Potentials for a modal shift from road to rail and ship - A methodological approach

ETC/ACC Technical Paper 2008/18

December 2008

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European Topic Centre on Air and Climate Change

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Table of Contents

List of Tables

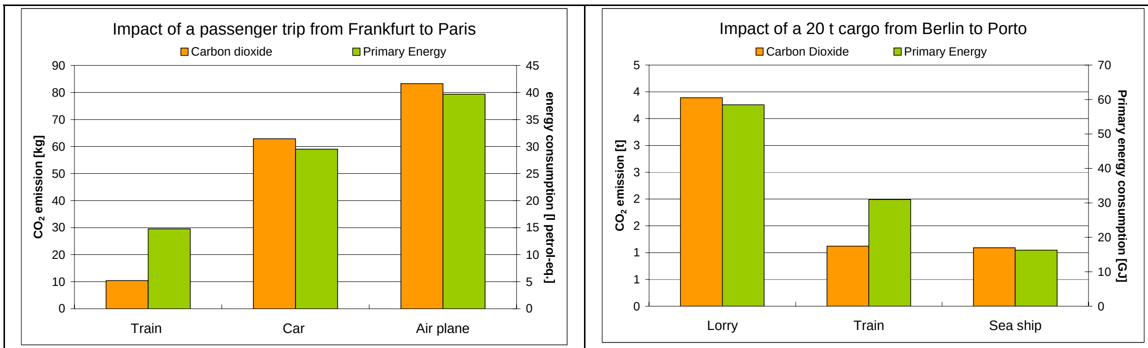
List of Figures

1 Introduction

Compared to the overall greenhouse gas emissions (which decreased by 1.5% from 1990 up to 2005), the greenhouse gas emissions of the transport sector have increased by 25.6% in the same time period (UNFCCC 2008). The share of transport emissions increased from 16% in 1990 to 21% in 2005. In order to meet the global EU emission target of 8% and to achieve further emissions reductions which are urgently required, it is necessary for the transport sector to substantially contribute to the reduction of greenhouse gas emissions.

In the last 15 years EU-27 passenger transport activity increased due to a 36% rise in private car activity and a 104% rise in aviation activity. In the business-as-usual scenario of (PRIMES 2007) a further rise is projected mainly for these two transport modes with the result that passenger transport activity will exceed 8,800 Gpkm in 2030 compared to around 6,000 Gpkm today. The growth rates of freight transport activity on the road are even higher. It experienced a growth of 60% between 1990 and 2005 and further increases are expected in the future. As a consequence, the transport sector represents the fastest-growing sector in terms of energy use. In 2030 energy use for transport is projected to be around 65% higher than in 1990. The consequence is that additional measures are urgently required so that the transport sector fulfils its target of achieving significantly higher CO_2 emission reductions. One key element for a more sustainable mobility is the use of more environmentally friendly transport modes. Per passenger or tonne kilometres respectively travelled or driven by rail and ship have a significant advantage in terms of energy use and CO_2 emissions compared to road transportation as shown in Figure 1.

Figure 1: CO_2 emissions and primary energy demand of a passenger trip from Frankfurt to Paris according to "EcoPassenger" and a freight trip from Berlin to Porto according to "EcoTransIT"



Source: Ecopassenger 2008

Source: EcoTransIT 2008

For example regarding the passenger transport, the energy consumption for a train trip from Frankfurt to Paris is half of the energy consumption compared to the same trip by car[1]. The CO_2 emissions are even better what is due to the share of renewable and nuclear energy in the electricity mix which is used for the trains. So a strong focus on policies in changing the modal split by targeting public and rail freight transport should, to all intents and purposes, be implemented in strategies for measures in the transport sector in order to reach ambitious CO_2 reductions. To support the implementation of such kind of policies and measures the knowledge about a theoretical maximum potential for a shift from road to rail and ship would be very helpful.

2 Scope of the report

The aim of the report is the development of a methodological approach to determine the potential for a modal shift from road to rail and ship for both passenger and freight transport. The basic idea is that it is more important as a first step to carry out this overall estimate than to hold a discussion on the political probability of which changes will happen in reality so as to clarify which policies are needed to tap the total theoretical potential. Thus, the objective is to determine an order of magnitude in terms of how much traffic could be transferred from road transport to rail/ship. In a second step possible measures can be considered that are needed to realise these potentials. In order to provide starting points to this end, the feasibility of tapping the maximum potential will be illustrated in chapters 4.3.3 and 5.4.4.

3 Structure of the report

As there are completely different structures, data availability and preconditions for passenger and freight transport, it was necessary to analyse them separately. As a result two different methodological approaches were developed and passenger and freight transport are presented in two parts. For each case the current methodologies for determining the modal shift potential will be presented, followed by a chapter on the available data on the EU level. As a next step a possible approach will be discussed for passenger transport as well as for freight transport; the subsequent chapter will address the determination of a modal shift potential in detail. In the last chapter the analysis will be summarised.

4 Passenger Transport

Categorisation by distances

Passenger transport could be divided into short- and long-distance transport. According to the literature, short- and long-distance trips are usually defined on the basis of physical distance. The first idea preparing this report was that we should not focus on passenger transport in general but on long-distance transport (LDT). Several reasons contributed to this decision. The crucial points were:

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[1] Here, the average load of the transport modes was taken into account. By changing the load factor, the emission factors can change significantly.

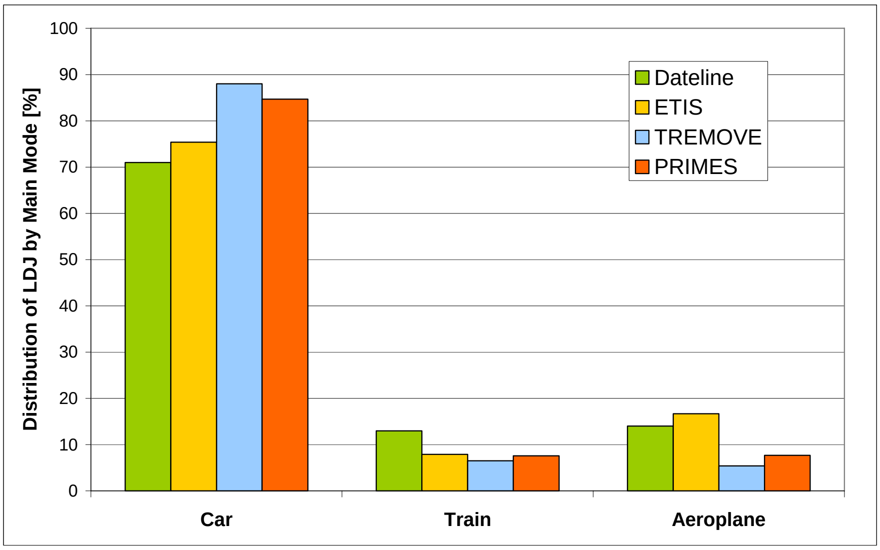
- Determining a modal shift potential from road to rail is much more complex for short-distances because they include much more complex trip chains and mode changes within a trip compared to long-distance travel, i.e. after work a person goes shopping and then picking up her children etc.. In contrast, long-distance trips are undertaken in general just for one purpose and with one main mode.
- Even if long-distance travel is a rare event from the individual perspective with a small share of trips of around 1%, it has a large share of the travelled mileage (Kuhnimhof 2007).
- Long-distance trips have high potentials for positive effects on behaviour changes (Kuhnimhof 2007).

But there is no commonly defined minimum distance as the thresholds used in various national travel surveys make clear: The range lays between 20 km for Italy up to 200 km for Belgium. The 100 km limit is a generally accepted standard for distinguishing long- and short-distance mobility and that definition has been used for the European long-distance travel mobility survey (DATELINE 2003). But several of the data available are not related to the categorisation short/long-distance, for instance the ETIS data which include most information needed for the determination of a modal shift potential (see chapter 4.2). Additionally, there is no uniform understanding that long-distance trips have especially high potentials for positive effects on behaviour changes as (Kuhnimhof 2007) stated. Thus, we differentiated finally not between short- and long-distance journeys in this report.

Main factors influencing modal choice

As in Figure 2 depicted, between 71% and 88% of the trips are undertaken by car and only 6.5 up to 13% by train – strongly depending on the data source and therefore also on the trip distance covered (Dateline just long distance, ETIS all trips between NUTS 2 regions, PRIMES and TRMOVE all trips in Europe, see also chapter 4.5.2).

Figure 2: Distribution of passenger trips by main mode according to Dateline, ETIS, TREMOVE, PRIMES

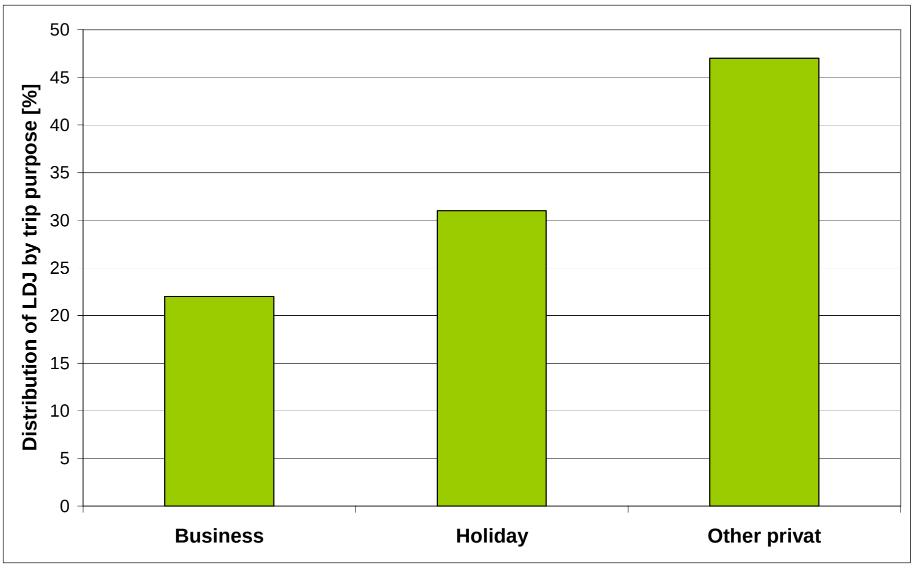


(Limtanakool 2006) identified three sets of variables capable of affecting mode choice:

1. Travel costs associated with the different costs (whereby time is an important constituent of travel costs)
2. Socio-economic characteristics of the traveller
3. Transport infrastructure at the origin and at destination of the trip

But the choice of mode in travel is not only a function of modal attributes and personal characteristics of the traveller; it is also closely tied to trip purpose (Ben Akiva and Lermann 1985). In a simple approach, trips can be differentiated between business, holidays and “other private” which is for example “visiting friends”. The Figure 3 shows that according to (DATELINE 2003) around 22% of the long-distance trips are business trips, 32% holiday and 47% “other private”.

Figure 3: Distribution of long-distance journeys by purpose in EU-15 according to DATELINE 2003

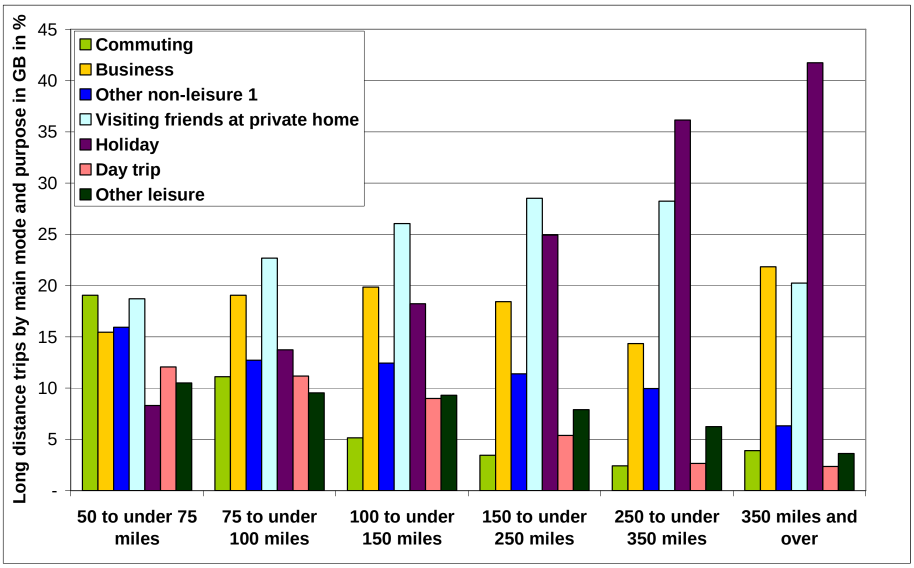


The national travel survey in Great Britain[2] goes with regard to the trip purpose into more detail, as shown in Figure 4 (GB NTS 2006). It has to be kept in mind that in the Great Britain national travel survey long-distance trips are defined as longer than 50 miles (~80 km). In 2006, “visiting friends” at their home was the most common trip purpose for trips over 50 miles (~80 km), accounting for 23%. This is followed by business trips which account for 18%. Holidays account for the largest proportion of trips of over 250 miles (~400 km). Related to the different distances travelled and further influencing factors which are described later in the report the decision variables for the mo-

[2] In contrast to UK data, Northern Ireland is excluded in the case of data on Great Britain.

dal choice have different values for different trip purposes and some variables are critical to one purpose but not relevant to another.

Figure 4: Distribution of long distance trips by main mode and purpose in Great Britain according to (GB NTS 2006)[3]



4.1 Methodologies in the literature

There are mainly three types of approaches for determining the modal shift potential for passenger transport in the literature: using capacity calculations, transport demand modelling or analyses of surveys.

4.1.1 Calculation on surplus capacities

In general, studies dealing with calculations on the potential for a modal shift from road to rail in passenger transport have capacity limitations as a starting point. In a first step the capacities of selected transport corridors are calculated. Then the traffic flow of the parallel road will be compared with the surplus capacity on the rail resulting from the modal shift potential. That methodology is limited to single transport corridors and cannot be used on a larger scale. And it does not take into account the possibility of enlargements of the rail capacities. Thus, it is focused on showing the possible shift in a dedicated transport corridor under the given infrastructure conditions.

[3] Note: 1 mile ~ 1.6 km

4.1.2 Transport demand modelling

Statements on the potential of a modal shift can also be derived from transport demand modelling by changing different factors, influencing the modal choice such as transport costs or time of trips. However, such studies are not undertaken to determine a maximum modal shift potential. In most cases they are carried out with the objective of showing the influence of different policies on the transport demand for different transport modes. There are a range of models for determining the passenger transport demand in the EU. According to (ThinkUp 2003) these models can be provisionally subdivided into the following rough groups:

- Trip generation (short distance) mobility (national models): Such kinds of models are mainly used to determine the trip mobility according to clusters based upon income, household and motorisation characteristics for short distances on the national level.
- Regional input/output models: The transport demand is derived from economic activity factors and a link is made between economy of regions and the volume of transport between regions. The problem is the economy data for which a high level of detail is needed.
- Regional gravitational models: These models could be used for regional economy and spatial planning. But the coupling transport – economy is missing.
- Logit/Utility based models: These kinds of models attempt to determine a probability of making one or another choice of transport organisation. For this approach detailed information is needed as well.

According to (Ortuzar and Willumsen 2006) the factors influencing the choice of mode in the passenger transport demand modelling can by classified into three groups:

1. Characteristics of the journey maker
   - Car availability and/or ownership
   - Possession of a driving licence
   - Household structure
   - Income
   - Decisions made elsewhere, for example the need to use a car at work, take children to school, etc.
   - Residential density
2. Characteristics of the journey
   - The purpose of the journey
   - Time of the day when the journey is undertaken (e.g. late trips are more difficult to accommodate by public transport)
3. Characteristics of the transport facility which can be divided into two categories:
   - Quantitative factors such as relative travel time, waiting, relative monetary costs (fares fuel, direct costs), availability and costs of parking; and
   - Qualitative factors such as comfort and convenience, reliability and regularity, protection and security.

The distance travelled is not mentioned as being an influence on transport mode choices since it is covered by the time travelled in combination with the time budget of the individual person.

By changing these factors, the transport demand of the different modes can be modelled to make travel forecasts (by considering the future trends of these factors) or to estimate the influence of different policies.

4.1.3 Determination of modal shift potential on the basis of surveys

A third approach to determine modal shift potentials in the literature is based on interviews to determine the willingness to change the transport mode under dedicated conditions. That approach is mainly used on a local level. In several counties surveys are carried out concerning the mobility behaviour of the population. In such contexts the willingness to undertake a modal shift was rarely surveyed. It is very likely that the national train companies have such data for their market analyses but the competitive aspects of the situation make it difficult to obtain these data.

4.2 Passenger data availability

For passenger transport there is much less relevant, international statistics available than for freight transport. This is due to the fact that foreign trade by transport modes have been linked to fiscal policies that have traditionally needed very detailed information on trade aspects. The main data sources and projects related to the development of databases for passenger transport (demand) are described shortly in the following sections.

4.2.1 Eurostat

The Eurostat database provides a high variety of data with regard to passenger transport and tourism. The UNECE Statistical Database contains a range of data with regard to transport statistics covering Europe as well as further countries with regard to, for example, road and railway traffic. A comparison between the Eurostat data and the UNECE data showed that the data are the same so only the Eurostat database will be described in the following:

Eurostat Database

<u>Transport statistics</u>

Modal share (car/coach/train), car ownership (number of cars per 1,000 inhabitants), motor vehicle mileage in vehicle-kilometres, road passenger transport in passenger-kilometres, railway passenger transport by type of transport (national/international) in passenger-kilometres, railway transport - quarterly passengers transported

<u>Tourism statistics</u>

Travels (number of tourist journeys of several days), number of trips by main mode of transport used (total, air, sea, land, railway, bus and coach, private and hired vehicles, other) and purpose (holidays, holidays - domestic, holidays – outbound, visits to relatives and friends, visits to relatives and friends- domestic, visits to relatives and friends-outbound), number of trips by gender and purpose, number of trips by age (0 - 14 years not inc. in total, 15 - 24 years, 25 - 44 years, 45 - 64 years, 65 years and over) and purpose

"Passenger mobility in Europe" in Statistics in Focus

The statistics presented in Statistics in Focus/Transport (SiF 87/2007) are derived from passenger mobility surveys carried out at national level. As passenger mobility surveys conducted in each country are not completely the same in most cases, they cannot be compared without delving into more detail. The information provided is:

Average number of trips/person/day, average travel distance km/person/day, average travel time minutes/person/day, number of passenger-kilometres by main mode of transport (walking, cycling, passenger car, other methods of motorised private transport, bus and coach, rail, air, water, other public transport), distribution (%) of distance travelled by purpose of travel (work, education, shopping, business, leisure, other), distribution (%) of travel time by purpose of travel (work, education, shopping, business, leisure, other).

Comment: The Eurostat database provides a high variety of data with regard to passenger transport and tourism. But the data are not available in cross correlation.

4.2.2 MESUDEMO

Description: The aim of the project MESUDEMO was to develop a methodology for creating a general European database on transport infrastructure and flows of passenger and goods (MESUDEMO 2000). The methodology addressed the establishing of the framework of the database as well as supplying a procedure for estimation of those variables which are urgently missing in a potential database. MESUDEMO has taken the indicators for transport demand, both for goods and passengers, and the indicators describing transport networks and outlined the data architecture for how to build ETIS (a European Transport Policy Information System) in the coming years.

Comment: The outcome of that project was not a database but a methodology on how to build one.

4.2.3 ETIS

Description: The aim of the ETIS project was to develop a core database for a European Transport Information System (ETIS 2005). ETIS had two main functions: firstly, to navigate the user through existing national transport data sources with accompanying information on their comparability; secondly to provide an interface which allows the production of comparable data across countries for different years. One task was intended for developing the core database of the ETIS covering the EU 27, called ETIS Base. It was designed for working towards building a consensus view of the reference pan-European transport modelling data set. An open methodology was developed to generate a version of a data set from existing international and national sources. The database includes origin-destination pairs between NUTS 2 regions, the number and the distance of the trips and the mode for the year 2000. This information can be complemented by a further set of data including the costs, rail service frequency and the travel time for the different modes for all OD pairs for the year 2003.

Comment: The ETIS Base provides the best harmonised available data for the year 2000 for passenger and for freight trips. They are used by the most of current European transport models. The data can be obtained by the DGENV.

4.2.4 DATELINE

Description: The DATELINE project started in April 2000 and continues until the end of June 2003 (DATELINE 2003). The project has presented concepts, methods and the potential for implementing a homogenous European travel survey of long-distance mobility in the EU-15. There have been four specific objectives of the project. Firstly, it has developed a survey design for long-distance passenger travel to be applied in all Member States. This addressed the needs of the respondent and implemented the state-of-the-art in travel behaviour surveys. Secondly, these surveys have been implemented in EU-15 plus Switzerland. The DATELINE project then worked on creating a database to provide answers to planning related issues and to provide input for future analysis. In the context of DATELINE a household-level survey of 86,000 residents of the EU-15 and Switzerland about their long-distance travel was carried out. Individuals over 15 years of age reported travel of over 100 km crow-fly distance for the purposes of “holiday” in the previous 12 months, as well as “other private” and “business” in the previous 3 months, and “commuting” for the previous 4 weeks. The survey was carried out from October, 2001 through October, 2002. Among other variables, the dataset contains travel date, destination, duration, and mode.

Comment: The Dateline project surveyed all journeys exceeding 100 km where a journey was defined as a series of trips starting and ending at home or a temporary location. Analyses showed that within the DATELINE project the 100 km length trips are underestimated compared to national travel surveys (Kuhnimhof 2007). Their website is already deactivated but data can be obtained from a report including the macro results.

4.2.5 National Travel surveys

According to (METSUMO 2000) a significant number of European countries have collected valuable data about long-distance passenger flows, including border-crossing traffic, in household and/or passenger surveys. In some countries hardly any harmonised passenger data exists on national level. The national travel surveys collect information from a sample of population contacted by phone or mail and asked to answer a certain number of questions focusing on their travelling behaviour during a fixed period prior to the moment when each respondent answers the mobility questions. These surveys are designed for national purposes and there are presently no agreed standards for conducting comparable and reliable surveys. So the methodological differences between countries’ surveys do not allow a full comparison of the data obtained; but they could be used to identify ranges and behaviour tendencies. The survey which is on one side public available and on the other side contains detailed information is the British national travel survey (GB NTS 2006).

4.3 Approach for the determination of a modal shift potential via segmentation

The first approach arising from the literature research on modal shift in passenger transport was the use of a segmentation approach to identify trips which could not be undertaken by train and to calculate the shift potential by providing the essential segments by data:

1. Definition of the deciding segments/modal choice parameters
2. Definition of exclusion criteria
3. Filling of the segments by data which availability already codetermine the definition of segments

4.3.1 Segmentation of the Passenger Transport Market

In the framework of the ThinkUp project one main task was related to the segmentation of the passenger transport market. The project was a thematic network project of the European Commission's 5th Framework Programme for Research and Development and was finished in 2003. It aimed to draw together results on transport demand forecasting and scenario building and to discuss and compare the methodologies used, the underlying hypotheses and the results obtained. The project considered in particular the subjects of passenger and freight transport markets, the institutional context and policy variables, and issues concerning prediction tools and trend estimation. Within the project the consortium came to the following conclusion concerning the subject “Potentials for Modal Shift: A Segmentation Approach for the European Transport Market” (ThinkUp 2002):

As the passenger transport market is highly complex, it is often described by market segments. Defining market segments is a compromise between differentiation and aggregation since for modelling transport at European level it is not feasible to model mobility behaviour for each individual person. Thus there is a requirement of defining market segments, which subdivide the whole population into groups. The particular segments should be differentiable, while the elements within a segment have to be as homogenous as possible.

The segmentation approach developed for the purposes of ThinkUp resembles very much the parameters influencing the modal choice in transport demand modelling described above. The variables consist of the demand and the supply side variables. The demand side variables can be further subdivided into trip characteristics (travel purpose, regularity of a trip, trip length, time of the trip, spatial character of a trip) and user characteristics (socio-demographic variables, socio-economic variables, pre-commitments, subjective factors). The resulting segmentation in the project ThinkUp consisted of following levels and segmentation criteria:

- Level 1: Functional trip, which combines the two variables “distance of the trip” and “spatial character of the trip”

- Level 2: Mode
- Level 3: Trip purpose (work, education, shopping, leisure (social and recreational), business, holiday)
- Level 4: Age group
- Level 5: Other socio-demographic and –economic user variables (gender, households size, household income, employment)

According to ThinkUp the "regularity of a trip" variable has a high affinity to the trip purpose and can be combined with this variable and the "time of a trip" variable can be attached to the trip purpose as a "time tag". Subjective variables like individual level of information about services, perceptions, constraints and the individual assessment of the degree to which a trip has utility for its own sake, have an influence on the mobility behaviour as well. As a result, they are recommended to be added by an "additional layer".

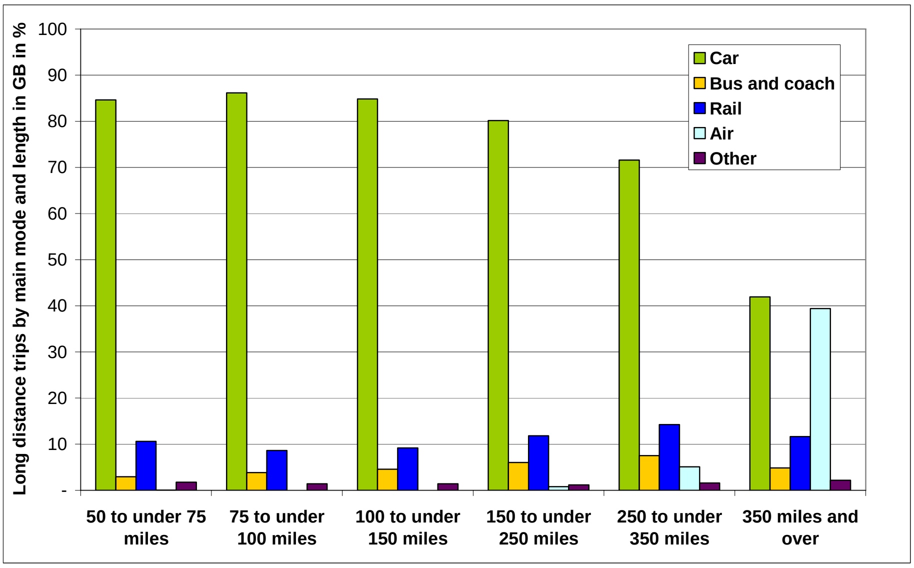
4.3.2 Definition of exclusion criteria and data availability

All described parameters or segments have a more or less strong influence on the modal choice. But it is extremely arbitrary to decide which criteria for the modal choice could definitively exclude the use of the train. In the following section the single factors influencing the modal choice will be discussed in more detail.

Distance of the trip: The trip distance is not per se an exclusion criterion as car travel doesn't have necessarily a time advantage compared to the train. In the national travel survey in Great Britain the mode is depicted differentiated by trip length. As Figure 5 shows, a maximum distance for train travel could be only defined with regard to air travel. In this country-specific data the vast majority of all long-distance trips are made by car and a further 10% by rail. The car is the most common mode for all length of trips. But, the use of the car declines for very long trips, for which air travel is increasingly popular. Nearly 40% of the trips with a distance of more than 350 miles (~560 km) are undertaken by aeroplane. Here, it has to be kept in mind that in Great Britain long-distance trips to the European continent have to be undertaken in most cases by aeroplane due to geographical reasons. Thus, these data are not transferable to other European countries. But anyway, in general - combined with the time of the trip - the distance could determine the modal choice for the benefit of air transport and account of car transport. But no definitive numbers of kilometres for the shift from road and rail to air could be found in the literature for all transport purposes. Only with regard to business as a trip purpose, a "3-hour target" could be found to meet the requirements of the business segment operators.

However, looking at the shift from road to rail there is probably no time advantage for using a car from a certain distance onwards. So basically all long distance trips could be shifted to rail transport in terms of time budgets and therefore of trip distances if the train has a time advantage compared to the road. Concerning the available data, the ETIS database provides the number of trips per distance and – more important – the travel time for road and rail so that the time ratio road/rail could be used for a data analysis.

Figure 5: *Distribution of long distance trips by main mode and length in Great Britain (GB NTS 2006)*[4]



Spatial character: The spatial character could be a practicable criterion to exclude certain trips from a shift to train in terms of accessibility, as the infrastructure is often small in rural areas and the accessibility to train is not always given. It was described that good access from the urban centre to train stations increases the use of trains, particularly for business trips (Limtanakool 2006, see also Table 2). It is also reported that the most important characteristic for train use by vacationers is the presence/absence of a train station. Higher population densities are associated with smaller shares of private car use. This is because higher densities and associated higher demand of public transport facilitate well-developed rail networks. So the modal choice depends significantly on the spatial character of the origin as well as of the destination. It could be stated that - as the objective of this study is to define an approach for the theoretical potential to shift from road to train, for which a possible expansion of infrastructure has to be taken into account - this criterion does not lead to exclusion in terms of enlargement of the infrastructure. But it is a very important factor. In standard GIS-programs data for the population density and the number of train station can be derived for the different NUTS levels.

Trip purpose: For the trip purpose it can be stated that there is probably no purpose which definitively excludes train use, just different probabilities for the modal choice. The trip purpose would be interesting to look on regarding the modal choice as the decision variables for the modal choice have different values for different trip purposes and some variables are critical to one purpose but not relevant to another.

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[4] Note: 1 mile ~ 1.6 km

For holiday trips a bit more information is available as for business trips. For example, holiday trips are more often undertaken with other people what may make travelling cheaper by private car and also more convenient for instance when luggage has to be taken into account. And the distance to train stations does not appear to affect train use as much as it does for business travel which may be derives from the fact that leisure trips are not subject to time constrains to the same degree. According to (Schmied and Götz 2007) the family orientated vacationer is a group with an especial high affinity to cars due to a higher mobility at the destination, the higher flexibility of time, the possibility to travel without train changes and the possibility of an easy transportation of luggage. The motivation for the choice of the transport modes car and train in holidays are summarised in Table 1.

Table 1: Motivation for the modal choice in holidays

Car	Train
Independence, flexibility (regional, temporal)	Stress-free and relaxing
Assurance of the mobility at the destination	Cheap
Stress-free (no train changing)	Possibility to enjoy the landscape
Unproblematic transportation of luggage	Meeting people
Cheap	More environmentally sustainable and safe
	Source: (Schmied and Götz 2007)

Thus, in principle the trip purpose should be regarded separately for a segmentation approach – at least a differentiation between business and non-business. But as the ETIS database doesn't differentiate between these two cases, different assumptions for these two purposes cannot be taken into account.

Regularity of the trip: Even if regular trips are easier to shift to rail that also does not constitute an exclusion criteria as a matter of principle.

Time of the trip: An interesting point is the time of the day of the trip since late trips are more difficult to accommodate. By furthering the service of public transport the influence of that factor can be reduced; but certainly not excluded. Concerning the data availability it has to be stated that no data with regard to the time of the trip could be found. It is very likely that train companies have such data but don't publish them due to reasons of competition.

Socio-demographic and socio-economic factors: All socio-demographic and socio-economic factors of the trip maker - such as age group, car availability, income, education and household structure - influence the probability of using the train. According to (Limtanakool 2006) more highly educated travellers and those on low incomes are more likely to travel by train (Table 2). And for example, car availability, as in everyday traffic, is consistent influence on mode choice for all trip purposes. But these do not constitute exclusion criteria. Why shouldn't a special age group use the train? Why not take a shift to train into account even if the trip maker has a car at home (travelling by train could be, for example, much cheaper or much faster in these cases)? So these criteria do not lead to definitive exclusion criteria but they are important in terms of probability. The general data could be obtained by Eurostat but they are not related to other important trip variables such as purpose or distance. The only source which could be found and which include information about socio-economic attributes related to the transport mode in long-distance travel was (Limtanakool 2006). Based on the Netherlands national travel survey 1998 they modelled the modal share related to socio-economic factors for medium- and long-distance transportation, whereby all distances over 50 km were covered. Some results are summarised in Table 2.

Table 2: Modal split for medium- and long-distance travel (>50 km) by trip purpose, socio-economic and land use factors (Limtanakool 2006)

	Commute		Business		Leisure	
	Car	Train	Car	Train	Car	Train
Gender						
Female	62.0	38.0	79.1	20.9	79.9	20.1
Male	81.6	18.4	91.8	8.2	84.4	15.6
Household type						
Single worker	68.1	31.9	90.0	10.0	73.1	26.9
Couple one worker	74.0	26.0	90.3	9.7	86.6	13.4
Couple two workers	75.0	25.0	87.1	12.9	87.8	12.2
Family one worker	84.8	15.2	91.9	8.1	78.5	21.5
Family two workers	80.5	19.5	84.5	15.5	74.5	25.5
Family more than two workers	76.8	23.2	92.1	8.0	84.9	15.1
Other type of household	84.6	15.4	93.6	6.4	83.1	16.9
Level of education						
High education	69.3	30.7	86.5	13.5	82.2	17.8
Medium education	82.8	17.2	94.6	5.4	77.6	22.4
Low education	93.5	6.5	95.1	4.9	87.2	12.8
Household income						
High income	78.7	21.3	90.1	9.9	87.9	12.1
Medium income	76.9	23.1	91.6	8.4	81.9	18.1
Low income	0.0	0.0	0.0	0.0	56.4	43.6
Population density (origin)						
Less than 15 persons/ha	84.6	15.4	92.7	7.3	87.6	12.4
15 to less than 30 persons/ha	77.6	22.4	89.8	10.2	76.4	23.6
30 to less than 45 persons/ha	61.0	39.0	83.9	16.1	70.8	29.2
More than 45 persons/ha	51.3	48.7	78.7	21.3	73.2	26.8

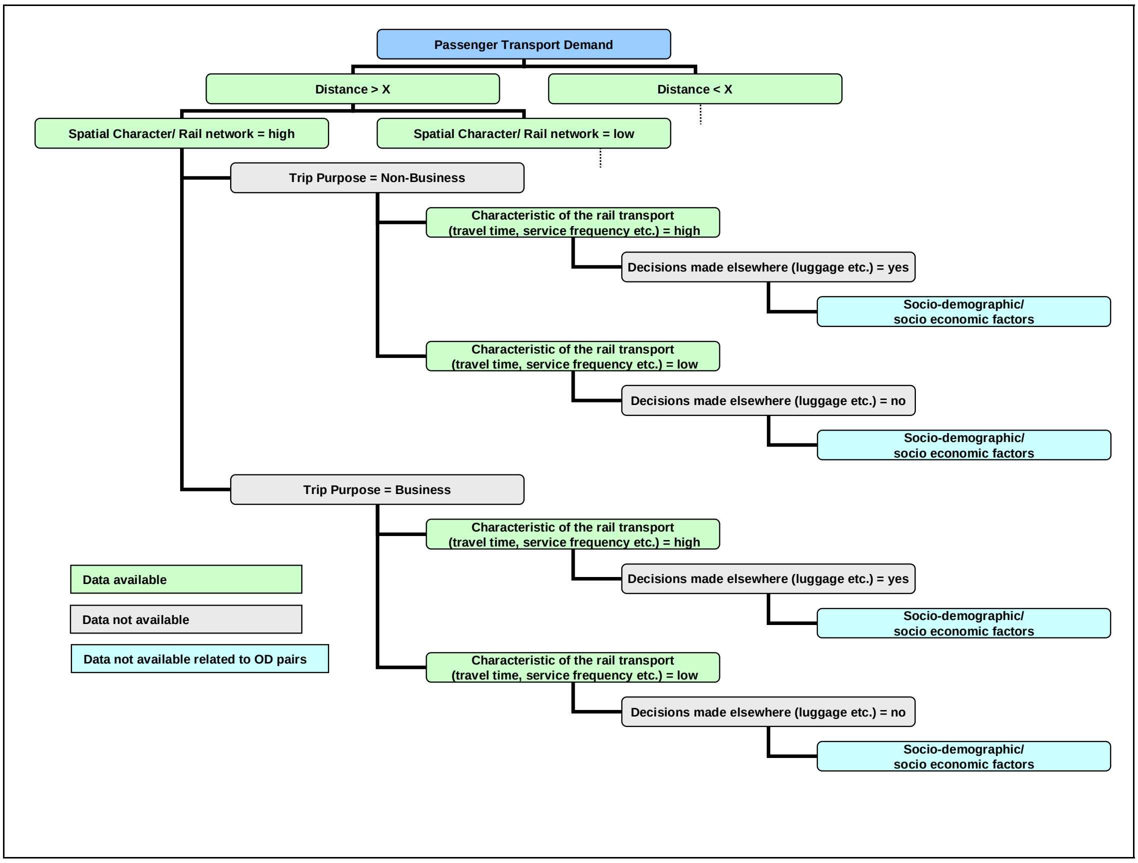
Decisions made elsewhere: For example the need to use a car at the destination or the need to transport objects which could not be transported by train would lower the probability of taking the train for a trip.

Characteristics of the transport facility: Characteristics of the transport facility affect the modal choice as well. On the one hand there are quantitative factors such as costs and on the other hand qualitative factors such as comfort and security. However, all these factors could be influenced by politics in such a way, that the probability of a shift from road to rail could by significantly supported.

4.3.3 Conclusion

For determining a maximum potential for a shift from road to rail in passenger transport the segmentation approach could be conceivable. The following segmentation tree shows all relevant criteria discussed above.

Figure 6: Approach for the determination of a modal shift potential via segmentation



4.4 Approach for the determination of a modal shift potential via transport demand modelling

Another possible approach is the determination of modal shift potentials via transport demand modelling and changing of key parameters such as costs (transport costs for road as well as for the train), accessibility and the time of trips to a maximum extent. But one has to be careful here: Too high cost changes cannot be taken into account as most of the models work with elasticises which are derived from past experiences and are not usable for untypical high cost changes. There were already some studies which look at the modal shift by changing different types of transport costs. According to [Vestner 2004] the change in modal shift by internalisation of the external costs in Germany is significant as shown in Table 3.

Table 3: Modal shift by internalisation of the external costs in Germany

Transport mode	Change in costs	Change in passenger kilometres	Change in modal shift share
Passenger car	6.50 € to 19.39 €	-35.4%	75.7% to 63.9%
Bus	5.46 € to 10.38 €	-17.6%	6.1% to 6.6%
Train	11.08 € to 14.72 €	+66.5%	9.2% to 20.1%
Aviation	31.00 € to 40.00 €	-20.2%	9.0% to 9.4%
Source: Vestner 2004			

For determining such estimations of the influence of costs on the modal shift, European transport demand models are needed. Therefore research about the current models concerning passenger transport modelling on the European level was undertaken and is summarised in the following chapter.

4.4.1 Studies on EU-level concerning passenger transport modelling

A range of projects using passenger transport modelling were carried out. But most of them are no longer traceable as the respective websites have been shut down, the database was not transparent or the project led not to a model but rather to the research needed for the development of models and databases that are consistent on a European level. There are several models which include passenger demand modules and which are more or less transparent.

4.4.1.1 EXPEDITE

Description: EXPEDITE is an EU-5th Framework project that started in May 2000 and was completed in October 2002 (EXPEDITE 2002). EXPEDITE had the following aims:

- Producing multi-modal demand forecasts up to 2020 for passenger and freight transport in Europe (using the NUTS 2 zoning system for Europe, with about 250 zones in the study area, comprising the current Member States and accession countries);
- Identifying market segments which react most to control measures; and
- Formulating efficient policy bundles to achieve mode-switching in line with CommonTransport Policy (CTP) objectives (this means substitution away from car and air transport for passengers and away from road transport in freight).

This project was closely linked to the THINK-UP thematic network.

Comment: No actual information is available nor is the model offered on the website.

4.4.1.2 SCENES

Description: The SCENES project was funded by the European Commission (DG Transport and Energy) and was finished according to the final report in 2002 (SCENES 2002). The main objectives of the SCENES project – European Transport Scenarios – can be summarised as follows:

- The development of a databank of variables, covering EU countries and a range of countries in Eastern Europe;
- The development of detailed forecasts of factors which will affect transport demand into the future, incorporating institutional factors and studies on breaks in trends;
- Extension to Eastern Europe and enhancing with new data and a strategic transport model of the EU as well as carrying out model runs based on the scenarios - this model will be linked to an "appended" logistics module; and
- Implementation of transport demand scenarios for the EU for 2020 and beyond. These scenarios are made up of external, socio economic scenarios, and sets of policy scenarios.

Comment: Talking to the person responsible for the database resulted in the understanding that the data are no longer up-to-date and should not be used for the estimations of modal shift potentials. Also the possibility of downloading the data is no longer possible.

4.4.1.3 ASTRA

Description: The approach for the original development of ASTRA was to build an integrative coded model that is implemented with the System Dynamics standard software Vensim (ASTRA 1998). Core models that spin off for ASTRA are the European transport model STREAMS and its updated version SCENES, the macroeconomic system dynamics model ESCOT and a set of environmental models that have been developed for the purposes of Strategic Environmental Assessment of the German federal cross-modal transport infrastructure plan. The ASTRA model has been developed, extended and applied throughout a series of EC funded research projects since 2000. It was designed for the strategic analysis of EU transport policies with special emphasis on feedbacks between different economic sectors and long-term developments. The ASTRA model consists of eight modules that are all implemented.

Comments: Basically, ASTRA is capable of determining the modal shift potential by changing input travel cost data. As there is no network in the background of that model, because it is working on an aggregated level, changes in rail infrastructure and related effects cannot be focused so as to determine the modal shift by ASTRA. The model is not publicly available.

4.4.1.4 TREMOVE

Description: TREMOVE is a transport and emissions simulation model developed for the European Commission. The model has been developed by the Catholic University of Leuven and Transport & Mobility Leuven. The latest version available is from the year 2007 (TREMOVE 2007). The TREMOVE model consists of 31 separate country models. Each country model describes transport flows and emissions in three model regions: one metropolitan area, an aggregate of all other urban areas and an aggregate of all non-urban areas. Trips in the non-urban areas are further separated into short (< 500 km) and long (> 500 km) distance trips. The transport demand module represents the number of passenger-kilometres or ton-kilometres that will be performed in each “model region” of the country considered. Three freight categories are distinguished (bulk, unitized and general cargo) as well as three passenger trip purposes (non-work, commuting and business). Also, transport flows are allocated to peak and off-peak periods. The decision processes of households are modelled using nested constant elasticity of substitution utility functions. These represent the preference relation of all households for the different transport options. The demand for business transport (freight transport and business passenger trips) is modelled as a result of the decision processes within firms. The business transport demand is determined by generalised prices, desired production quantities and substitution possibilities with other production factors.

Comment: The model is publicly available. Similar to ASTRA, the reaction of price signals can be reproduced but it is not possible to determine changes in infrastructure due to the aggregate level of the model.

4.4.1.5 TransTools

Description: The aim of the TransTools project was to construct a new modelling structure for the Commission, taking into account the shortcomings in current European models (TransTools 2006). The TransTools model is constructed as an IPR free instrument based on available knowledge. The TransTools model is a network-based transport model of Europe. The passenger demand model tackles passenger transport modelling at European level and covers the first three steps of the classic four-step-approach, which are trip generation, trip distribution and modal split. Trip generation as the first stage of the classical four-step transport modelling approach is implemented in ASTRA. After the generation of trips emanating from European NUTS 3 zones these trips are distributed among destinations. The spatial trip distribution is represented by the second stage of the ASTRA transport modelling approach. In the third step the mode for travel is chosen. Hence impedance data from the TransTools assignment model as well as O/D matrices per trip purpose from the ETIS database are applied. Travel costs, travel time and information about the trip itself such as frequencies and number of transfers are used to split the trips between the modes. Subsequently, for each origin-destination pair, the modal split model calculates the probability of selecting a modal alternative from a set of available modes. The explanatory variables represent the transport service level between two zones, e.g. in terms of the two aspects of travel costs and travel time. The output of TransTools passenger demand model to assignment model are unimodal passenger O/D transport matrices at NUTS 3 level in number of passengers per mode (rail, road, air) and trip purpose as well as unimodal passenger O/D transport matrices at NUTS 3 level in number of vehicles for road relations per trip purpose.

Comment: The model is available from the project leader. The TransTools Model could address changes to land use and economics. Thus, determining the modal shift should be possible by changes in network and in travel costs. TransTools is associated at the JRC IPTS and at the moment it is under further development and improvement which is planned to be finished in the end of this year. But even if it can be officially used for research purposes, it seems not to be useable without prior training.

4.5 Calculating the potential of a theoretical modal shift from road to rail – Passenger transport

There are two theoretical ways to estimate the potential for a shift from road to rail passenger transport: via a segmentation approach or via transport demand modelling.

Two current European models for the passenger transport demand are public available: TransTools and TREMOVE. Both could be used to determine modal shift potentials by changing travel costs for different transport modes. However, this does not exactly reflect the objective of our report: the determination of the maximum potential for a modal shift. It could just show the modal shift potential by a shift in modal costs and – in the case of TransTools - in a further development of the infrastructure. Additionally, it has to be questioned if elasticities derived from past experiences can be transferred to much higher travel costs to produce reliable data for a theoretical modal shift potential. However, as these two models are highly complex they cannot be made usable in the framework of this technical report.

As the ETIS data could be obtained from the European Commission the segmentation approach was chosen to calculate a modal shift potential from road to rail based on additional data analyses. A further advantage of the segmentation approach is that this way would be easier to undertake on a more theoretical basis.

4.5.1 Which data was used?

The best information available on trips on the EU-27 level is the ETIS database. This database contains the number of trips for different trip distances (origin-destination pairs/ OD pairs) combined with the modes used for the year 2000 (making up over 50,000 OD pairs). Only those trips are considered which are undertaken from one NUTS 2 region to another; therefore, information about all trips within a NUTS 2 region is not included in the database. Contrary to expectations, the data are not differentiated by trip purpose, i.e. business/non-business. Thus, this information is not available and cannot be included in further considerations.

In the framework of ETIS there is another dataset that is related to passenger transport service and costs, which can additionally be used as a basis for calculating a modal shift potential. The travel time, distance and costs for road and rail as well as the rail service frequency per OD pair according to ETIS are included.

By using a GIS program, the NUTS 2 regions can be combined with data on population density and the train station density (Michael Bauer Research GmbH I.G.; Euro-Geographics; Data Solutions, B.V.).

4.5.2 How were the data analysed and what were the results?

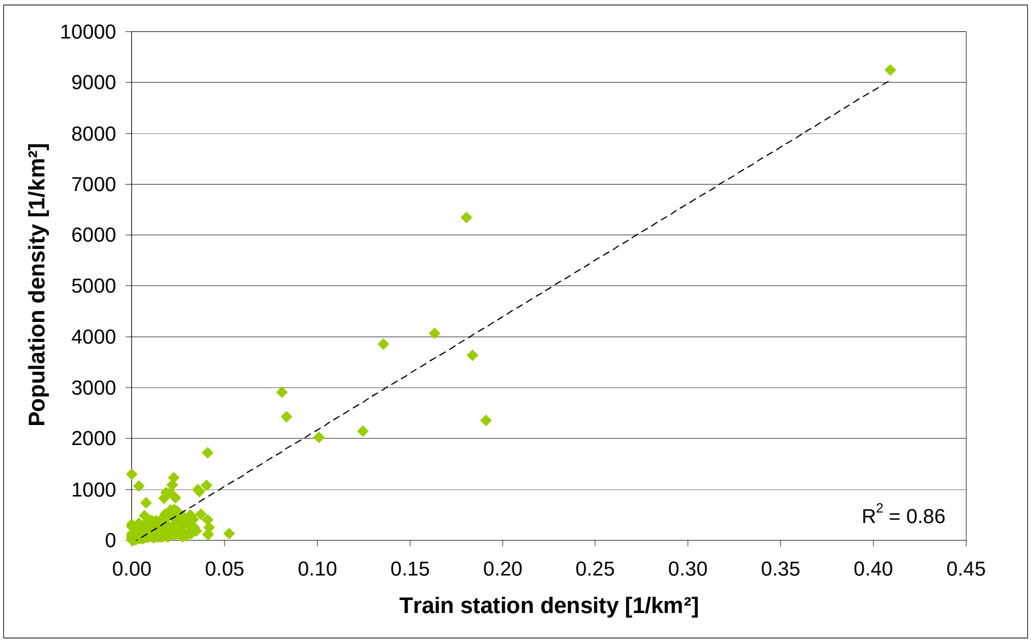
In the following section the results of the data analyses for the OD pairs are presented. These analyses provide the basis for the calculation of the modal shift potential.

Different correlations for all OD pairs within the EU-27 were analysed to make clearer which aspects influence the modal share and – above all – the extent to which this is the case.

Population density / train station density / other aspects of rail transport

The first assumption to be examined is that population density could serve as an indicator of the density of rail infrastructure. In this sense, the higher the population density is, the closer the infrastructure and the higher the share of trips by rail is. The following figure shows the correlation between the population density and the density of train stations within the NUTS 2 regions. A coefficient of 0.86 was obtained, which means that the correlation is not as high as expected.

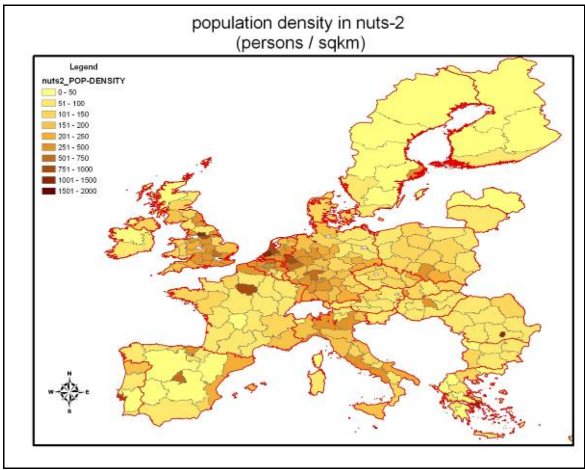
Figure 7: Relation between population density and train station density in NUTS 2 (EU-27)

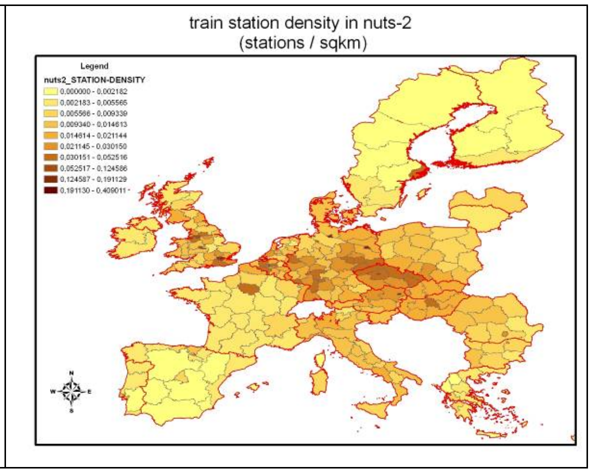


When observing the distribution of the population density and the density of train stations in Figure 8 and Figure 9 it becomes clear that there is basically a significant correlation between these two indicators. However, this impression is to some extent distorted by the fact that – against the background of historical growth – the train station density in the new Member States is higher than in the former EU-15.

Figure 8: Population density in NUTS 2 in EU-27

Figure 9: Train station density in NUTS 2 in EU- 27





Source: Öko-Institut and Michael Bauer Research GmbH I.G.; EuroGeographics; Data Solutions, B.V

Population density data will be used in the following considerations as an indicator of the rail infrastructure and service quality for the following reasons:

- the quality of the data for population density is higher than that which is available for train stations;
- it includes indirectly rail network service quality; and
- it includes indirectly information about infrastructure at local traffic (proximity to the rail network).

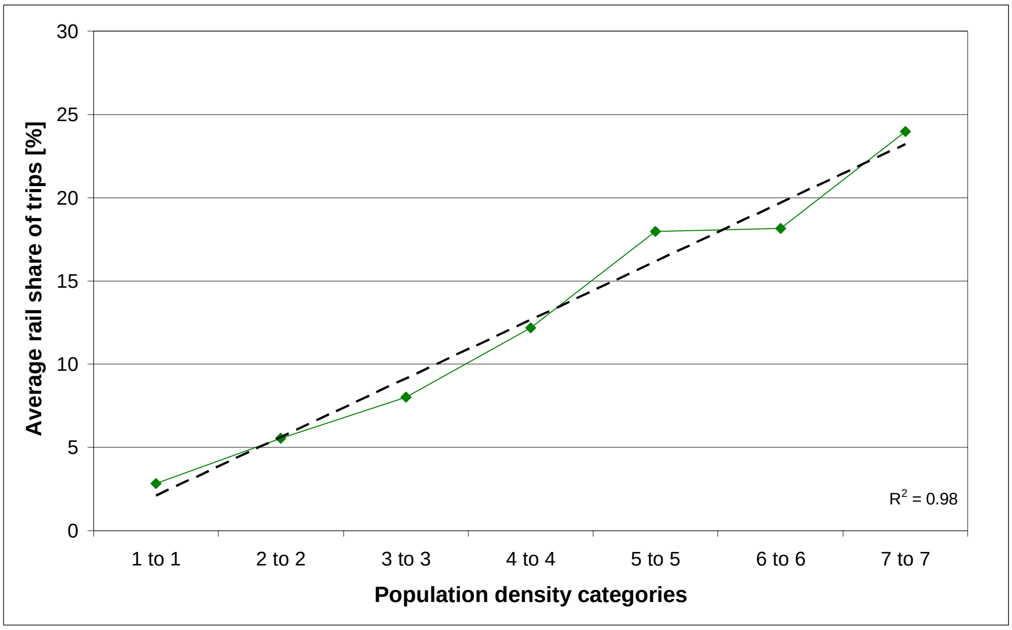
To establish whether this indicator correlates with the share of trips by rail, the following analysis was undertaken. The population density was categorised into 7 groups, ranging from a "very low" to "very high" population density (1/km²).

Table 4: Population density categories

Category number	Population density [1/km²]
Category 1	<100
Category 2	100-200
Category 3	200-300
Category 4	300-400
Category 5	400-500
Category 6	500-600
Category 7	>600

In Figure 10 all origin-destination pairs within the same category (1 to 1, 2 to 2, etc.) are depicted to establish whether there is a correlation with the share of trips by rail. Such a correlation would substantiate the assumption that the rail infrastructure in high population regions is higher than in low population regions and – due to the denser infrastructure – the rail share for each trip would be higher. As shown by Figure 10, a very high correlation (0.98) can be observed.

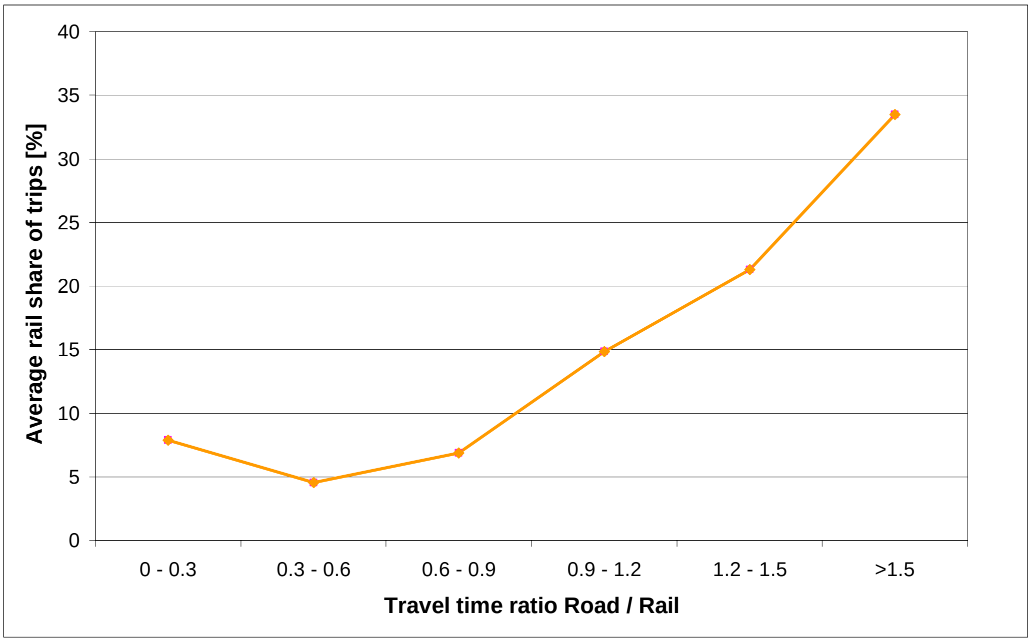
Figure 10: Relation between share of trips by rail and population density categories in EU-27



Travel time ratio for road to rail

Another important aspect influencing the choice of the transport mode is the travel time for each individual trip. Therefore, a correlation was made between the share of trips by rail and the travel time ratio for road to rail. Figure 11 shows very clearly that for all trips with a shorter travel time on the road, the rail share varies from around 5 to 9%, which corresponds (+/-) to the average share (grey area). However, as soon as the travel time by rail is shorter than that on the road, the share of trips by rail increases nearly linearly with the travel time ratio.

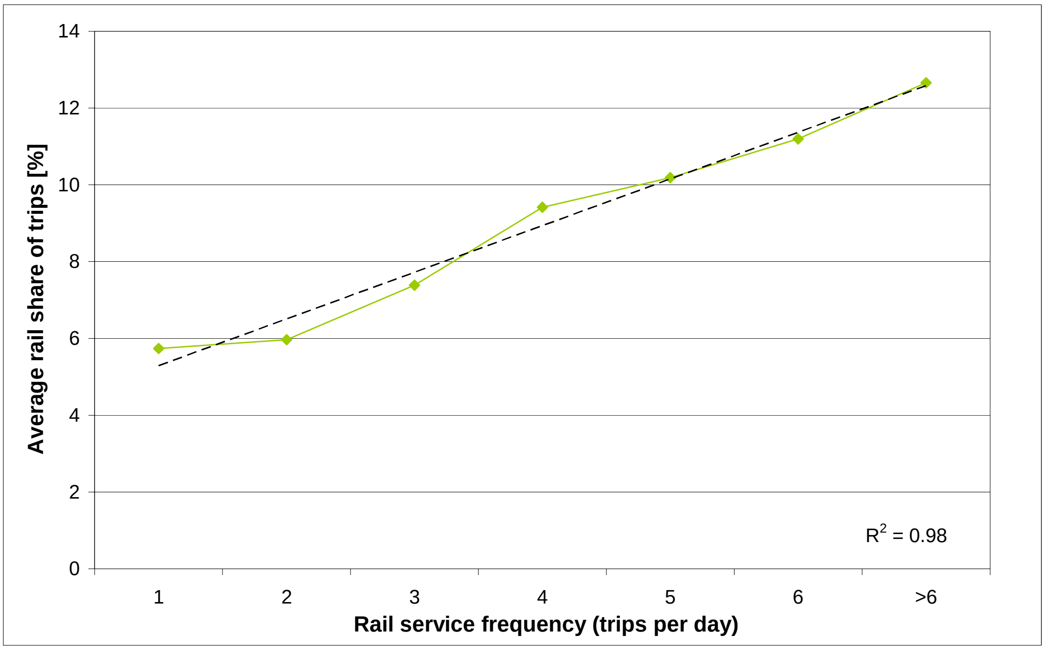
Figure 11: Relation between the share of trips by rail and travel time ratio in EU-27



Rail service frequency

As expected, the share of trips by rail increases proportionally to the rail service frequency per origin-destination pair. The correlation amounts to 98%.

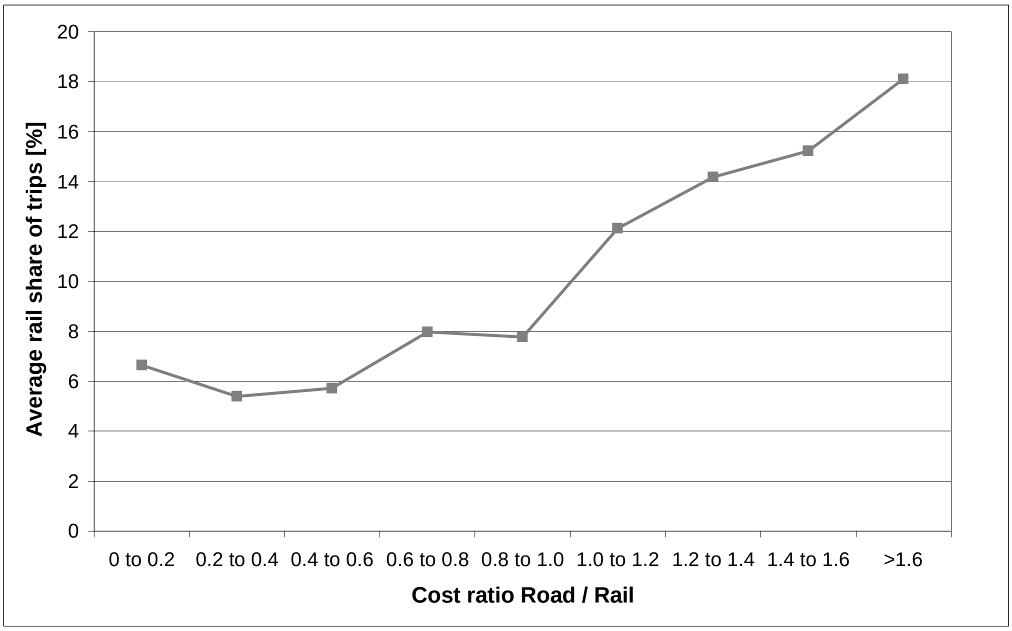
Figure 12: Relation between share of trips by rail and service frequency in EU-27



Cost ratio of road to rail

Regarding the correlation of the rail share with the cost ratio of road to rail, then nearly the same picture as for the travel time ratio arises. As long as the trip costs on the road are cheaper, the share of trips by rail varies from around 5 to 9%. However, if travelling by train is cheaper, then the ratio increases nearly linearly with the cost ratio.

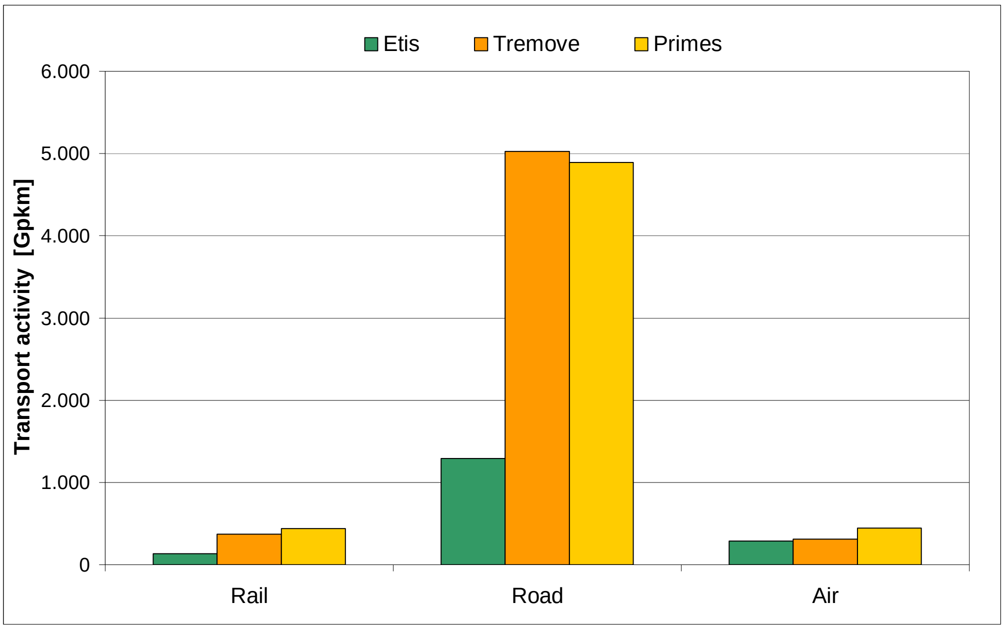
Figure 13: Relation between share of trips by rail and travel cost ratio in EU-27



Mileage covered by the ETIS data

The following figure shows a comparison of ETIS data with data from TREMOVE and PRIMES for the EU-27. As ETIS only covers the trips between the different NUTS 2 regions, the resultant passenger transport activity is significantly lower than in the two other studies. The figure demonstrates that in terms of activity driven passenger transport has comparable magnitudes in the TREMOVE and PRIMES data. There are only slight differences between the TREMOVE and ETIS air transport activity. As travelling by plane is probably only rarely undertaken within NUTS 2 regions, the data for ETIS and TREMOVE can also be regarded as comparable, taking into account the differences due to the trips within NUTS 2 regions. Based on the TREMOVE calculations, the ETIS data cover around 26% in terms of the passenger transport demand regarding road and rail in the EU-27. Thus, all calculations on modal shift potential made in this report correspond to 26% of the passenger transport demand with regard to road and rail in the EU-27.

Figure 14: *Comparison of different data sets*



4.5.3 Assumptions and results

Based on the analyses conducted in the previous section, the assumptions made for a calculation of the modal shift potential using the ETIS data are described.

First assumption

The precondition for rail infrastructure, service quality, etc. could be brought into line with the conditions in high population density regions (> 400 P/km²).

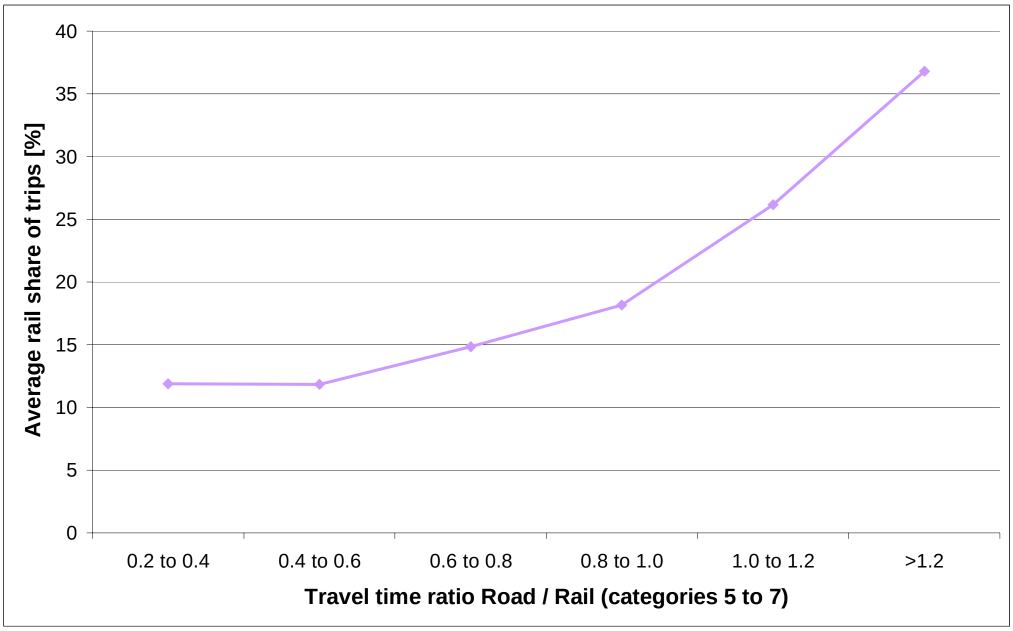
To determine the modal shift potential for this first assumption, a data analysis of the OD pairs in high population density regions (categories 5 to 7) were made. The average share of trips by rail for all combinations of the three categories amounts to 20.6%. Thus, the assumption is made that – if the conditions related to infrastructure, proximity to the rail network, service frequency, etc. could be improved in low population density regions to the conditions in high population density region – the share of all trips made within the EU-27 will reach in total 20.6% due to an improved infrastructure, rail network or rail service. An analysis of the correlation between the service frequency and the share of trips by rail in high population density regions supports the assumption that the infrastructure and the rail service quality in these regions are much more developed (there is no further improvement between rail share and service frequency). And regarding the proximity to the rail network: In high population density regions (> 400 P/km²) the average train station density is around 0.058 per km² compared to 0,012 train stations per km² in regions with a low population density (< 400 P/km²).

<u>Second assumption</u>

By improving the travel time to the extent that the time ratio of road to rail is > 1 a further shift can be realised.

For determining the additional shift potential a cross correlation between the trips among the population density categories 5 to 7 were made with regard to the travel time ratio. As shown by Figure 15, even if a high rail share is already reached, it could be further increased by changing the travel time ratio in favour of rail trips.

Figure 15: Relation between share of trips by rail and travel time in NUTS 2 regions with a high population density



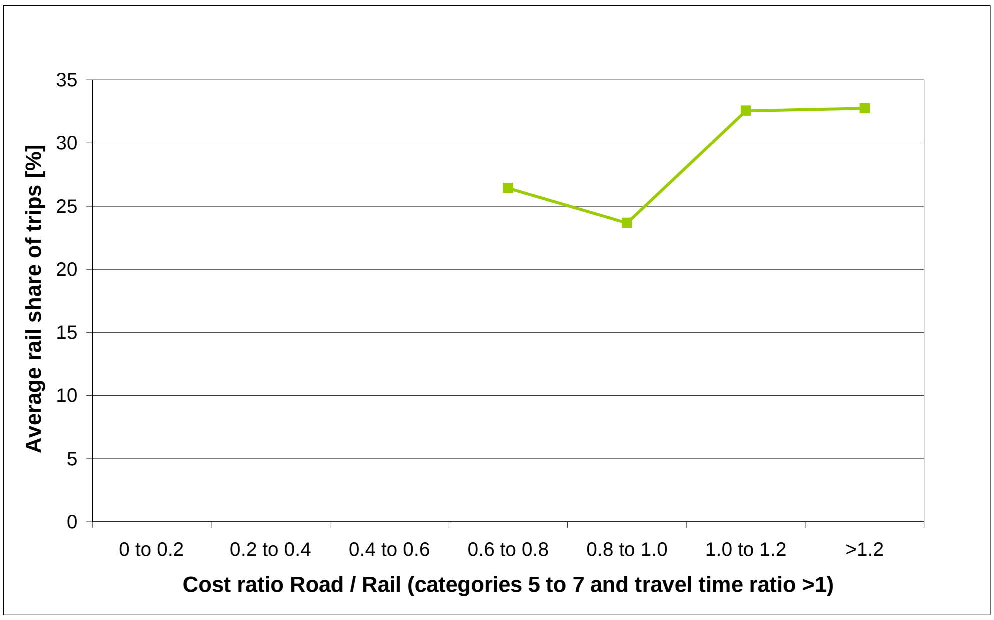
Therefore, the second assumption is a further increase in the share of trips by rail in a range of 8.1% if the train is faster than the trip on the road (average of all trips among category 5 to 7 and travel time ratio >1).

<u>Third assumption</u>

By lowering the costs for rail trips to a lower level than the costs for the same trip by car, a further shift can be realised.

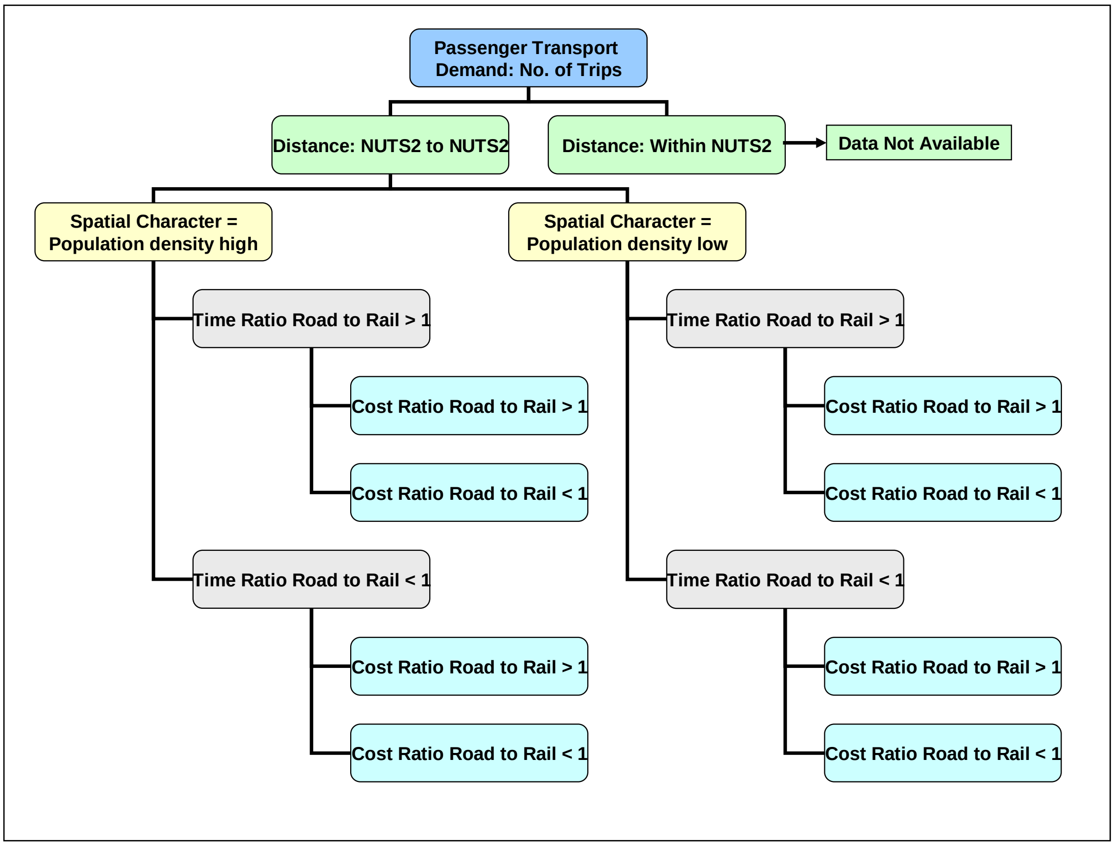
For this additional shift a further correlation analysis between the OD trips among the population density categories 5 to 7, a travel time ratio > 1 and the cost ratio was undertaken. The next figure shows the result. It is interesting to see that in the case of such a high range in terms of the rail share, low cost ratios do not occur. However, by changing the cost ratio to above 1, a further shift of 4.1% can be achieved (average of all trips among category 5 to 7, travel time ratio >1 and cost ratio > 1).

Figure 16: Relation between share of trips by rail and travel costs in NUTS 2 regions with a high population density



Based on the assumptions made and the results of the correlations, the following segmentation tree emerges as a basis for the calculation of a maximal modal shift potential.

Figure 17: Resulting segmentation tree



It has to be kept in mind that the described method for calculating a modal shift potential for passenger transport is based on real data from 2000 and 2003. It does not, perhaps, reflect a maximum potential since, for example, no further shift for high population density regions is assumed. However, the method used constitutes the best approach for achieving results that are as reliable as possible because they are based on data which reflect “real” behaviour. It also allows the inclusion of the other factors described in chapter 4.3.2 for which no data are available. The trip purpose, socio-demographic and socio-economic factors and “decisions made elsewhere” are indirectly considered as they form part of the real data from which the potential was derived.

Unfortunately, only trips between NUTS 2 regions can be taken into account as for trips within NUTS 2 regions the data available doesn’t include the information needed for an analyses as described before. Thus, no basis is available to calculate on a theoretical way via a segmentation approach a shift potential for all trips in Europe, but for trips between different NUTS 2 regions.

Based on the described approach the share of all OD pairs between different NUTS 2 regions was determined to be 32.8% according to the three assumption steps and the related correlations. The share of OD pairs with a value higher than 32.8% were retained. The average share that resulted was adapted to the passenger activity per OD pair. The final modal shift potential of passenger transport activity from road to rail between NUTS 2 regions of EU-27 was calculated as 33.0%, based on the assumption that the rail network quality is similar across Europe to high population density regions and the travel time and cost ratios are for all OD pairs above 1. In absolute numbers the modal shift potential of trips between NUTS 2 regions results in 336.3 billion Pkm.

Discussion of theoretical shift potentials should also address the feasibility of the calculated shift. Limitations on capacities were not considered in the above calculation, meaning that use of the described approach would result in an increase of capacity needs exceeding 300% for several OD pairs. To increase the level of feasibility in the assumptions made, a doubling of current capacity needs should be regarded as a maximum modal shift potential per OD pair. This leads to a fourth assumption being made in the process of developing a theoretical modal shift potential since more than doubling capacity compared to levels recorded in the ETIS data collection in 2000 does not seem feasible without high investment costs in the short and medium term.

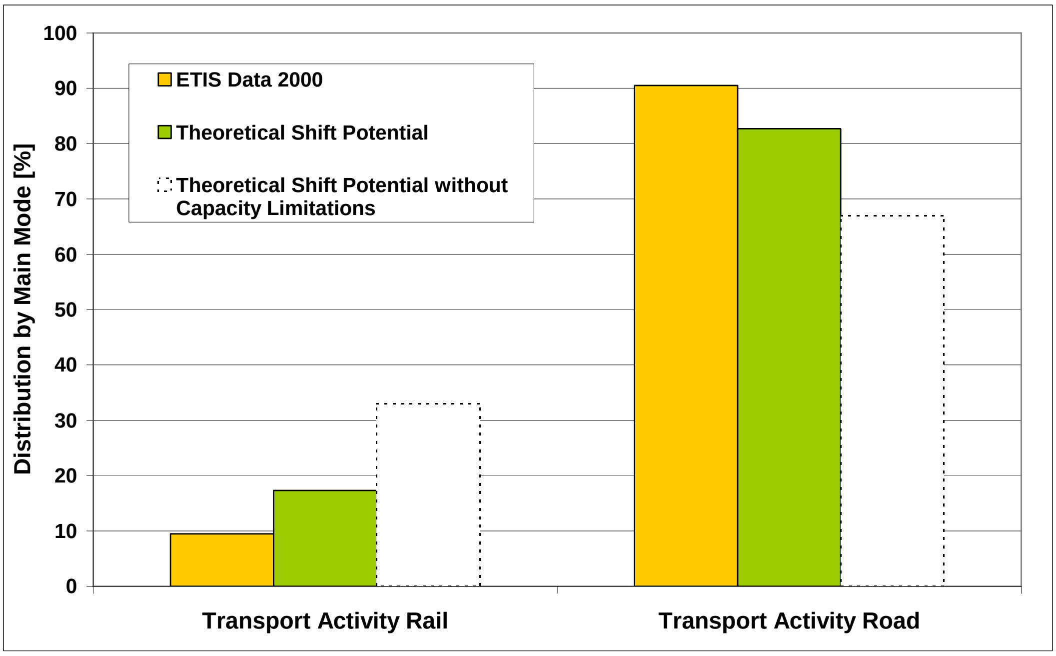
Fourth assumption

For each OD pair the maximum modal shift potential is not allowed to exceed a doubling of current rail activity.

Based on this fourth assumption the calculation approach was further developed as follows: For all OD pairs with a rail share that is lower than (32.8/2=16.4) percent only a doubling of rail transport activity was assumed.

The resulting modal shift potential of trips between NUTS 2 is thus reduced to 17.3%, correlating in absolute terms to 246.7 billion Pkm, which seems more realistic in respect of capacity needs.

Figure 18: Distribution by main mode, ETIS data and theoretical shift potential between NUTS 2 regions



4.5.4 Review of the results

The analyses of the ETIS data showed very clearly that the modal shift correlates significantly to the population density, which is assumed to be due to the higher rail infrastructure, higher service quality and higher proximity to train stations in regions with high population density. If these factors are brought into line with the conditions in high population density regions (> 400 P/km² and a train station density of around 0.058 per km²), the modal shift could even amount to 20.6%. Another important aspect influencing the choice of transport mode is the travel time for each individual trip. As soon as the travel time by rail is shorter than that on the road, the share of trips by rail increases nearly linearly with the travel time ratio. The third aspect which it was possible to reflect in the current data is the travel costs. As long as the trip costs on the road are cheaper, the share of trips by rail varies from around 5-9%; when this ratio is inversed the share of rail increases significantly.

If all these factors are combined to the maximum extent possible – which means among other things that no capacity restrictions are assumed – the calculations made in the scope of this report showed a modal shift potential from road to rail passenger transport of 32.8%. As this value seems to be somewhat unrealistically high in the short and long term without high additional investment costs to enhance the capacities to the extent needed for reaching that rail share, a further assumption was made. A doubling of current capacity needs was assumed to be the maximum modal shift potential per origin destination pair. With this additional factor added to better reflect the feasibility, the share of rail in passenger transport decreases to 17.3%.

The PRIMES scenario, which reflects a trend up to 2030 in a European energy and transport scenario, shows an increase in passenger transport activity on rail from 446 billion Pkm in 2005 up to 667 billion Pkm in 2030, amounting to a growth of approx. 50% (PRIMES 2007). The transport forecast for Germany published by the Federal Ministry of Transport, Building and Urban Affairs included a much lower increase in rail passenger transport: 25% for 2025 (ITP/BVU 2007). However, as these two scenarios are trend scenarios, a shift to 17.3% from the current level of 9.5% seems feasible if further ambitious policies and measures are implemented with regard to costs, travel time and railway network.

5 Freight transport

5.1 Factors determining modal shift

Rail and inland navigation offer ecological benefits compared to the road transport particularly with long hauls. A large proportion of freight transport in Europe is nevertheless conducted by road. This has particularly to do with the multitude of factors that influence the choice of mode of transport. This influence varies according to the type of freight to be transported. Under present conditions, the result of this weighing-up process is frequently the decision to transport goods by road.

Figure 19 shows that besides the cost of transport its quality is especially important (Bühler 2006; Rapp 2005; Schulz et al. 1996). Apart from the legal and political framework, this is determined by the technical and institutional preconditions of the mode of transport, which depend, in turn, on the location of the shipper and recipient. On this basis, transport quality is determined for a specific transport. Statistical averaging is therefore not particularly convincing. Besides influencing factors on the supply side, the choice of mode of transport is also affected by demand-side criteria. On the one hand, the goods to be transported and the dimensions of the shipment determine the mode of transport. On the other hand, customers often make their own demands regarding transport quality or even express preferences for particular modes of transport.

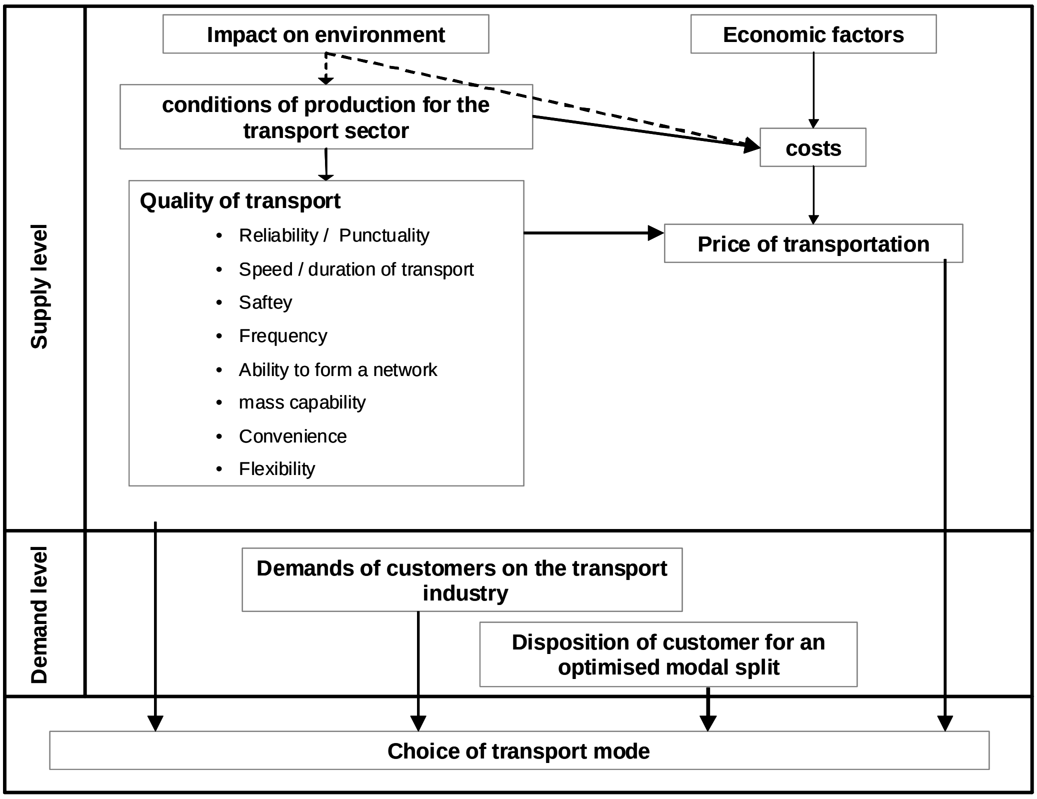


Figure 19 Determining factors of modal shift for freight transport

In the publications of transport researchers seven quality characteristics are identified for the assessment of supply profile in freight transport (Voigt 1973; Bühler 2006; Rapp 2005):

- Reliability: Reliability as a quality factor is frequently regarded as a combination of punctuality and security. Rigid adherence to time schedules and delivery deadlines are nowadays demanded by most customers. As a result of worldwide procurement activities and global distribution of goods the time factor is increasingly important.
- Speed: Speed largely determines the duration of transportation of goods from shipper to recipient. Transport duration includes loading and unloading, carriage duration and cross-loading times (particularly relevant for combined transport). In the case of transport with a wider delivery period, the punctuality factor is more important than speed.
- Security: In this context, security means protection of goods against damage during transportation as well as against theft or loss. A low damage or loss ratio is particularly cost-relevant for companies in the case of high-value goods (direct cost of loss or damage and indirect follow-up costs through the adverse effect on customer satisfaction).
- Frequency: Frequency describes the number of runs or hauls on offer within a particular period. Delivery frequency is greatly dependent on the demands of the recipient (for example, just-in-time production for the automobile industry and the freshness of food products).
- Network capability: Network capability is an important criterion for the conduct of nation-wide transportation. This quality parameter depends, above all, on the infrastructure density of the mode of transport. In terms of this criterion, freight transport by road is practically unbeatable.
- Bulk capability: Bulk capability concerns the transportation of large quantities at low cost. Here, rail transport and inland navigation enjoy advantages compared to other modes of transport. In the case of high-value goods price is not as important as other quality demands such as punctuality and transport security, price is not so important, so that the capability of the carrier to transport bulk goods is less important.
- Convenience: A high level of convenience exists on the part of shippers and haulage companies when the cost of transport organization and packaging is low.

Further quality demands have arisen in recent years through the development of sophisticated and international logistics concepts. Transportation flexibility, in particular, has gained in importance. This concerns, on the one hand, time-related flexibility, that is, transportation on demand, and on the other hand spatial flexibility and the ability to offer transportation at a national, European or global level (Rapp 2005).

Furthermore, additional logistical services are increasingly importance. Besides pure transport organization, other transport-related services such as packaging, commissioning, storage, processing, returned-goods management and customs clearance are demanded of haulage companies (Rapp 2005; Fischer 2008).

Table 5: Advantages and disadvantages of road, rail and ship transport (TCI 2007; RAPP 200)

	Advantages	**Disadvantages**
Road	▪ Low shipment volume/weight (package freight) ▪ Surface operation through high network density (door-to-door transport) ▪ High level of flexibility (in terms of time, space), especially in the case of short order and delivery cycles ▪ Coverage of all market segments (cer-tain restrictions in the case of transport of hazardous materials) ▪ Simple information flow between actors and customers ▪ Can personally accompany goods ▪ Low rate of damaged goods	▪ Legal restrictions (prohibitions of night-time and weekend travel, weight restrictions) ▪ Overloading of roads and dependence on traffic congestion as well as weather (punctuality) ▪ Susceptible to disruptions due to high accident frequency ▪ Limited storage facilities ▪ High degree of environmental impact and high energy consumption
Rail	▪ High shipment volume/weight (mass transport of goods) over long distances according to timetables ▪ Its own routes and track system (independent of traffic congestion, generally a high level of punctuality), 24 hour operation ▪ Low environmental impact (especially energy consumption, surface requirement, air pollutants) ▪ High safety level, predominantly free of disruptions ▪ Not weather-dependent ▪ No travel prohibitions on Sundays or holidays	▪ High operation costs on relations with low quantities (shunting) and in terms of delivery / collection ▪ Track developments (railway sidings) necessitate high investments ▪ Rail cannot cover all market segments ▪ Shipments by rail have to be planned in good time (timetable, availability, rolling stock) ▪ Low spatial and temporal flexibility, lower network density ▪ Precedence of passenger transportation ▪ Local noise pollution
Inland Vessel	▪ Cost-effective transportation ▪ Large individual payloads ▪ Large storage capacity ▪ Low land usage for infrastructure	▪ Limited route network ▪ Direct transportation is generally not possible ▪ Dependent on environmental influences (e.g. water level, ice and fog) ▪ Low speed

Relatively few investigations are available concerning the assessment of the importance of individual factors influencing the choice of mode of transport, and these are based on surveys of shippers, logistics companies and transport contractors (see Bühler 2006, Liedtke 2006, LOGIQ 2000, Baumgartner et al. 1998, Engel 1996 and Prognos 1994). The results of all investigations show that price and reliability as well as punctuality are the decisive factors for shippers and logistics companies in their choice of mode of transport. Other important factors are speed, security and flexibility. Environmental aspects, on the other hand, hardly play a role in the choice of mode of transport. Attention is drawn once more to the fact that these factors can vary in importance depending on the type of freight (Rapp 2005; Schwarz 2006).

Modes of transport meet these demands in different ways. Table 5 summarizes the advantages and disadvantages of rail and road transport as well as inland navigation. Lorries, in particular, have advantages as far as spatio-temporal flexibility is concerned. The dense road network enables an efficient network capability. Rail and inland navigation, on the other hand, enjoy particular advantages in the low-cost transportation of bulk goods, while security and independence from environmental factors and congestion are also positive features of these modes of transport (TCI 2007; Rapp 2005).

On the basis of these advantages and disadvantages, strengths and weaknesses can be formulated related to the above-mentioned transport qualities. Table 6 provides a summarized assessment of road, rail and inland navigation as far as quality strengths and weaknesses are concerned.

Table 6: Quality strengths and weaknesses of different traffic modes in Central Europe

	Road	**Rail**	**Inland navigation**
Reliability / Punctuality	Ø	+	+
Speed / duration of transport	Ø	Ø	-
Frequency	+	Ø	Ø
Ability to form a network	+	Ø	Ø
Mass capability	-	+	+
Convenience	+	-	-
Flexibility – temporal	+	-	-
Flexibility – spatial	+	Ø	-
Ecology	-	+	+
Legend: + = quality strengths; Ø = neutral; - = quality weaknesses			

5.2 Methodologies

Two approaches can be basically distinguished in the determination of the potential for shifting freight transport from road to rail and inland navigation. It concerns, on the one hand, detailed – in part also haul-specific – analysis of modal shift potentials as a part of freight transport models. On the other hand, simplified specific approaches have been developed to enable shift potentials to be determined. Both approaches are presented below.

In recent years there has been extensive discussion on modal shift potentials in urban areas, including the potential for freight tramlines and inner-city logistics centres. The development of methods for determining modal shift potentials in urban areas is, however, still at the research stage. Furthermore, appropriate data for modelling has up to now been rarely available (Browne/Allen 2006). The following presentations therefore focus exclusively on approaches for medium- and long-haul transport.

5.2.1 Freight transport models

Typically freight transport models are based on a four-step approach (see Figure 20) (Jong et al. 2004):

- Production and attraction: In the first step, the quantities of goods to be transported from the various origin region and the quantities to be transported to the various destination region are calculated.
- Distribution: In the second step, the flows between the origin and destination regions are determined (cells of the origin-destination matrix; OD matrix).
- Modal split: In the third model step, the allocation of the commodity flows to modes is calculated.
- Assignment: Last but not least after converting the freight flows to vehicle units, they will be assigned to road networks.

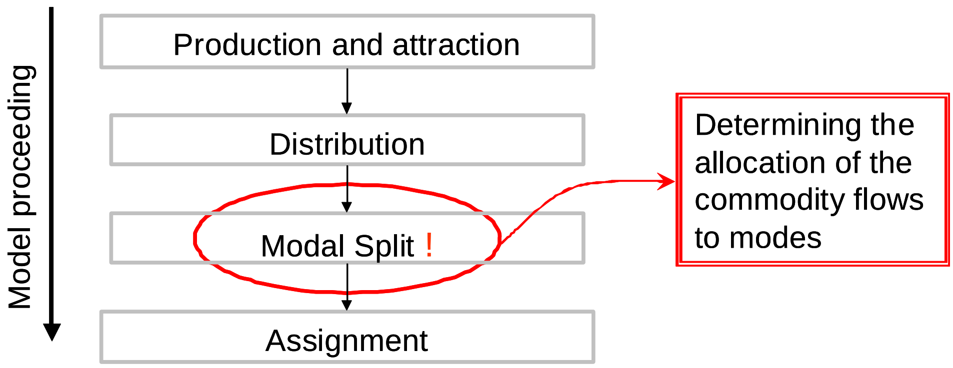


Figure 20: Four-step approach of freight transport models

Within the traffic economic literature different modal split sub models are distinguished. The three most import model approaches are (Bühler 2005; Jong et al. 2004; ME&P 2002):

- Direct demand models: In demand models, the number of trips or kilometres by different modes is predicted directly. The modal split is result of the traffic volume calculated by each mode. Direct demand model contains the first three steps of a freight transport mode (Production/attraction, distribution and modal split). The modal split is not calculated separately. The model is based on correlation between traffic volume by mode and external variables.
- Neoclassical economic models: These models are based on the economic theory of companies. For a cost function, with transport services as one of the inputs, a demand function for transport can be derived. The explanatory variable is the budget share of some mode in total cost. This type of model is also hard to integrate in four-steps model.

- Disaggregate modal split models: This model type use data from surveys of shippers, commodity surveys and/or stated preference surveys. Typically these models are multinomial logit or nested logit models, which for disaggregate observations can be based on random utility maximisation theory. Forerunners of these model types are aggregate modal split models, which mostly use binominal logit approaches (e.g. R&D project SCENES).

Disaggregate modal split approaches are sophisticated models that are commonly used at a national or regional level (e.g. for the German Federal Transport Infrastructure Plan) (Bühler 2005; Schneider et al. 2004). These models take into account most of the determining factors influencing the choice of mode (e.g. costs, duration of transport, reliability). This is why this model approach should be favoured for the calculation of the modal shift potential of freight transport. The disadvantage of this approach is the need of a lot of disaggregated data (see above). Therefore, application at the European level is hardly achievable. Furthermore, a widely-accepted European freight model is currently not available (Tardieu 2005).

5.2.2 Simplified Approaches

In contrast to detailed transport models, simplified approaches attempt to ascertain modal shift potential on the basis of existing data and the results of surveys. Questions concerning the extent to which existing rail and inland navigation capacities are sufficient to absorb this potential additional transport are not considered. Two approaches can basically be distinguished, and these are presented below.

Shift potential for container transport

Rail and inland navigation are particularly suitable for the long-haul transport of containers. It is therefore useful to identify road transport of containers over a defined distance. This traffic can then basically be regarded as shiftable.

This approach has been applied, for instance, by the German Federal Statistics Office in a research project carried out on behalf of the German Federal Transport Ministry. It was assumed for the purposes of calculation that container transport over distances in excess of 300 kilometres could, in principle, be shifted from road to rail or inland navigation. The Statistics Office came to the conclusion that in Germany 13.9% of containers transported annually by road (1.5 million TEU[5]) would be suitable in future for combined transport (see Table 7) (StBA 2005).

The calculation solely concerns theoretical potential, which in reality could only be partly exploited even in favourable conditions. Related to the total volume of combined container transport by rail in Germany 2004 this would mean growth of 35 per cent. Were the total quantity to be shifted to inland navigation this would be equivalent to an

[5] Twenty Foot Equivalent Unit: standardized unit of measurement for containers.

increase of 75 per cent in inland navigation. These figures show that considerable quantities would have to be shifted from road to rail or inland navigation (TCI 2007).

The determination of real modal shift potential is hardly possible on the basis of these figures, since additional data such as the types of freight transported or access to combined transport terminals is not available. An additional problem is that data on container transport by road is not available for Europe in the required form (see below).

Table 7: *Distribution of road transport of containers by German lorries in 2004 depending on distance, and the shift potential derived from it (StBA 2005)*

	Number of containers		**Tonnage**		**Tonne-kilometres**	
	1,000 TEU[1)]	*Share*	*1,000 t*	*Share*	*Mill. t/km*	*Share*
Up to 149 km	7,659	68.9%	45,912	67.0%	2,151	20.8%
150 - 299 km	1,913	17.2%	11,884	17.3%	2,594	25.1%
300 - 499 km	574	5.1%	3,838	5.6%	1,333	12.9%
500 km and more	977	8.8%	6,923	10.1%	4,249	41.1%
Total	**11,123**	**100.0%**	**68,557**	**100.0%**	**10,327**	**100.0%**
Modal shift potential[2)]	**1,551**	**13.9%**	**10,761**	**15.7%**	**5,582**	**54.1%**

[1)] TEU = Twenty-feet Equivalent Unit. – [2)] Theoretical potential (transport distance over 300 km).

Shift potential depending on type of freight, distance and supply quality

A more comprehensive approach would be to include not only container transport in the analysis but rather all kind of good transport. With this approach, the identification of modal shift potential from road to rail basically takes place according to the method shown in Figure 21.[6] In an initial step, based on the volume of road freight transport, shift potential from road to rail is narrowed down by type of freight. Due to the characteristics of modes of transport, as described above, not every type of freight is equally suitable for modal shifting. Important restrictive factors include the dimensions of shipments, bulk goods and the timing of deliveries. The volumes suitable for rail transport could be determined my means of interviews or workshops with experts. They could, however, be deduced from surveys that have already been carried out. It was established for Germany, for instance, that around 60% of the current volume of chemical products transported by road (measured in tonnes) could be shifted to rail, while in the case of

6 This method was developed for the determination of potential modal shift from road to rail at a national level. It is difficult to determine potential modal shift from road transport to inland navigation with this global approach, since access to waterways from ports is not possible on the scale offered by rail transportation. The potential modal shift to inland navigation would have to be determined along waterways on the basis of selected transportation corridors and can therefore not be taken into account in the more global approach in this report.

agricultural and forest products the share was merely 25% (see Table 8) (TRANSCARE 2008, Zobel 2006).

In a second step, transport has to be identified that, on account of the short distances involved, is regarded as not suitable for modal shifting. Basically, a general limit of 300 kilometres could be set, as in the report prepared by the German Federal Statistics Office (see above). A report on Germany and France assumes that for distances of 100 to 250 km 10%, for distances of 250 to 500 km 50% and for distances in excess of 500 km 100% of freight volume currently transported by road could be shifted to rail (TRANSCARE 2008, Zobel 2006). These first two steps provide a theoretical shift potential, and they can be carried out whenever statistical data on the type of freight and transport distances are available. For Europe this is the case (see below).

To further estimate the realism in the potential, transport has to be determined that, on economic grounds or on account of time-related or qualitative demands, is not suitable for rail transport. The above-mentioned report on Germany and France, for instance, comes to the conclusion that

- for 35 per cent of the volume of goods suitable for rail transport, access to combined transport is not economically justifiable (costs for pre-runs and onward carriage in relation to main carriage are too high);
- for 25 per cent, corresponding time windows in rail transport are not available, and
- for 10%, specific quality demands (for example, temperature control and intermediate off-loading points) are not met (TRANSCARE 2008, Zobel 2006).

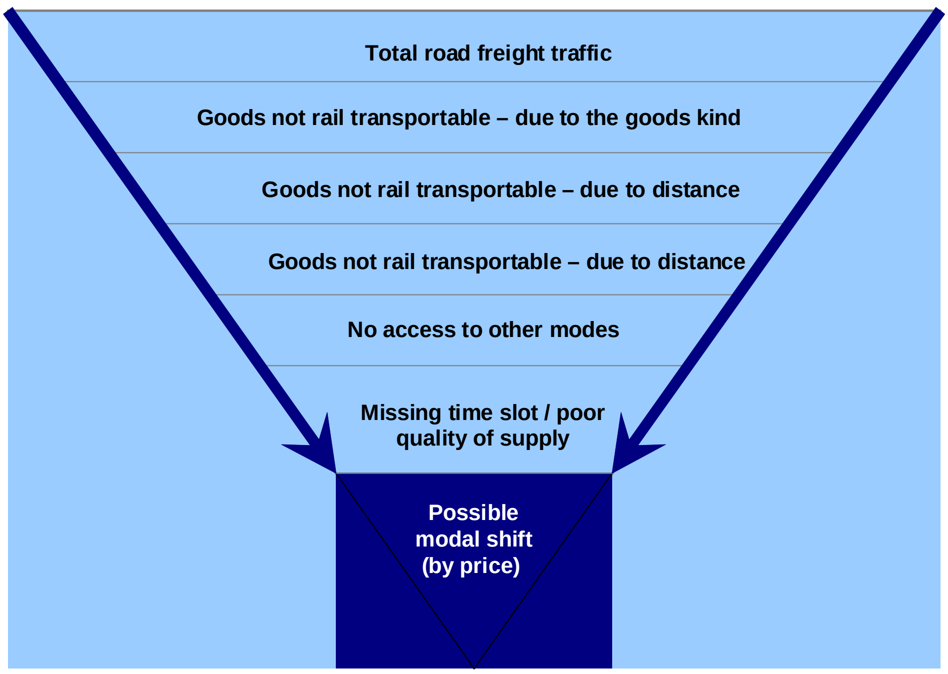


Figure 21 *Identification of shift potential depending on type of freight, distance and supply quality (Zobel 2006)*

On the basis of this report, real shift potential is merely 30 per cent of theoretical potential. On the other hand, here only a shift to rail is considered. Through improvements in services and a changed political framework (for example, more realistic treatment of external environmental costs) this share could be increased.

Based on this approach, TRANSCARE established for Germany, on behalf of the *Bundesverband Güterverkehr und Logistik (BGL)* and the International Road Transport Union (IRU), that around one-third of road-transport volume, depending on type of freight, is suitable for rail transport. If only long-haul transport is regarded as shiftable the share is reduced to around 4.1%. If the described economic and qualitative demands are taken into account the share is reduced to 1.2% of German road freight transport volumes. This is equivalent to a volume of 58.8 million tonnes, which would correspond to a growth in rail freight transport of around 20% (Zobel 2006, TCI 2007). Corresponding shares were also established for France. The report comes to the conclusion that in all major European countries a high division of work and thus transport structure exists that is similar to that in Germany and France, which is why the determined shares could also be applied to other countries (Zobel 2006).

Table 8: Traffic volumes suitable for rail transport due to the characteristics of modes for Germany 2005 (TRANSCARE 2008)

	Share of volume suitable for modal shifting	**Freight traffic volumes 2005 in Germany**	**Volumes suitable for rail transport in Germany**
	%	Mio. t	Mio. t
Agricultural products and live animals	25%	141,0	35,3
Foodstuff and animal fodder	35%	304,0	106,4
Solid mineral fuels	0%	12,3	0,0
Petroleum products	37%	105,1	38,9
Ores and metal waste	10%	28,6	2,9
Metal products	35%	72,1	25,2
Crude and manuf. minerals, building materials	15%	1.361,1	204,2
Fertilizers	30%	20,0	6,0
Chemicals	63%	209,6	132,0
Machinery, transport equipment, manufactured articles	68%	474,1	322,4
Total	**32%**	**2.727,9**	**873,2**

5.3 Availability and quality of freight traffic data

Eurostat collects road transport data from all EU Member States. The data are based on sample surveys carried out in the reporting countries and represent the transport of road goods performed by vehicles registered in these countries. According to Eurostat double counting is avoided since reporting relates only to resident carriers of the reporting countries (Eurostat 2008).

The data are provided for the international and national level as well as for the total transport (i.e. the sum of international and national transport), at all times with reference to the reporting country. International road freight transport refers to cross-border transport loaded in the reporting country, cross-border transport unloaded in the reporting country and cross-trade. Cabotage, normally considered as international transport, is documented in separate tables. National transport means road freight transport performed by vehicles registered in the reporting country and taking place within its national borders (Eurostat 2008).

For road transport (national and international), data is available from Eurostat on transport volumes (measured in tonnes) and transportation performance (measured in tonne-kilometres for all 27 EU member States (excluding Malta) and Norway, differentiated according to type of goods and distance (see, for example, Table 9) (Eurostat 2008). With this data, and on the basis of the TRANSCARE approach described above, the theoretical potential modal shift from road to rail can be calculated without the need for further surveys. The quality of Eurostat data is sufficient for estimation of theoretically potential modal shift from road to rail.

Table 9 *Road freight transport quantities (in 1,000 tonnes) and performances (in million tonne-kilometres) for Sweden 2006 by type of goods and distance classes (national and international transport)*

	Type of goods[1)]										**Total**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
1,000 tonnes											
0-50 km	29,283	4,562	557	7,008	3,522	1,132	87,331	341	4,984	29,383	168,190
50-150 km	42,993	8,654	822	5,977	2,466	1,471	11,903	477	2,945	20,700	98,447
150-500 km	16,519	10,842	488	3,247	1,266	2,118	3,945	231	4,074	26,685	69,512
≥ 500 km	1,330	2,234	0	263	134	583	666	0	674	7,334	13,457
total	*90,197*	*26,292*	*1,882*	*16,498*	*7,459*	*5,311*	*103,863*	*1,086*	*12,915*	*84,105*	*349,606*
Million tonnes-kilometres											
0-50 km	659	94	10	149	50	22	1,383	8	95	466	2,937
50-150 km	3,948	623	75	455	232	134	907	46	256	1,489	8,168
150-500 km	3,454	2,299	99	588	303	579	1,040	58	1,004	6,176	15,622
≥ 500 km	985	1,563	0	116	84	423	413	0	442	5,225	9,479
total	9,104	4,579	192	1,312	732	1,172	3,762	142	1,852	13,360	36,206

1) Type of goods: 0 = Agricultural products and live animals, 1 = Foodstuff and animal fodder, 2 = Solid minerals fuels, 3 = Petroleum products, 4 = Ores and metal waste, 5 = Metal products, 6 = Crude and manuf. minerals, building materials, 7 = Fertilizers, 8, = Chemicals, 9 = Machinery, transport equipment, manufactured & miscellaneous articles.

Sources: Eurostat 2008, own calculation.

5.4 Calculating the potential of a theoretical modal shift from road to rail – Freight transport

5.4.1 Approach for the estimation of modal shift potential of freight transport

The determination of modal shift potentials in freight transport with the help of transport models leads to more realistic results. Transport models at a national level are available in many countries; a Europe-wide accepted model does not as yet exist. The situation is made more difficult by the fact that the use of transport models for the determination of modal shift potentials demands extensive data, which is not available in harmonized form at the European level. Moreover, the application of corresponding models involves considerable costs.

Only a simplified method, such as that developed by TRANSCARE, can therefore be applied within the scope of this report for the calculation of theoretical modal shift potential. The calculation of the theoretical potential shift from road to rail[7] takes account of type of goods and transportation distances. The share of shiftable freight transport by type of goods and transportation distance can be taken from the TRANSCARE report. Though these values have been determined for Germany and France, they can also be applied for other countries, since the established percentages relate merely to the type of goods and transportation distance and therefore not to a specific country.

On the other hand, a further restriction of modal shift potential – as applied in the above-mentioned TRANSCARE report – through lack of rail access, unsuitable time slots for freight transport (for example, overnight hauls) and other restrictive demands on quality (for example, temperature-controlled goods) is not possible. These factors depend to a great extent on current rail infrastructure capacity and the density of transhipment terminals in the country under investigation. This last step in determining theoretical modal shift potential can therefore not be applied to other European countries. Current research on the part of TRANSCARE has shown, moreover, that corresponding estimates of modal shift potential are not available in other European countries (TRANSCARE 2008). Country-specific modification of these factors is therefore not possible.

For this report, the following method of determining theoretical modal shift potential was selected:

1. The modal shift potentials per type of goods, as established by TRANSCARE and shown in Table 8, are adopted for all countries.
2. In addition, shift potential per distance class is adopted from TRANSCARE. Since Eurostat transport statistics are based on other distance classes, TRANSCARE percentages have to be applied to these Eurostat distance classes (see Figure 22). For this report, a modal shift potential of 5% of the volume transported by road was assumed for the distance class of 50-150 km, 40% for 150-500 and 100% for distances in excess of 500 km.

[7] The estimation of modal shift potential in this report is made solely for rail, since analysis of specific inland navigation corridors was not possible within the scope of this report (see above).

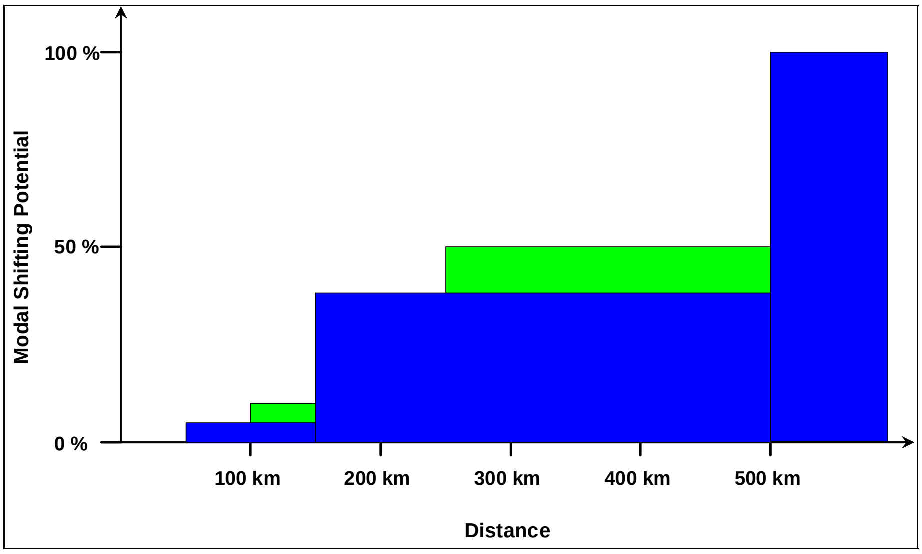


Figure 22 *Comparison of modal shift potential differentiated according to TRANSCARE distance classes (purple and dark green) and the values applied in this report*

3. Theoretical modal shift potential is determined for each country, taking account of both of these restrictions (point 1 and point 2, see above). The volume of goods shifted from road to rail is shown in tonnes and transportation performance in thousands of kilometres. Volumes of shiftable goods thus determined are also set in relation to the volume of goods presently transported by rail. Since it is unrealistic to expect that the volume of goods transported by rail will more than double in the short to medium term (up to 2030), theoretical modal shift potential is limited in a third step for all countries to the volume of goods that is currently transported by rail. This step therefore affects only those countries, in which steps 1 and 2 establish a theoretical shift potential that is in excess of 100% of the volume of goods currently transported by rail.

5.4.2 Applied data

Eurostat data on types of goods and transportation distances for road transport is available for EU-27 countries (excluding Malta) and Norway, so that the method is applicable without an additional need for data. However, Eurostat shows data for transportation volume and performance, differentiated according to type of goods and distance class only when case figures in the survey are statistically reliable. For this reason, there is a difference between the volume of goods arising from the sum of distance classes and types of goods, on the one hand, and data shown in statistics as country total values. As shown in Table 10, the difference can amount to up to 3% in individual countries. Since modal shift potential is determined by means of differentiated values, there is a slight underestimate of theoretical modal shift potential. Related to all 27 EU member States, however, the error is negligible (0.2%, see Table 10).

Table 10 Transport quantities according to Eurostat and own calculation based on values differentiated by distance classes and type of goods, 2006 (in 1,000 tonnes)

Country	**Code**	**Eurostat country values**	**Sum of values differentiated by distance classes and type of goods**	**Difference between Eurostat value and calculated value**
		1,000 tonnes	***1,000 tonnes***	**in%**
Belgium	BE	348,527	348,300	-0.1%
Bulgaria	BG	151,582	148,777	-1.9%
Czech Republic	CZ	444,609	444,116	-0.1%
Denmark	DK	193,021	191,582	-0.7%
Germany	DE	3,103,202	3,102,775	0.0%
Estonia	EE	33,780	32,812	-2.9%
Ireland	IE	305,916	305,066	-0.3%
Greece	EL	510,742	507,701	-0.6%
Spain	ES	2,387,538	2,386,554	0.0%
France	FR	2,181,715	2,180,727	0.0%
Italy[1)]	IT	1,508,701	1,507,445	-0.1%
Cyprus	CY	43,634	43,038	-1.4%
Latvia	LV	54,682	54,066	-1.1%
Lithuania	LT	56,026	55,696	-0.6%
Luxembourg	LU	53,016	52,926	-0.2%
Hungary	HU	257,427	257,331	0.0%
Netherlands	NL	615,304	615,068	0.0%
Austria	AT	358,850	358,483	-0.1%
Poland	PL	897,414	896,716	-0.1%
Portugal	PT	321,236	320,285	-0.3%
Romania	RO	336,032	333,791	-0.7%
Slovenia	SI	86,896	86,386	-0.6%
Slovakia	SK	181,521	180,412	-0.6%
Finland	FI	396,792	392,694	-1.0%
Sweden	SE	349,606	349,144	-0.1%
United Kingdom	UK	1,903,898	1,902,914	-0.1%
EU-27 (without MT)	**EU-27**	**17,081,667**	**17,054,805**	**-0.2%**
Norway	NO	250,858	250,133	-0.3%

[1)] 2005.

Sources: Eurostat 2008, own calculation.

5.4.3 Results

The calculation of theoretical modal shift potential, taking account of restrictions depending on type of goods and distance classes (steps 1 and 2, see above), shows that a total of around 950.6 million tonnes of goods could be shifted from road to rail in the 27 EU Member States (excluding Malta). Of this, "machinery, transport equipment, manufactured & miscellaneous articles" (Group 9 goods) make the greatest contribution to theoretical modal shift potential from road to rail with around 544.3 million tonnes (about 57.3%) (see Table 11 and Annex). Group 1 goods – "foodstuff and animal fodder" – also make a major contribution to shift potential with 136.6 million tonnes or 14.4%. As far as concerns distance classes, the greatest shift potential is generated between 150 und 500 km (around 50.5% of total modal shift potential from road to rail, see Table 11). Distances in excess of 500 km account for 42.9% of shift potential, and distances below 150 km around 6.6%.

Table 11 Transport quantities 2006[1)] and modal shifting potential from road to rail for the EU 27 member states (without Malta)

	Type of goods[2)]										Total
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
	Million tonnes	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*	*Million tonnes*
Road total											
0-50 km	506.7	552.7	110.1	249.0	147.2	160.9	6,491.2	100.8	328.1	1,294.2	9,945.5
50-150 km	435.7	584.1	32.6	252.5	54.9	118.9	1,106.6	38.6	155.9	779.6	3,563.0
150-500 km	299.5	556.0	22.1	125.1	35.9	154.2	386.9	29.0	179.9	951.2	2,744.4
≥ 500 km	89.1	138.7	2.7	7.4	8.8	62.9	52.0	3.6	68.7	381.0	828.7
Total	*1,336.1*	*1,832.8*	*169.4*	*636.7*	*250.2*	*497.3*	*8,038.2*	*174.7*	*738.4*	*3,407.7*	*17,081.7*
Shifting Potential											
0-50 km	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50-150 km	5.4	10.2	0.0	4.6	0.3	2.1	8.3	0.6	4.9	26.5	62.9
150-500 km	30.0	77.8	0.0	18.5	1.4	21.6	23.2	3.5	45.3	258.7	480.0
≥ 500 km	22.3	48.5	0.0	2.7	0.9	22.0	7.8	1.1	43.3	259.1	407.7
Total	*57.7*	*136.6*	*0.0*	*25.9*	*2.6*	*45.7*	*39.3*	*5.1*	*93.5*	*544.3*	*950.6*
Share in potential											
0-50 km	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
50-150 km	0.6%	1.1%	0.0%	0.5%	0.0%	0.2%	0.9%	0.1%	0.5%	2.8%	6.6%
150-500 km	3.2%	8.2%	0.0%	1.9%	0.2%	2.3%	2.4%	0.4%	4.8%	27.2%	50.5%
≥ 500 km	2.3%	5.1%	0.0%	0.3%	0.1%	2.3%	0.8%	0.1%	4.6%	27.3%	42.9%
Total	*6.1%*	*14.4%*	*0.0%*	*2.7%*	*0.3%*	*4.8%*	*4.1%*	*0.5%*	*9.8%*	*57.3%*	*100.0%*

[1)] Italy: 2005; [2)] Type of goods: 0 = Agricultural products and live animals, 1 = Foodstuff and animal fodder, 2 = Solid minerals fuels, 3 = Petroleum products, 4 = Ores and metal waste, 5 = Metal products, 6 = Crude and manuf. minerals, building materials, 7 = Fertilizers, 8, = Chemicals, 9 = Machinery, transport equipment, manufactured & miscellaneous articles.

Sources: Eurostat 2008, own calculation.

Figure 23 shows for each country the share of goods transported by road that could theoretically be shifted to rail on the basis of the calculations made. In the 27 EU Member States (excluding Malta) as a whole, around 5.6% of the total volume of goods transported by road (measured in tonnes) could be shifted to rail. The highest value was achieved by Lithuania with 10.7%, the lowest by Ireland with 2.3% and Cyprus (that has no rail network) with 0%. The differences are attributable to freight structure and transportation distances.

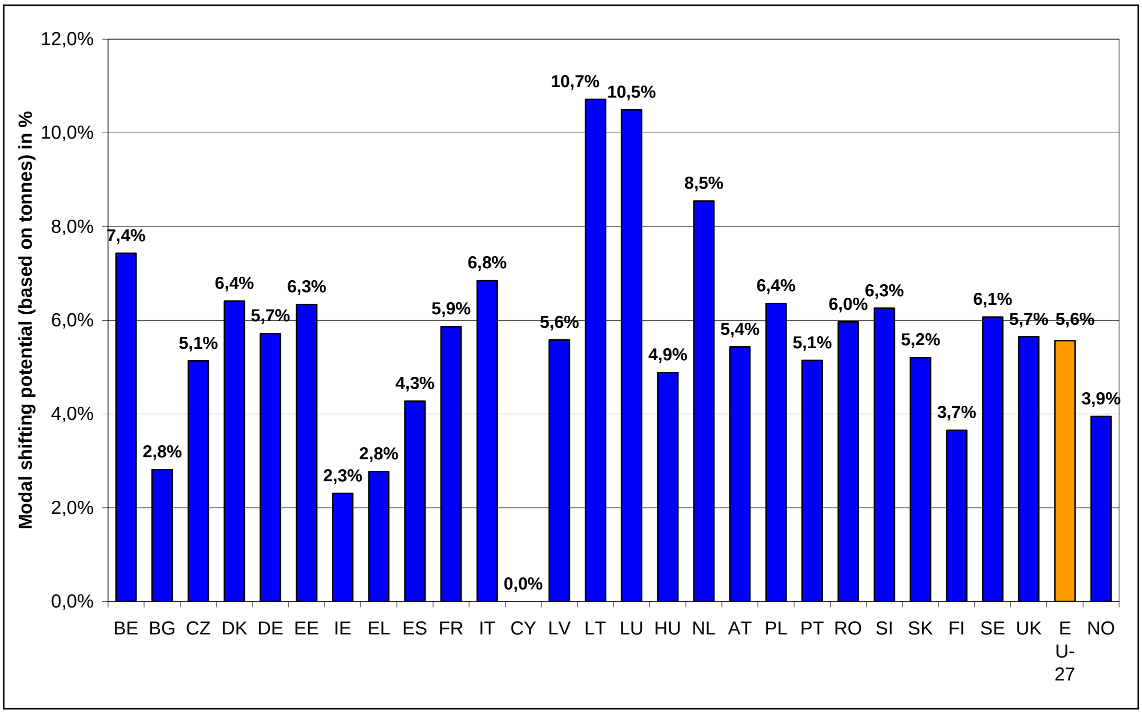


Figure 23 *Share of the theoretically shiftable volume of goods in the total volume of goods transport by road (tonnes) by country, 2006*

If one relates the volume of goods that could be shifted to the current volume of goods transported by rail the result is as shown in Figure 24. In countries such as Ireland, Greece and Spain, the calculated theoretical modal shift potential exceeds the current volume of goods transported by rail by a factor of 3.7 to 5.7). In countries such as Denmark, France, Italy, the Netherlands and Portugal, however, modal shift potential exceeds the current volume of goods transported by rail by a factor of 1 to 2.

As already mentioned, it is unrealistic to expect that, even with a massive expansion of rail infrastructure, the volume of goods that could additionally be shifted could be greater than the volume of goods presently transported by rail. For this reason, theoretical modal shift potential was recalculated under the premise that the share of the shiftable volume of transported goods in the volume of goods transported by rail may not exceed 100%.

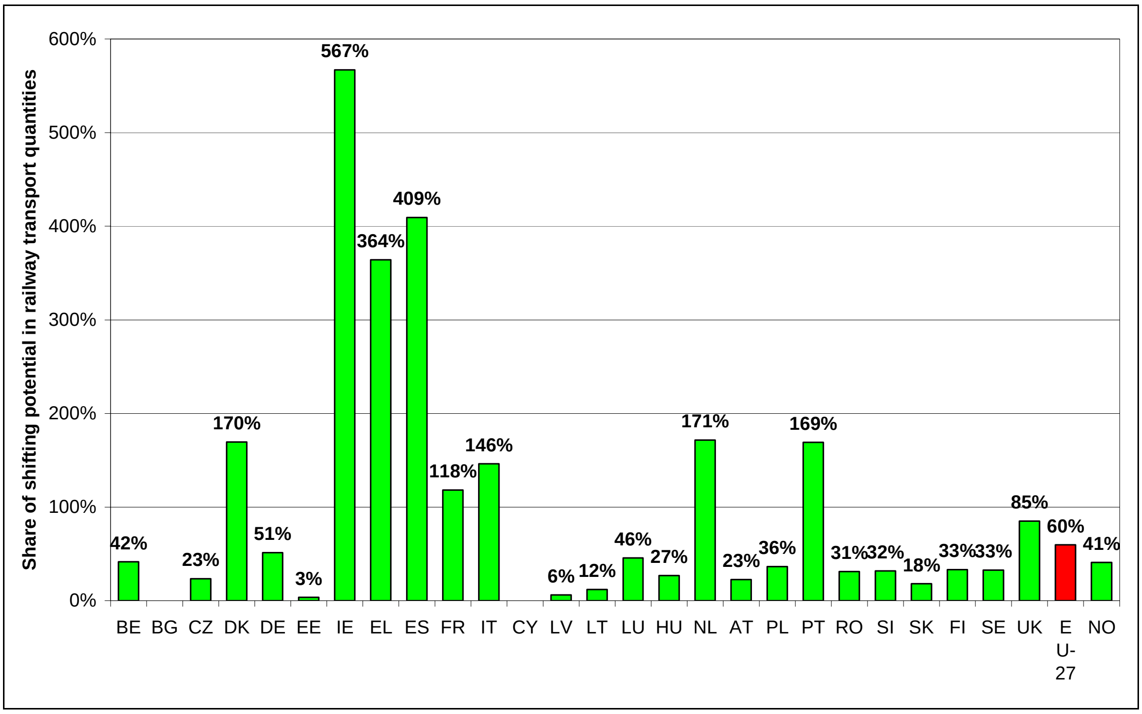


Figure 24 *Percentage share of the theoretically shiftable volume of transported goods in the total volume of goods transported by rail in 2006*

Taking account of this requirement, a modified theoretical modal shift potential of 771.3 million tonnes arises for the 27 EU Member States (instead of 950.6 million tonnes, that is -19%, see table in the Annex). This is equivalent to 4.5% of the volume of goods transported by road in the 27 Member States of the EU (see Figure 25). On the basis of this estimated volume, theoretically shiftable transportation performance, measured in tonne-kilometres, was determined in a further step. As a result, 361.6 billion tonne-kilometres could be shifted from road to rail in the EU 27 (see table in the Annex). This theoretical modal shift potential corresponds, for the EU 27, to around 19.3% of road freight transport performance in 2006 (see Figure 26). The much higher percentage, compared to transport volume (measured in tonnes), is attributable to the fact that transportation over long distances is regarded, in particular, as shiftable (see above).

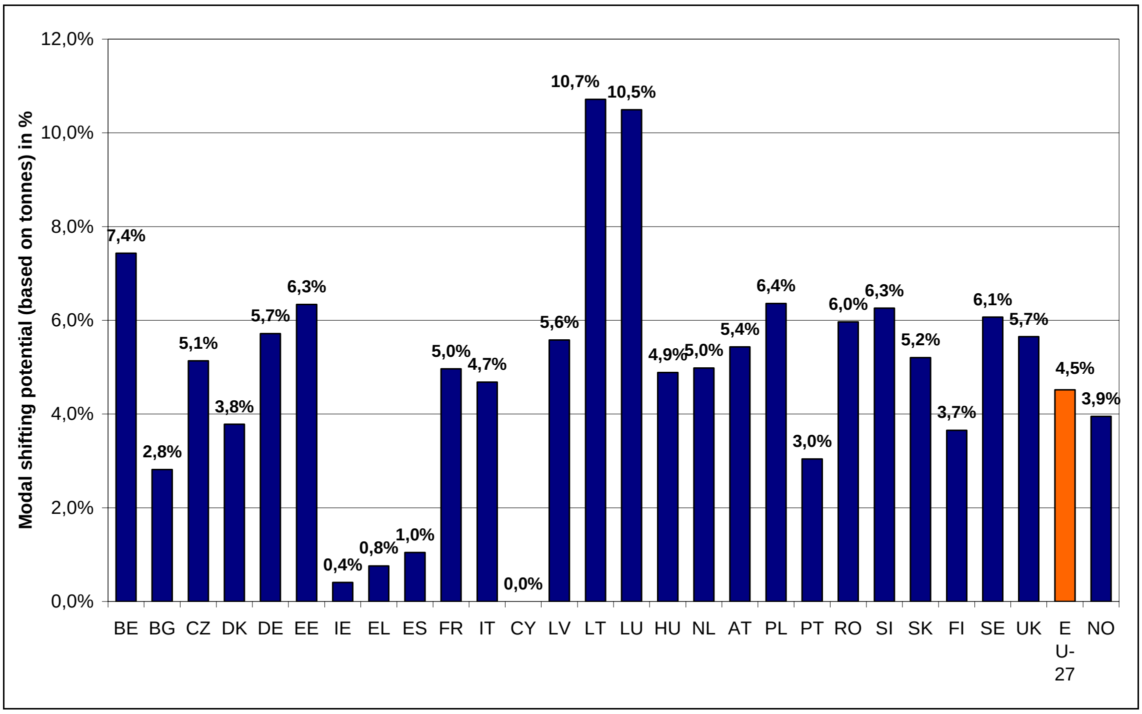


Figure 25 *Share of the theoretically shiftable volume of goods in the total volume of goods transported by road (based on tonnes), taking account of a 100% cap for freight transport by rail (see above), 2006*

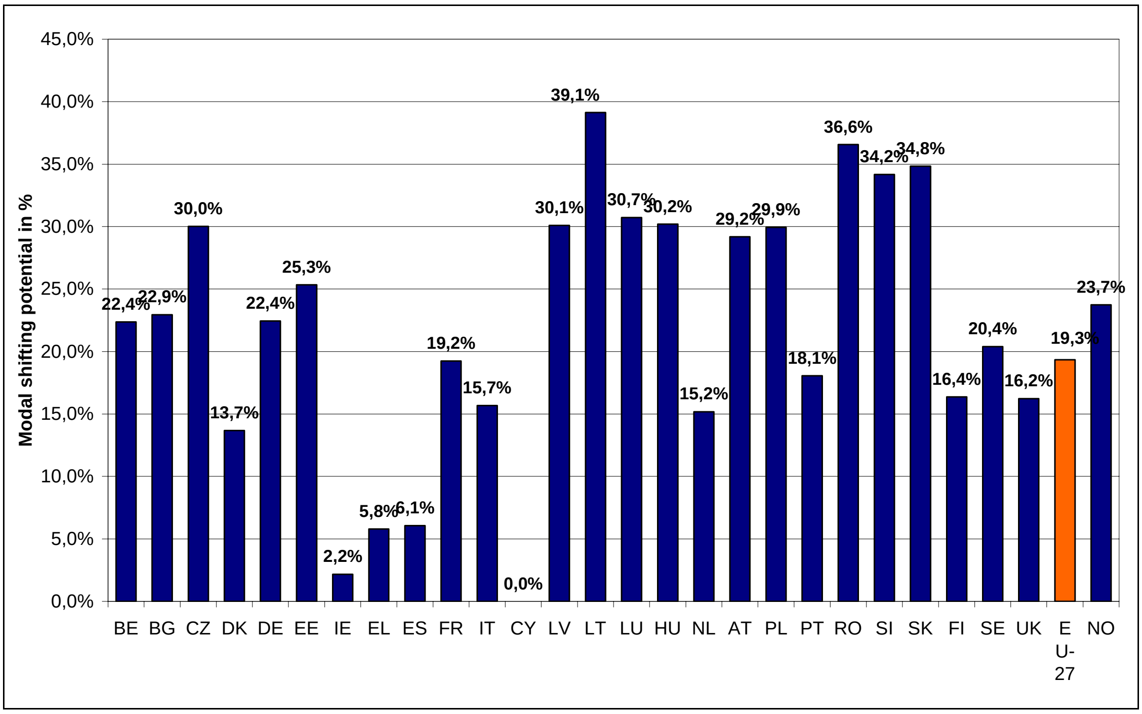


Figure 26 *Share of the theoretically shiftable volume of goods in total transportation performance of road freight transport (based on tonne-kilometres, taking account of a 100% cap for freight transport by rail (see above), 2006*

5.4.4 Review of the results

Germany provides the largest single contribution to potential European modal shift from road to rail with 177.5 million tonnes (equivalent to 23%), followed by France with 108.3 million tonnes (14%) and the United Kingdom with 107.6 million tonnes (14%). In its above-mentioned report, TRANSCARE assumes that, due to bottlenecks in the rail network and qualitative demands on freight transport (for example, temperature-controlled goods), only around 30% of the calculated potential for Germany and France will be exploitable in the medium term (up to 2030). On the other hand, the German Transport Ministry assumes that freight transport by rail will increase in the period up to 2025 by 34% compared to 2004 (ITB/BVU 2007). By comparison, the present report identifies the theoretical shift potential for 2006 at around 51% of the volume of goods transported. A recent forecast on freight transport by rail in the United Kingdom assumes that between 2006 and 2030 the volume of goods transported by rail will increase by 60% (Bennett 2008, Garratt 2008). In this report, freight volume amounting to 85% of current freight transport by rail is calculated as modal shift potential for the United Kingdom.

This comparison shows that with medium- to long-term expansion of rail infrastructure identified modal shift potential could actually be exploited. The urgent need for expansion of rail infrastructure is displayed in Figure 27 exemplarily for the United Kingdom. The figure shows rail capacity utilization for freight transport (daily freight train movements), as the sum of both directions for the years 2006 and 2030, taking account of the forecast 60% growth in freight transport. It can be clearly seen that capacity utilization on a large part of the rail network will increase to such an extent that the limits of rail network capacity will be reached. A similar picture can also be drawn for Germany (acatech 2006).

Besides infrastructure needs, forecasts also show that future growth in freight transport will exhaust the capacity needed for transportation that can presently be shifted to rail. Identified modal shift potential thus competes for free rail capacity with forecast growth in volume. This inevitably means that, on the basis of present infrastructure planning on the part of the EU 27, capacity for additional modal shifts will hardly be available. A sustainable transport policy should therefore at least be directed at the exploitation of additional modal shift potentials. This implies that future rates of growth in freight transport by rail are higher than growth rates in road transport. For road transport in Germany, for example, 55% growth in the volume of goods was forecast; for rail transport – as already mentioned – growth of 34% was determined (ITP/BVU 2007). This means that the contribution to future growth of freight transport by rail will, in relative terms, be too large. This report shows that sufficient potential exists for rail transport, and that growth, in relative terms, could be too small. It is up to policymakers to adapt rail infrastructure to demand.

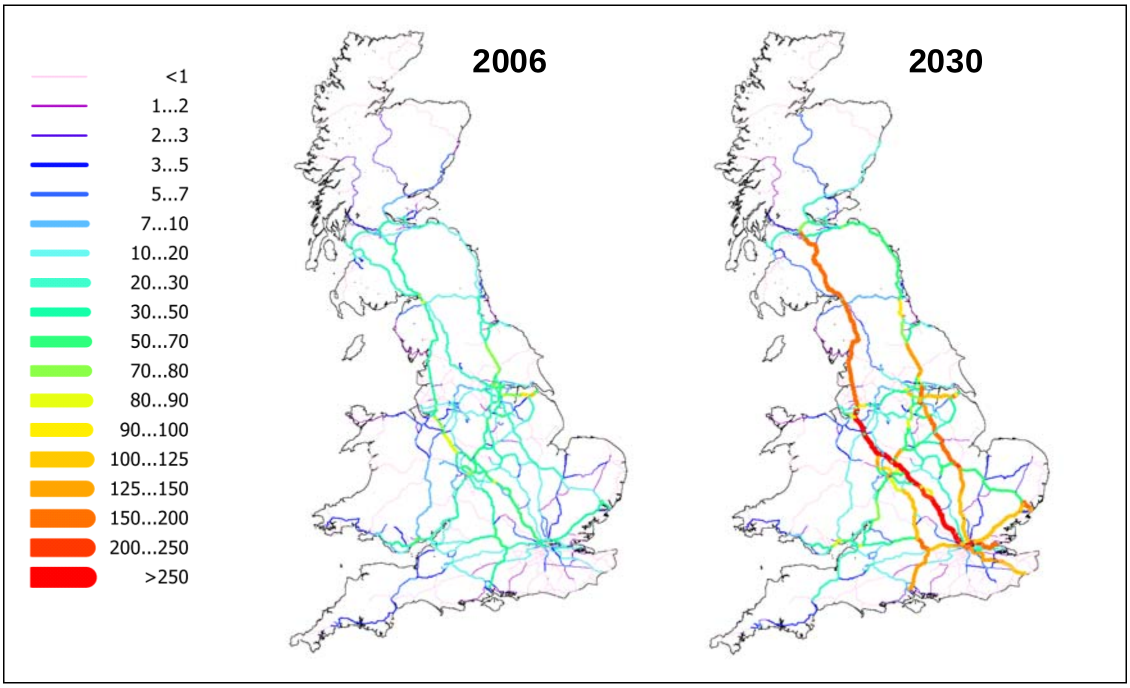


Figure 27 *Daily Freight Train Movements 2006 and 2030 (Sum of both directions (Garratt 2008)*

6 Summary

The aim of this report was the development of a methodological approach to determine a theoretical potential for a modal shift from road to rail and ship for both passenger and freight transport. The basic idea was that it is more important as a first step to carry out this overall estimate than to hold a discussion on the political probability of which changes will happen in reality so as to clarify which policies are needed to tap the total theoretical potential. Thus, the objective was to determine an order of magnitude in terms of how much traffic could be theoretically transferred from road transport to rail/ship and to illustrate the feasibility of tapping the calculated theoretical shift potential using some studies on trend scenarios as examples.

The existing methodologies for determining the modal shift potential described and used in the current literature were reviewed, followed by research on the data availability on the EU level. On this basis a possible approach was developed. As there are completely different structures, data availability and preconditions for passenger and freight transport, it was necessary to analyse them separately. As a result two different methodological approaches were developed. Since in the scope of passenger transport inland navigation is not relevant in nearly all countries and freight transport analyses of inland navigation require a completely different approach on the level of single corridors, the estimation of the modal shift potential was ultimately regarded solely for rail.

There are two theoretical ways for estimating the potential for a shift from road to rail passenger transport: via a segmentation approach or via transport demand modelling. Transport demand modelling could be used to determine modal shift potentials by incorporating different travel costs for different transport modes. However, this does not reflect the precise objective of our report: the determination of the maximum potential for a modal shift. It would just show the modal shift potential by a shift in modal costs and in further development of the infrastructure. Therefore, the segmentation approach was chosen to calculate a modal shift potential from road to rail. Based on analyses of the ETIS data complemented by additional information, three assumptions were generated and used for a calculation of the modal shift potential in passenger transport:

1. The precondition for rail infrastructure, service quality, etc. could be brought into line with the conditions in high population density regions (> 400 P/km²).
2. By improving the travel time to the extent that the time ratio of road to rail is > 1 a further shift can be realised.
3. By lowering the costs for rail trips to a lower level than the costs for the same trip by car, a further shift can be realised.

The developed approach is based on real data from 2000 and 2003. It does not, perhaps, reflect a maximum potential since, for example, no further shift for high population density regions is assumed. However, the method used constitutes the best approach for achieving results that are as reliable as possible because they are based on data which reflect “real” behaviour. However, only trips between NUTS 2 regions could be taken into account since the available data on trips within NUTS 2 regions does not include sufficient information for the analysis needed to carry out the calculations. As a result, no basis is available on which to calculate a shift potential for all trips in Europe on a theoretical level via a segmentation approach. But such a basis is available for trips between different NUTS 2 regions, which covers around 26% of the road and rail passenger transport. If the three assumptions mentioned above are combined to the maximum extent possible – which means among other things that no capacity restrictions are assumed – the calculations made in the scope of this report showed a modal shift potential from road to rail passenger transport of 32.8%. As this value seems to be somewhat unrealistically high in the short and long term without high additional investment costs to enhance the capacities to the extent needed for reaching that rail share, a further assumption was made: A doubling of current capacity needs was assumed to be the maximum modal shift potential per origin destination pair. With this additional factor added in the calculations to better reflect the feasibility, the share of rail in passenger transport increases to 17.3%. In the light of different trend scenarios, which show a growth in passenger transport activity on rail in the range 25% to 50% in a business-as-usual case up to 2030, the calculated theoretical modal shift to 17.3% from the current level of 9.5% should be feasible if further ambitious policies and measures are implemented with regard to travel costs, travel time and railway network.

For freight transport a different calculation approach was developed. The theoretical modal shift potential of freight transport from road to rail can be estimated on the basis of different types of goods and transportation distances. This approach has been pursued within the scope of the present report. On the one hand, it was assumed that certain types of goods are more suitable for modal shift to rail than others (for example, 60% of chemicals and 0% of solid fuels presently transported by road), while on the other hand, with increasing distance the share of shiftable freight transport is assumed to increase (50-150 km: 5% of the volume of goods currently transported by road; 150-500 km: 40%; over 500 km: 100%). It was also assumed that more goods could not be additionally shifted to rail than the volume of goods presently transported by rail. The application of all three prerequisites results in a theoretical modal shift potential for the 27 EU Member States of around 771.3 million tonnes on the basis of 2006 figures. This corresponds to around 4.5% of the volume of goods (measured in tonnes) currently transported by road. As a European average, this would mean a growth in the volume of goods transported by rail of around 48% compared to 2006, whilst in certain countries (for example, France, Italy and the Netherlands) the growth would be 100%. Related to transportation performance, the potential modal shift from road to rail amounts to 361.6 billion tonne kilometres. This corresponds to around 9.3% of the present transportation performance by road. The higher share of the transportation performance is accounted for by the fact that transportation over long distances in particular is regarded as shiftable. It was also pointed out that the exploitation of this theoretical modal shift potential in freight transport requires massive expansion of rail infrastructure in many countries. This situation is aggravated by the fact that the expected future growth in freight transport will exhaust the present expansion of infrastructure capacity.

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8 Annex

Table 12 *Modal shifting potential from road to railway for the freight transport in 2006[1)] with and without 100% railway cap (in 1,000 tonnes)*

	Type of goods[2)]										Shift potential consider-ing type of goods and distances	**Shift potential with 100% railway cap**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	1,000 tonnes	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	*1,000 tonnes*	***1,000 tonnes***
BE	1,301	3,561	0	544	31	1,388	1,018	274	4,477	13,308	25,900	**25,900**
BG	309	594	0	273	1	149	257	0	263	2,423	4,268	**4,268**
CZ	1,613	2,469	0	296	145	1,635	733	44	2,655	13,256	22,848	**22,848**
DK	725	2,750	0	483	19	223	530	69	640	6,935	12,374	**7,300**
DE	7,182	25,439	0	3,396	405	7,847	7,079	581	23,645	101,907	177,481	**177,481**
EE	172	361	0	77	0	38	175	0	0	1,318	2,141	**2,141**
IE	479	1,431	0	399	16	162	358	98	281	3,835	7,059	**1,245**
EL	884	2,548	0	1,063	11	730	839	81	1,055	6,935	14,145	**3,884**
ES	8,305	17,102	0	2,357	355	6,571	5,951	709	9,824	50,892	102,065	**24,935**
FR	9,219	16,058	0	4,296	381	2,548	4,384	1,265	7,980	81,842	127,973	**108,333**
IT	6,193	13,053	0	4,047	384	10,313	5,628	496	11,532	51,646	103,292	**70,604**
CY	0	0	0	0	0	0	0	0	0	0	0	**0**
LV	484	437	0	63	1	79	134	2	163	1,687	3,051	**3,051**
LT	422	703	0	141	0	90	132	12	389	4,115	6,003	**6,003**
LU	193	320	0	171	1	549	77	18	252	3,980	5,562	**5,562**
HU	800	2,011	0	225	31	606	711	91	1,164	6,938	12,577	**12,577**
NL	3,683	6,991	0	693	78	1,731	1,364	391	6,959	30,683	52,573	**30,655**
AT	1,420	1,795	0	693	36	1,192	556	34	1,806	11,954	19,485	**19,485**
PL	2,881	7,686	0	1,178	366	2,724	2,688	521	6,545	32,463	57,051	**57,051**
PT	995	2,247	0	516	22	834	1,051	35	1,632	9,198	16,530	**9,775**
RO	576	3,227	0	460	54	1,021	826	8	379	13,484	20,035	**20,035**
SI	271	388	0	145	4	527	178	8	550	3,366	5,437	**5,437**
SK	428	794	0	69	8	998	276	1	572	6,300	9,446	**9,446**
FI	1,942	2,164	0	914	25	644	402	61	1,472	6,877	14,501	**14,501**
SE	2,522	2,451	0	688	76	526	426	35	1,544	12,949	21,218	**21,218**
UK	4,657	19,975	0	2,721	138	2,535	3,514	302	7,759	65,976	107,577	**107,577**
EU-27	**57,653**	**136,555**	**0**	**25,907**	**2,588**	**45,659**	**39,289**	**5,137**	**93,536**	**544,266**	**950,591**	**771,312**
NO	395	1,973	0	375	16	293	225	13	779	5,831	9,900	**9,900**

[1)] Italy: 2005; [2)] Type of goods: 0 = Agricultural products and live animals, 1 = Foodstuff and animal fodder, 2 = Solid minerals fuels, 3 = Petroleum products, 4 = Ores and metal waste, 5 = Metal products, 6 = Crude and manuf. minerals, building materials, 7 = Fertilizers, 8, = Chemicals, 9 = Machinery, transport equipment, manufactured & miscellaneous articles.

Sources: Eurostat 2008; own calculation.

Table 13 *Modal shifting potential from road to railway for the freight transport in 2006[1)] with and without 100% railway cap (in million tonnes-kilometres)*

	Type of goods[2)]										Shift potential consider-ing type of goods and distances	**Shift potential with 100% railway cap**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**		
	million tkm	*million tkm*	*million tkm*	*million tkm*	*million tkm*	*million tkm*	*million tkm*	*million tkm*	*million tkm*	*million tkm*	*million tkm*	***million tkm***
BE	480	1,382	0	142	7	574	288	81	1,825	5,927	10,706	**10,706**
BG	95	216	0	66	0	61	143	0	119	2,458	3,158	**3,158**
CZ	1,142	1,145	0	75	98	1,189	264	11	2,020	9,173	15,116	**15,116**
DK	276	909	0	58	4	109	108	10	274	3,180	4,926	**2,906**
DE	2,801	9,316	0	708	128	3,226	2,038	184	10,565	43,161	72,126	**72,126**
EE	139	184	0	17	0	15	56	0	0	1,026	1,438	**1,438**
IE	126	477	0	68	3	32	57	18	77	1,287	2,145	**378**
EL	482	1,353	0	224	1	385	197	20	616	3,906	7,184	**1,973**
ES	6,284	9,025	0	518	152	3,727	2,019	219	5,900	32,220	60,062	**14,674**
FR	2,991	5,644	0	881	119	1,141	1,274	391	3,444	32,146	48,030	**40,659**
IT	3,141	6,342	0	1,169	145	4,536	1,534	178	5,478	26,011	48,533	**33,174**
CY	0	0	0	0	0	0	0	0	0	0	0	**0**
LV	414	334	0	13	0	93	73	0	203	2,108	3,239	**3,239**
LT	527	711	0	43	0	85	87	7	454	5,175	7,089	**7,089**
LU	80	145	0	31	0	244	22	7	145	2,032	2,705	**2,705**
HU	453	963	0	49	19	490	210	27	1,030	5,922	9,163	**9,163**
NL	1,604	2,369	0	146	22	618	364	93	2,744	13,691	21,652	**12,625**
AT	683	915	0	262	16	723	177	8	1,089	7,055	10,929	**10,929**
PL	1,771	3,839	0	362	210	1,909	990	221	4,663	24,462	38,427	**38,427**
PT	631	1,079	0	108	5	549	391	9	1,341	9,557	13,670	**8,084**
RO	253	1,567	0	95	17	1,171	195	2	117	17,520	20,937	**20,937**
SI	135	227	0	30	1	381	77	3	390	2,888	4,132	**4,132**
SK	239	283	0	13	2	942	88	0	401	5,752	7,720	**7,720**
FI	536	669	0	187	6	290	112	16	591	2,456	4,865	**4,865**
SE	616	825	0	134	21	217	125	8	512	4,928	7,386	**7,386**
UK	1,300	4,871	0	448	27	643	715	68	2,291	17,674	28,038	**28,038**
EU-27	**27,200**	**54,789**	**0**	**5,845**	**1,001**	**23,350**	**11,604**	**1,580**	**46,290**	**281,716**	**453,375**	**361,645**
NO	146	770	0	90	8	144	79	2	371	2,610	4,220	**4,220**

[1)] Italy: 2005; [2)] Type of goods: 0 = Agricultural products and live animals, 1 = Foodstuff and animal fodder, 2 = Solid minerals fuels, 3 = Petroleum products, 4 = Ores and metal waste, 5 = Metal products, 6 = Crude and manuf. minerals, building materials, 7 = Fertilizers, 8, = Chemicals, 9 = Machinery, transport equipment, manufactured & miscellaneous articles.

Sources: Eurostat 2008; own calculation.