 to 22.1 billion tkm in 2012). Source: Union Routière de France (URF), Faits et Chiffres 2013, 2014.

[19] See Laroche (2013).

however, that after the decline of SNCF Fret, the independent competitors seem to stabilize railway freight in France. Currently, 18 operators are registered in the French market besides SNCF. Their transport volume grew from 0.2 billion ton-km in 2006 to 10.4 billion in 2012. In 2012 the share of competitors in terms of ton-km was about 30% (and thus similar to Germany). As an example, STEF, the leader for refrigerated transports in France, is operating a refrigerated container (21 tons – yogurt from YEO company near Toulouse) every day between St Jory (North of Toulouse) and Paris (with the newcomer rail operator T3M as tractioneer): 700 km on the railways within 13h30 during the night hours are combined with 2 hours of road-based pre- and post-haulage. This combined rail-road transport is about 10 to 15 % more expensive than pure road transport, but the future road pricing system "Eco-tax", if it will be implemented, will put some advantages back for combined transport.[20]

Combined transport rail-road is representing 25 % of railway freight traffic in France (in ton-km, source: URF, 2014). Particularly interesting is the rolling railway ("ferroutage"), where trucks are loaded on trains. France is expecting a strong growth of this type of traffic. The average distance of the rolling railway traffic in France is 541 km, compared to 336 km for conventional rail freight. France is operating two interesting rolling motorways: an Alpine link to Italy (175 km) and the link between Perpignan (near Spain) to Bettembourg (Luxembourg). On the latter one, 4000 trucks are loaded on trains each month for more than 1000 km distance. The French Ministry of Transport has decided to boost this way of modern freight operation with the new "autoroute ferroviaire atlantique" decided in 2014 between Longueau (Picardie) and Bayonne (Pays Basque), although the success of this policy initiative is discussed controversially because the relief effects for the motorways are very small (about 1% on the Perpignan-Bettembourg link).

There are also some first attempts to revitalize single wagon transports since this network is also needed for the handling of empty and damaged wagons and many repair shops for wagons are located nearby the marshalling yards.

Overall, there is enough empty capacity for further railway freight transports, but there is a lacking ability of the incumbent operator SNCF Fret to open new markets and to develop service innovations. Also the government does not push for such solutions. There are some improvements in the attractiveness of French ports, especially Le Havre and Marseille, that would give some hope of a recovery of rail freight transport from and to these ports. The situation is clearly recognized by experts and decisions makers in France, but there is a lack of political will to revitalize the incumbent operator and to support free market initiatives in the French railway sector.

[20] Source: Les Echos, 04.06.2012.

5 Recapitulation and recommendations for EU freight railway policy

5.1 Recapitulation

Railway freight needs long distances and large quantities. Railways become an economically viable and ecologically friendly alternative for road transports on long distances (over 400 km) and – in the cases of large consignments – even at shorter distances. In contrast, dispersed transports over distances of less than 200 km are generally not suitable for the railways.[21]

Thus, in view of the rather small average country size in Western and Central Europe, there should be a grid of European international rail freight corridors, each of them easily exceeding the 200, 300, or even 400 km thresholds. The question emerges, whether there are enough quantities of goods to be transported on each of these corridors. A closer look at European freight flows shows that there is a considerable heterogeneity in terms of capacity utilization and potential market volume for railways.

In particular, we identified a group of "first tier railway corridors" which offer really favorable conditions for railway freight. They run in North-South direction within the continental Blue Banana – from the North, where the ports are, to the South, where many of the industrial centers are located – or parallel and close to it in the Western or Eastern Adjacencies of the Blue Banana (i.e. parts of EU railway corridors No. 1, 2 and 3).[22] Moreover, there are also some East-West connections between the Blue Banana and the Eastern Adjacency in Germany and possibly also in Northern Italy (i.e. parts of EU railway corridors No. 8 and 6), and probably some extensions of these lines to East Central Europe.

The single most important freight corridor is the Rotterdam-Milano corridor (officially called "Rotterdam-Genoa" corridor, but up to date, Genoa is not really connected to it). This corridor is therefore rightly called "EU railway corridor No. 1", we refer to it as the "central corridor".

The "second tier railway corridors" refer to all the other EU railway freight corridors, as well as to some lengthy extensions of the first tier corridors. These corridors have substantially less traffic compared to the first tier corridors. Examples are corridor No. 4 from Portugal to Spain and France or the part of corridor No. 3 that goes from Hamburg to Scandinavia.

[21] This is to be qualified, as there are some important short distance railway transports as well, for example for coal and iron ore, building waste, or chemical goods. Such short distance transports make up a fairly high share of railway transport volume (in tons) but only a small share of ton-km. Moreover, there seems to be very limited shifting potential for railways on the short distances. See the discussion in section 2.

[22] For the definition of these European regions see section 3. EU railway corridors are numbered in accordance with the Appendix of EU Regulation 913/2010.

Because of this heterogeneity, railway freight policy faces a very different set of problems on the first tier corridors as on the second tier corridors, as we will work out as follows.

5.2 Policy implications for first tier corridors

The first tier corridors are almost bursting from traffic. This holds practically for the whole central corridor and for some sections the other first tier corridors. The first tier corridors run through the most densely populated areas of the continent, where freight trains have to compete with passenger trains (long distance or regional) for train paths. As a result, freight trains face substantial quality of service problems during daytime, and many of them are shifted to the night slots. But this is particularly cumbersome, since at the current state of technology freight trains cause a lot of noise, disturbing a large number of people living close to the rails in the center of the Blue Banana.

In these areas, shifting more freight to the roads is not an option either. First, this is generally not desired (CO_2 emissions, truck noise, etc.), and second, the motorways in the Blue Banana and its Eastern Adjacency are bursting from traffic as well. Quite on the contrary, when the Swiss will open the new base tunnel at the Gotthard and at the same time reduce road freight traffic over the Alps, the central railway corridor and the people living close to it will suffer from a further increase of railway traffic.

The potential ways out of these problems of the first tier corridors are the following: (i) The capacity of the corridors needs to be increased by intelligent management (e.g. one-stop shops selling internationally integrated train slots), but partly also by punctual infrastructure investments, (ii) the efficient use of capacity needs to be increased by renewing rolling stock, and (iii) the noise caused by freight trains needs to be reduced by renewing or adapting rolling stock as well as infrastructure. We will address these options in more detail in section 5.4.

An additional way of reducing the problems of the first tier corridors would be the development of alternative routes and the rerouting of freight trains. There is still excess capacity (or easily expandable capacity) on corridor No. 2 through Belgium and France in order to bypass the German middle or upper Rhine area. But this cannot fully substitute for the need to increase efficiency and reduce noise on the main corridors.

5.3 Policy implications for second tier corridors

On the second tier corridors, capacity shortages and noise also come up here and there, and in some places even pose major problems, but all in all they are more locally confined than on the first tier corridors. Thus, in many instances where these problems do appear, they could be overcome by relatively small local investments – if governments would just see the importance of rail freight and of making such investments.

On the second tier corridors it would really be interesting to try and shift more traffic from the roads to the rails, thereby also improving railway network utilization. However, there could be several problems for railway freight on the second tier corridors: First, it could be imagined that the market is just too small. Second, there could be little spatial concentration of transport demand. Thirdly, road transport is cheap and reliable. When freight flows are rather dispersed and only of intermediate distances, the truck cannot really be denied of its suitability.[23] This gives trucking interests an edge when lobbying against a further development of railway freight.

Therefore, one cannot expect that countries hosting the second tier corridors will make big and expensive efforts to increase efficiency or renew the rolling stock fleet. Large scale upgrades of wagons and infrastructure appear unnecessary – and indeed, in view of their cost, a waste of money – for these parts of the European railway grid, at least on first sight.

Still, the states can at least try to stabilize or moderately increase the modal share of railways. They could try to achieve some goal alignment with the trucking industry by supporting intelligent multimodal concepts. For example, central intermodal logistics centers could be developed along these corridors, where trucking companies perform the pre- and post-haulage and might also be involved in the organization of railway transports. Freight railway operators, too, develop such centers (see, for instance, concepts by Kühne & Nagel, or DB Schenker Railports and DB Schenker Logistics Centers in Austria, Romania, Great Britain, Northern Italy and Sweden).

There are some measures that can be taken in order to enhance the utilization of the second tier corridors. For example, the employment of longer trains reduces the unit cost and increases the attractiveness of railway transports. This option was realized on the railway line from Hamburg to Denmark, which is a typical second tier corridor. Moreover, when innovative and more efficient solutions have been developed and successfully implemented on the first tier corridors, parts of these innovations might also migrate to the second tier corridors, improving their efficiency as well.

In fact, once the capacity problems and innovation barriers on the first tier corridors have been removed, these corridors can constitute the germ for the further development of a European railway commodity transport network: Railways can demonstrate to be highly competitive and economically self-sustaining; with little effort, further transports can be shifted from the congested motorways to the rails. To achieve a real network, new gateways should be developed at the crossings of first with second tier corridors.

Since the transport markets in the Blue Banana support the development of several competing operators, and of business models using different technologies, competition within the Blue Banana is crucial for the development of innovation on the other corridors. In line with

[23] Also the long-term CO_2-goals of the EU do not necessarily require a shift from trucks to railways. Trucks can still be trimmed to consume less conventional fuel, or to convert to Bio-fuels, or, in a more distant future (but already in sight), to hydrogen fuel (produced maybe by solar power plants or windmills).

this idea, the implementation of a new railway standard can be envisaged. We therefore come to our main policy recommendation.

5.4 Implications for technological standardization and innovation policy

We think that it is time to start the upgrade of at least a part of the European fleet of freight railway wagons. The upgrade should consist of several interacting technological changes:[24]

- The most important innovation is the introduction of **automatic central couplings**. This comes along with an automatic electronic connection of the whole train. Maybe pneumatic force will still be used for brakes; in this case the automatic coupling should also include an automatic connection of the pneumatic pipes. In any case, brakes of the individual wagons should be controlled by the central electronic system of the train.[25] Such a system will make time-consuming brake tests obsolete since they will be replaced by electronic monitoring systems.
- Another essential innovation is the replacement of block brakes by **wheel brakes**, with positive (i.e. reducing) effects on noise emissions and wheel wear (the latter aspect in comparison to K- or LL-block brakes).
- The introduction of electronic couplings and modern brake systems enable further innovations: High speed **bogies** and aerodynamically efficient **chassis and superstructures** can be introduced in order to enable higher train speeds (120 or even 160 km/h) and, thus, a better infrastructure capacity utilization in network sections domineered by (fast) passenger trains.
- Some supplementary innovations could be the following ones: In the long run, pneumatic brake force could also be replaced by electric force. This would enable partial energetic recovery, as is the current practice with passenger trains. It would also facility the introduction of power cars allowing self-propelled last mile and marshaling operations. As a final aspect, the upgraded wagons can be freed from the requirement to be shunted over the hump in traditional marshalling yards. These operations require shock resistant wagons and thus, they contribute to the necessity to employ wagons with a high deadweight.

This set of upgrades will in particular reduce standstill periods for both rolling stock and railway infrastructure.[26] Altogether, this upgrade will have beneficial effects on noise emissions, energy consumption, and capital and labor costs.

This upgrade, however, is a relevant issue first and foremost for the first tier corridors. For the second tier corridors (and other parts of the railway network), the related investments would not pay back for some time to come. Therefore, we propose that the principle of a

[24] On the following compare König and Hecht (2012), Hecht (2013), RailBusiness (2014), Siegmann (2014).
[25] In case of a combination of pneumatic brake force and electronic brake control this is called the "electro-pneumatic brake".
[26] See in particular König and Hecht (2012): White Paper Innovative Rail Freight Wagon 2030.

homogeneous fleet of wagons for all Europe should be replaced by a pair of two different standards coexisting: the conventional standard and a new upgrade standard.

The upgrade standard should be freed from the requirement of downward compatibility – this in particular would be a novel twist of EU railway policy, since up to now downward compatibility is one of its core principles (and in many other respects rightly so). But there is no sense in making the upgrade wagons compatible with the conventional ones.[27] This would just lead to complicated compromises in design and doubling of components and would thus severely add to the costs and empty weight of the high standard wagons. At the same time it would greatly reduce their achievements in noise reduction, since a train with only a few loud wagons is loud (the logarithmic nature of noise). Locomotives could be licensed for only one type of freight train, but double-standard locomotives shouldn't be too expensive to set up.

Thus, there would then be two very different types of freight trains in the EU, purely conventional ones and purely high standard ones. Note, however, that both types of trains could and should be perfectly interoperable within the EU (if the engines are), i.e. capable of being used in any member state with the normal gauge. The high standard wagons will constitute a new homogenous and interchangeable fleet of wagons among themselves. That means: wagons and trains that leave the conventional standard behind will not be developed in a dispersed non-compatible way. This alone might give industry direction and incentive to develop for and invest in new promising technologies.

In order to support the deployment of the new standard, some regulatory steps are necessary. A recent development in the formulation of the TSI norms (Technical Specifications for Interoperability) helps along: Until recently, the TSI norms for wagons were very much tied to the "UIC heritage", aiming to keep wagons in line with the inherited fleet. Only recently the TSI norms have been freed from this goal and thus, they allow for more flexibility. The TSI for wagons now confines itself to essential safety and interoperability standards. Therefore, the first regulatory step for the upgrade is to establish an alternative set of technical requirements in "TSI Wagon" (addressing couplings, electric and pneumatic systems, and brake tests). A wagon type can then be licensed for the traditional or for the upgrade set of requirements. It will be forbidden to couple these wagons directly (if multi-system wagons were developed, they would have to meet both sets of standards).

In a second step, the EU should specify a more comprehensive "vision" of the new upgraded wagon type, not in a mandatory way, but just in order to give industry impulse towards a joint development direction. Moreover, a part of this vision can be underpinned by regulatory recommendations issued by the EU. For example, the EU could define requirements for a "very silent train", which can only be met by upgrade wagons and engines.

[27] Compare RailBusiness (2014).

In a third step, the EU should allow and encourage infrastructure managers or corridor boards towards incentive oriented schemes of railway access charges. Some examples: There could be discounts for very silent trains or particularly dynamic trains occupying less dynamic capacity. If these rebates for the high standard trains lead to a loss of revenue (implying that the upgrade of the fleet is making progress), then the general track access charges on the corridor need to be increased, speeding up the sorting effect for the high standard trains still further. Particularly attractive train paths could be auctioned, and the winners will most likely be the more efficient high standard trains. That is, the economic incentives by themselves will be such that railway undertakings will prefer using high standard trains. Note, however, that all these measures will not be done by some profit maximizing (or national interests maximizing) national incumbent, but by the international management board of the corridor which is more committed to pursue European welfare goals.

In order to get the process moving, the states involved with the first tier corridors (or the EU) should be ready to help with some financial support for a startup period. First of all, some basic support service for the upgrade wagons will be necessary along the corridors, like repair shops and engines capable of handling with damaged upgrade wagons. In the beginning this will probably require the use of some subsidies. Moreover, maybe the acquisition of upgrade wagons (or "very silent wagons") could also be subsidized for some period of time.

But what happens with the second tier corridors? Assuming that the new standard trains can operate on traditional railway tracks, too, it can be expected that, after some time, the first "pioneers" will appear. These will most likely be logistics trains or intermodal block trains. After some time, more complex operational structures such as dividing train concepts or liner trains are expected to emerge. These operational structures exhibit little economies of scale and, therefore, little market barriers have to be overcome. But once a critical mass of new wagons is circulating, also a new generation of single wagon traffic can be imagined.

Our summary of problems and recommendations are quite close to those of the EU White Paper (2011) item 26: "Rail, especially for freight, is sometimes seen as an unattractive mode. But examples in some Member States prove that it can offer quality service. The challenge is to ensure structural change to enable rail to compete effectively and take a significantly greater proportion of medium and long distance freight (and also passengers – see below). Considerable investment will be needed to expand or to upgrade the capacity of the rail network. New rolling stock with silent brakes and automatic couplings should gradually be introduced."

However, we are sceptic concerning the "considerable investments" in the network and the "gradualness" of the process. In many parts of the European railway network, investments are rather needed for setting up intelligent intermodal nodes together with the private sector than for upgrading railway lines. In other parts – i.e. in particular in the Blue Banana – a technological leap is indicated and concerns mainly the rolling stock and traffic control.

Here, we want to issue a warning concerning too much gradualness: Things will only get ahead if a swift and bold action is taken. For example, requiring downward compatibility would surely spoil the whole endeavor. Or, if some of the other complementary innovations listed at the outset of this section are not taken on board from the beginning on, the economic potential will not be fully exploited.

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Appendix on Data

For the analysis of freight quantities ETISplus data were used in this study. ETISplus (European Transport policy Information System) was a project funded by the European Commission as a continuation of the prior ETIS project. Its main objectives were the collection and consolidation or – in case collected data were not available – the computation of data in order to establish a new reference data set for transport modelling and EU transport policy. The project ended in 2012 and produced data sets for the reference years 2005 and 2010 for the EU member states and all accession and neighboring countries. Though the accuracy of the data cannot be validated by us, ETISplus data are considered the most reliable recent data available. All data produced by the ETISplus project are publicly accessible on the ETISplus website, from where we obtained them for the current article.

There are three levels of data in ETISplus: Observed data with a close link to the original source, harmonised data based on combining, aggregating or splitting one or more observed sources, and modelled data including the estimation of missing elements with an analytical method. In this article the modelled data for the reference year 2010 were used. These data consist of O/D-tables (origin/destination) for four different modes of transportation: *Disaggregated Rail Freight by OD*, *Road Freight by OD*, *Disaggregated Inland Waterway (IWW) Freight by OD* and *Maritime Freight by OD*. Given the 2321 geographical cells used in ETISplus, this amounts to almost 30 million O/D-relations with corresponding cargo quantities.

Beside the inner-European transports ETISplus data also contain trade flows from Europe to several regions outside of Europe – like East Asia or North America – and vice versa. In ETISplus, these transport flows are broken at the ports. Thus, a ton of cargo from, say, Lyon via Antwerp (by train) to Shanghai (by sea vessel) was broken into two distinct flows: First a railway freight shipment of a ton of cargo from Lyon to Antwerp, next a maritime freight shipment of a ton of cargo from Antwerp to China.[28] This treatment is very favorable to our own purposes. Since we are interested in all freight flows potentially relevant for railways (including hinterland traffics), we simply included all flows within Europe into our calculations and ignored all flows to or from the Rest of the World (which are mainly maritime freight flows).

The O/D-tables of ETISplus are based on nine-digit integer codes. These so-called ETISplus Zones correspond for EU member states to the NUTS-3 standard. In a first step we ascribed every ETISplus Zone in the EU to one of the ten European strategic regions which we have defined for this study. Non-EU member states, as far as they were regarded relevant for this study, could be identified by the first three digits of the ETISplus codes. They could then be

[28] Consistently, more than 90% of the freight flows from all European regions to all regions outside of Europe have the mode of maritime freight flows.

ascribed to their strategic regions, as for these countries no further internal division was necessary.

Then, for every mode of transport, ETISplus Zones of origin and destination were replaced by the corresponding strategic region. Summing up the freight quantities from every region to every other region this resulted in a highly aggregated 10x10 O/D-matrix for every mode.[29] These were then summed up over all modes to get one final aggregated 10x10 O/D-matrix. The entries in the main diagonal of this O/D-matrix are the internal freight quantities within the respective strategic regions. For the inter-regional flows, the final step consisted in aggregating flow quantities of opposite direction. Thus, total quantities between two regions A and B are calculated by adding up flow volume from e.g. region A to B with the opposing flow from region B to A. As a result, the O/D-matrix was merged to a matrix with entries only on and above the main diagonal, showing all freight flows within and between the ten strategic regions. This matrix is shown below for total freight quantities and for freight quantities of more than 200 km, 300 km, and 400 km distances.

The 200km-filter was implemented as follows. ETISplus provides impedances-tables including the distances in km between the ETISplus Zones for each mode except maritime freight (hence the filter was not applied to maritime freight flows). After connecting the O/D-tables with the distances taken from the impedances-tables we filtered out all freight flows with more than 200 km distance and aggregated them as described above.[30] The 300km- and 400km-filters were implemented analogously.

Region	1	2	3	4	5	6	7	8	9	10
1	4 586 917	64 751	42 576	145 048	246 135	73 024	660 866	112 835	108 771	30 964
2		1 792 495	19 826	19 936	8 576	17 150	17 098	11 953	9 570	8 268
3			845 859	74 705	3 952	2 016	6 186	2 931	4 355	1 601
4				821 291	9 530	4 147	12 827	8 914	6 392	3 050
5					442 331	1 637	12 266	16 788	5 864	1 368
6						552 021	126 554	3 290	3 698	18 623
7							2 199 031	79 503	104 364	52 573
8								1 318 046	48 017	2 669
9									1 882 429	25 153
10										1 388 884

Table 1: Total freight quantities in thousand tons, 2010, between the European regions (region numbers explained in Table 5)

[29] The handling of the large set of ETISplus data was done with the help of Microsoft Access. In Access, the aggregation was done employing the GROUP BY clause. The matrices were then created by use of the PivotTable view.

[30] There are a few omissions in the distance data of ETISplus. To these flows a zero distance was (wrongly) assigned in the tables. For us, this had the consequence that some flows were wrongly filtered out. However, we checked that this misrepresentation amounts to less than 1% of total quantities of more than 200 km distance.

Region	1	2	3	4	5	6	7	8	9	10
1	615 335	64 745	42 505	120 961	148 351	64 734	364 832	112 547	108 704	30 840
2		173 818	18 561	19 936	8 576	17 150	17 091	11 953	9 569	8 268
3			46 718	37 768	3 952	2 016	6 177	2 931	4 355	1 601
4				41 176	9 530	4 147	12 797	8 914	6 392	3 050
5					50 263	1 637	12 262	16 788	5 864	1 368
6						185 956	81 102	3 290	3 698	18 622
7							232 728	79 219	97 691	48 453
8								293 940	47 889	2 669
9									347 548	22 516
10										114 210

Table 2: Freight quantities of more than 200 km distance in thousand tons, 2010, between the European regions (region numbers explained in Table 5)

Region	1	2	3	4	5	6	7	8	9	10
1	336 971	64 745	42 503	83 206	125 115	47 262	249 886	112 547	108 671	30 840
2		114 836	17 037	19 936	8 576	17 150	17 091	11 953	9 569	8 268
3			11 304	22 459	3 952	2 016	6 177	2 931	4 355	1 601
4				22 773	9 530	4 144	12 795	8 914	6 392	3 050
5					26 978	1 637	12 262	16 788	5 864	1 368
6						95 015	54 316	3 290	3 698	18 622
7							96 136	78 194	88 925	44 034
8								219 311	47 800	2 669
9									172 642	19 945
10										73 471

Table 3: Freight quantities of more than 300 km distance in thousand tons, 2010, between the European regions (region numbers explained in Table 5)

Region	1	2	3	4	5	6	7	8	9	10
1	254 224	64 745	39 235	61 592	116 496	36 972	190 138	112 547	108 356	30 616
2		86 041	15 592	19 927	8 576	17 150	17 091	11 953	9 569	8 268
3			5 255	17 441	3 952	2 016	6 177	2 931	4 355	1 601
4				10 005	9 530	4 135	12 749	8 914	6 392	3 050
5					22 020	1 637	12 262	16 788	5 864	1 368
6						70 065	34 678	3 290	3 698	18 619
7							59 163	76 911	79 371	37 174
8								173 798	47 698	2 669
9									98 584	17 591
10										54 643

Table 4: Freight quantities of more than 400 km distance in thousand tons, 2010, between the European regions (region numbers explained in Table 5)

Furthermore, the size of population, the area, as well as the GDP of the ten strategic regions were determined. Eurostat provides data for the EU member states and some other European countries on at least NUTS-2 level. Population data were used for the year 2011, except for a few cases in which they were not available and data from 2010 filled the gap. Data on the area relate to 2012, the GDP measured at current market prices to 2011. For each strategic region the respective values of the NUTS-regions it consists of were summed up. In cases Eurostat did not provide data for a non-EU country additional sources were used.

Region No.	Region name	Population (million)	Population in %	Area (km^2)	Density (inhabitants per km^2)	GDP (billion €, 2010)	GDP in %
1	Blue Banana	147.72	27.65%	437 198	337.88	4 908.69	36.33%
2	Spain and Portugal	56.73	10.62%	598 203	94.84	1 216.21	9.00%
3	Western France	23.64	4.42%	298 827	79.09	602.42	4.46%
4	Western Adjacency	31.36	5.87%	200 897	156.09	1 153.66	8.54%
5	Northern England, Scotland, Wales, and Ireland	17.71	3.31%	201 249	87.98	463.36	3.43%
6	Middle and Southern Italy	33.31	6.23%	181 392	183.63	708.23	5.24%
7	Eastern Adjacency	63.90	11.96%	401 328	159.22	1 998.52	14.79%
8	Scandinavia	25.36	4.75%	1 143 690	22.17	1 157.94	8.57%
9	East Central Europe to the North of Hungary	60.86	11.39%	615 670	98.85	662.67	4.90%
10	Hungary and Balkan Peninsula	73.73	13.80%	888 400	82.99	638.80	4.73%
	Sum (resp. overall)	**534.31**	**100.00%**	**4 966 853**	**107.57**	**13 510.49**	**100.00%**

Table 5: Population, Area, population density, and GDP of the European regions

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