Modal choice criteria in rail transport

Assessment of modal choice criteria in various rail transport market segments

CE Delft

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Content

Summary

Project objective: a better understanding of modal choice

Increasing the market share of both rail freight and passenger transport can potentially contribute to improved accessibility, reduce road congestion and at the same time reduce the environmental burden and climate impacts of transport, if sustainable energy is used for propulsion. The modal choice of transport users both in passenger and freight depend on various criteria.

The objective of this literature review is to get a better understanding of the criteria that transport users in different market segments in both passenger and freight transport use for choosing rail transport or a competing transport mode. In addition, future opportunities and challenges –endogenous and exogenous- for rail transport until 2030 have been identified.

Passenger transport: potential for growth

Door-to-door travel time, travel time reliability and comfort are in all market segments the most important criteria for modal choice, see Table 1. Commuters rank travel time and reliability highest. For commuters and leisure travellers, ticket prices are also important, while this is not the case for business travellers.

Table 1 - Ranking of performance criteria for rail passenger transport for different trip purposes

Criterion	Commuting	Business	Leisure
Travel time	+++	+++	++
Reliability	+++	+++	++
Comfort	++	++	+++
Accessibility	++	++	++
Price	++	+	++(+)*
Frequency	++	++	+
Convenience	+	+	+
Safety	+	+	+
Environment	+	+	+

*For long distance transport, ticket prices are evaluated to be more important than on shorter distance transport.

The evaluation of performance criteria shows that travel time and reliability of rail transport can be competitive for trip distances between 10 and 700 km. The travel speed of train is generally competitive compared to cars, but as travellers typically compare door-to-door travel time, the accessibility of the nearest railway station is crucial.
Rail competitiveness increases if road travel time reliability gets poor due to congestion. Rail performance on travel time reliability is very high in almost all Member States. Rail is generally also cost competitive, compared to solo or duo occupant cars. However, for long distance trips, air transport is often much cheaper. The perceived quality of rail service (in terms of reliability, cleanliness, ticketing, client focus and other comfort factors) varies highly between member states, suggesting that improvement strategies focussing on comfort can be beneficial, but should be country or situation specific.

Urbanisation, mobility-as-a-service (MaaS) and the increased demand for leisure trips and environmental awareness are expected to have the greatest impact on rail passenger transport in Europe in the next decade. In many urban areas, car transport does not perform well, because of congestion and parking problems. Therefore, urbanisation is an opportunity for growth of rail transport. However, this requires a high level of integration with other modes, such as walking/cycling, bus/tram/metro and private car or new shared car service concepts. MaaS is expected to contribute to this by offering seamless switching between modes.

Also the expected increase in the number of leisure trips (30% increase of intra-EU trips between 2010 and 2030) can be an opportunity for rail. However, as long as travel prices of international rail travel are not cost competitive with air, the potential for rail in international travel will depend on cost competitiveness. In addition, the requires an increase in the number of high speed rail connections.

Finally, also the increase of environmental awareness will provide opportunities for the rail sector. Especially stricter environmental policies at the EU and national level are likely to discourage car use. At the same time, the expected electrification of automobiles may in the longer run diminish the relative environmental advantages of rail.

Freight transport: challenges ahead

The vast amount of literature available illustrates the major importance of costs as a modal choice criterion in freight transport on distances where rail becomes competitive. Only in cases of high value goods transport or conditioned goods, costs is not the single most important decision criterion. In those cases transport time and on-time reliability are also more important, see Table 2.

Table 2 - Criteria importance ranking for maritime containers and continental freight

Criteria	Perishable goods/high value	Non-perishable goods/low value
Costs	+++	++++
Delivery time	++++	++
Punctuality	++++	++
Flexibility	++	++
Frequency	++	++
Transport safety	++	++
Transport security	++	++
Convenience	++	+
Network connectivity	++	+
Environmental efficiency	+	+

The continuous growth of import of maritime containers can to a large extent be explained by the focus on low-density-high-value goods, as Europeans consume more goods like electronics and conditioned goods. This implies that growth of rail transport is only possible when required service levels can be met, such as delivery time, punctuality and technical services as plug-in power and track and trace.

Various trends are likely to impact the rail freight market negatively in the next decade and need anticipation from the sector. The first one is the decrease in coal transport.
Coal imported has increased since the 1980's and accounts for 10% of rail freight transport in the EU. However, due to climate policies, the use of coal for power generation has started to shrink.

The share of rail freight transport in Europe is also under pressure, due to the decline of single wagon load transport (SWL), which amounts to a third of the overall market in the EU. The decrease of the size of shipments and 'just-in-time' (JIT) logistics supply regimes requires flexibility and timely delivery. This is disadvantageous for rail transport, as road transport generally performs better on these criteria. This lag behind road transport can be explained by low speeds, caused by persistent interoperability problems, especially outside the European rail freight corridors. Solving of these bottlenecks is expected to last until 2030. Reducing the border crossing difficulties and other interoperability problems would significantly improve the competitive position of rail.

Opportunities for rail freight transport can be found in new and upcoming markets. Maritime containers will continue to grow, although to a lesser extent than in previous decades and the opening of the New Silk route provides opportunities for European rail freight market. Trailer-on-train is a concept that may require more attention as a result of a stronger demand for climate neutral transport in the next Post Paris decade and increasing shortage of truck drivers and increasing road congestion. Like for passenger transport, also the environmental awareness and need for climate neutral transport is an opportunity for rail, although variations in the extent of network electrification are considerable between countries.

1 Introduction

1.1 Background

Increasing the market share of rail transport can potentially contribute to improved accessibility, reduce road congestion and at the same time reduce the environmental burden and climate impacts of transport. The modal choice of transport users both in passenger and freight depend on various criteria. Better insight in these criteria can help policy makers to develop effective policies.

In view of this CER (Community of European Railways) has commissioned CE Delft to carry out a desk study on the criteria that transport users use for their modal choice.
The results of this study should help CER to define its priorities for the next legislative period and will show the areas where a 'gap' between rail and other modes needs to be filled, or where rail already outperforms and probably can benefit from better positioning.
This report deals with both the current and future modal choice criteria for identified market segments.

1.2 Project objective, scope and methodology

The objective of this literature review is to get a better understanding of the criteria that transport users in different market segments of both passenger and freight transport use for choosing rail transport or a competing transport mode. The review also takes account of future trends that may impact the position of rail transport.

More specifically the objectives of this study are to:
1. Map the different market segments where rail is present (e.g. passenger vs. freight, business travellers vs leisure travellers, heavy goods vs light goods, short distance travel vs. long distance travel, etc.).
2. Identify the criteria that in each market segment ultimately 'drive customers' modal choices.
3. Map the comparative performance of rail in different relevant market segments.
4. Identify relevant trends and how they may affect the modal choice and pose opportunities or threats for the rail sector.

The time window that is considered in the study is the 2019-2024 period and the decade after that regarding the future trends impacting rail transport and its customers.
The project concerns a gathering of relevant available business and academic literature, under review of a group of CER members. This report does not provide a full picture of the potential of rail, as it does e.g. not focus on existing supply side bottlenecks in the rail market itself that hinder growth.

1.3 Outline

First, a chapter is dedicated to passenger transport (Chapter 2) and one to freight transport (Chapter 3). In each of these chapters, the relevant market segments and its relevance, the performance criteria in the various transport market segments are listed and ranked, followed by an assessment of the performance of rail versus other modes for the most important criteria. Chapter 4 provides an analysis of the market developments and exogenous trends that are relevant for rail transport and how they may affect future modal choice.

2 Passenger transport

In this chapter, the relevant performance criteria for passenger rail transport are discussed. First, the relevant market segments are identified. Next, based on literature review the performance criteria relevant for modal choice are described, resulting in a ranking of the most relevant criteria for market segments and passenger groups that can be identified. Finally the performance of rail transport is discussed for the main criteria.

The focus is on heavy rail transport. However, many studies on modal choice criteria take a broader perspective, e.g. considering also light rail (tram, metro) or even all public transport.

2.1 Market segmentation and market shares

Market segmentation

The share or rail in the modal split of passenger transport and potential for growth depends on various parameters. Also the criteria used for making the modal choice is not the same for all travellers. In this section the main market segments are described that are relevant to distinguish, when assessing the criteria used for the modal choice.

Based on the review of the literature and the discussion with the steering committee of this study, a basic market segmentation has been developed, which is depicted in Table 3.
The purpose of transport (demand side) has been chosen as the first discerning parameter, since this is an important factor for the criteria of transport users when making a modal choice. For example: travel time is one of the most important criteria for business travel, but less important for leisure trips, which is reflected by the much higher valuation of travel times for business, compared to leisure (Kouwenhoven, et al., 2015).

The second parameter concerns the segmentation to regional, national and international trips, which is mainly linked to the length of the trip. The availability and competitiveness of rail transport is generally highest for medium distances, and lower for very short distances (less than 10 km) or very long distances (more than 700 km). Therefore the potential of rail transport in regional and international travel is most significant in the sub-segments of relatively short international and long regional trips, while for most national trips rail is a suitable option, at least for locations that are sufficiently close to a (main) railway station or well accessible by multimodal connections.

In Table 3, the main competitors for rail transport and the most relevant sub-segments of rail transport are described for each market segment. For example, in the market segment international business transport, air travel is the main competitor of rail transport. In this market segment High Speed Rail (HSR) is able to compete with air travel. The same holds for international leisure trips. However, also car and coach are competitors for train travel in that market segment. Trips to cities well accessible by high speed rail seems to be the most relevant sub segment for international leisure travel by rail.

Table 3 - Segments in passenger transport market and relevance of rail per segment

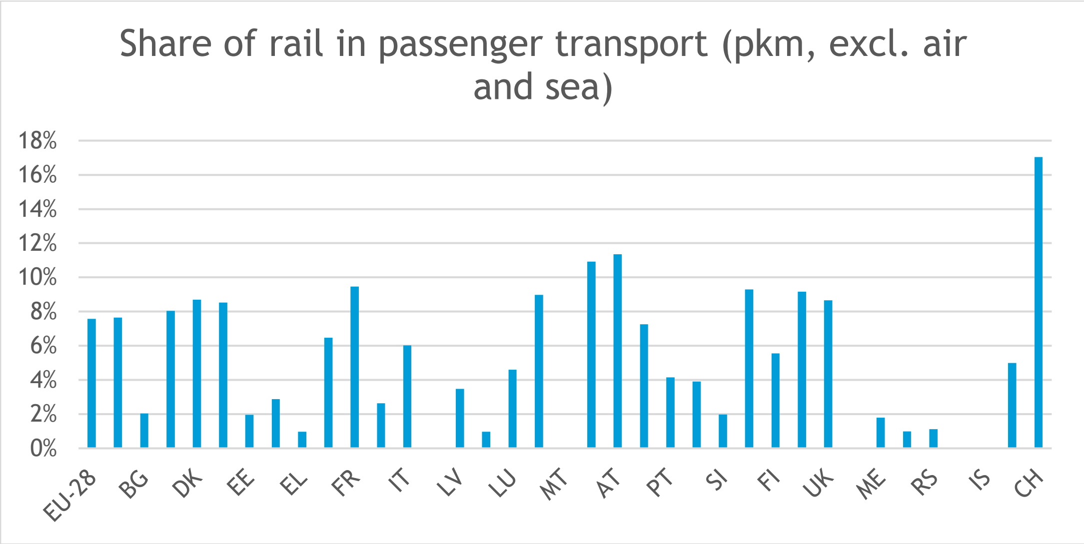
Distance	Commuters	Business	Leisure
International (200+ km)	*Hardly existing*	**Competitors**: air **Relevance rail transport**: Relatively short distances (<700 km) and locations well accessible by high speed rail	**Competitors**: air, coach, car **Relevance rail transport**: Relatively short distances (<700 km) and locations well accessible by high speed rail (mainly city trips)
National (50-700 km)	**Competitors**: air, car **Relevance rail transport**: Commuters without a car, locations close to railway station or well accessible by multimodal connections	**Competitors**: air, car **Relevance rail transport**: Locations close to railway station or well accessible by multimodal connections	**Competitors**: air, coach, car **Relevance rail transport**: Households without a car, locations close to railway station or well accessible by multimodal connections
Regional (0-50 km)	**Competitors**: car, (electric) bicycle, bus/tram/metro **Relevance rail transport**: Commuters without a car, locations close to railway station or well accessible by multimodal connections, short to long commuting distances	**Competitors**: car, (electric) bicycle, bus/tram/metro **Relevance rail transport**: Locations close to railway station or well accessible by multimodal connections, medium to long distances	**Competitors**: car, (electric) bicycle, bus/tram/metro **Relevance rail transport**: Locations close to railway station or well accessible by multimodal connections, medium to long distances

Market share of rail transport

In the EU as a whole, rail transport accounted in 2015 for 6.7% of all passenger-kilometres. When only considering land-based passenger transport, so excluding air and sea travel, the share of rail is 7.6% (2016). The market share differs per country, as shown in Figure 1. In most countries the share is between 6% and 11%. In countries like the Baltic states, Ireland, Bulgaria, Romania, Slovenia and Greece, the share is significantly lower. On Malta and Cyprus there is no rail network.

For long distance trips (>100 km) in countries with a well-developed HSR network, rail modal share is relatively high. For example, in France the modal share for 300-600 km trips is ca. 20% and for 600-1,000 km trips ca. 25% (UIC, 2018) while the overall rail modal share in France is ca. 9.5%. Related to air transport, rail can even dominate the market for trips with a train travel time of <2 hours.

Figure 1 - Market share of rail in land-based passenger transport in EU-28 and European countries (2016)

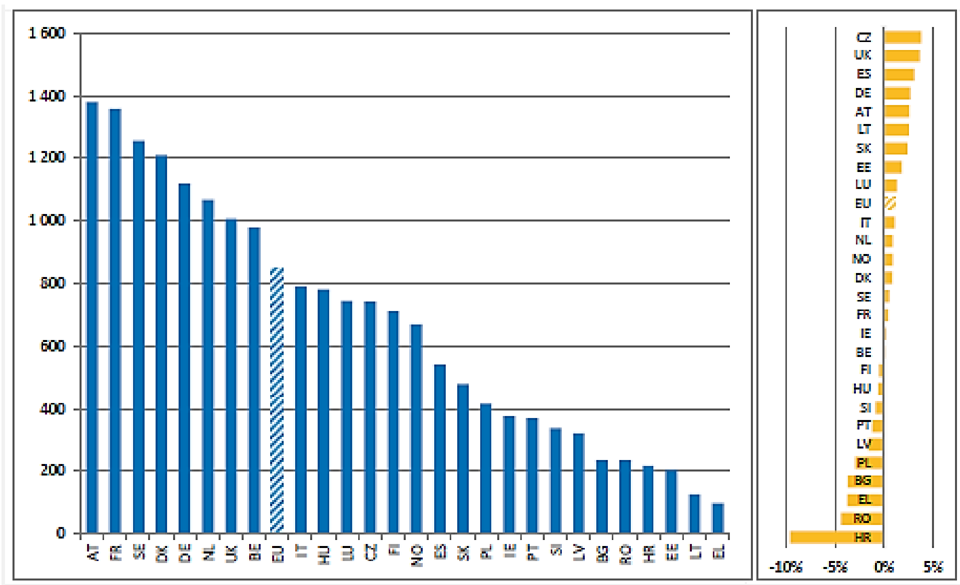


Source: Pocketbook DG MOVE

Of all European countries, Switzerland has the highest share of rail in passenger transport, with 17% of the total passenger-kilometres of land-based transport modes in 2016. Particularly in urban areas, rail has a relatively high market share. This comes together with lower car ownership : 73% of the urban households own a car, against 87% in areas outside the influence of urban centres. The share of rail transport in Swiss agglomerations varies from 9% (Lugano) to 30% (Bern).

Figure 2 shows a comparison of average rail travel in 2014 for inhabitants of all EU Member States and also the annual change in the period 2009-2014 (EC, 2016a).

Figure 2 - Propensity to travel by rail (2014) and its average annual change since 2009. (p-km per year per inhabitant)

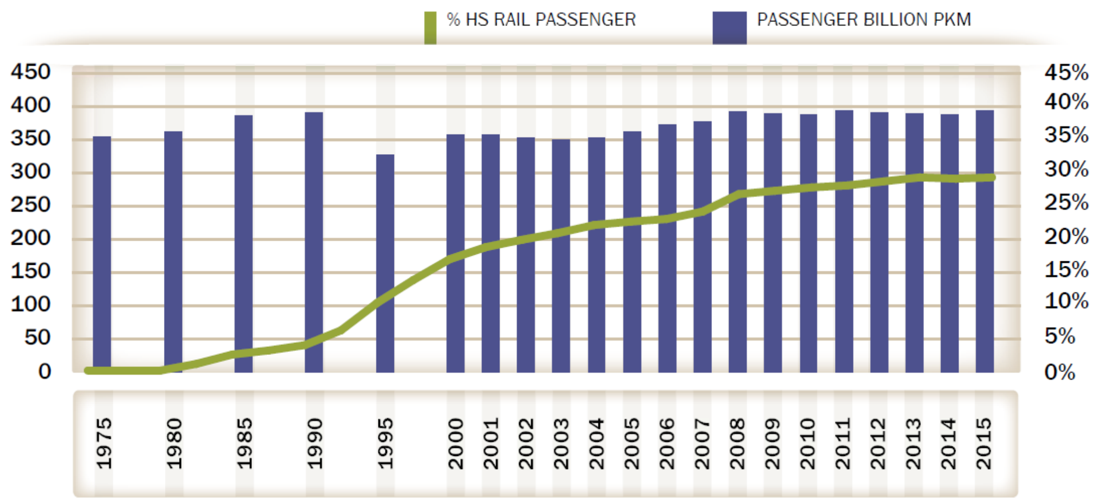


Size of market segments

Most of the trips by rail are domestic travel, less than 6% of pkm concerns international trips (EC, 2016a). As international trips will on average be longer than domestic ones, the international share in the number of rail trips is even much lower.

HSR plays an important role in the rail market for trips >100km. High speed lines make up part of the rail networks of Belgium, Germany, Spain, France, Italy, the United Kingdom, the Netherlands, Austria and Poland. Ca. 26%-30% of all p-km are run on high speed lines, see Figure 3. In France this share is ca. 50% (EC, 2016a) (IEA ; UIC, 2017).

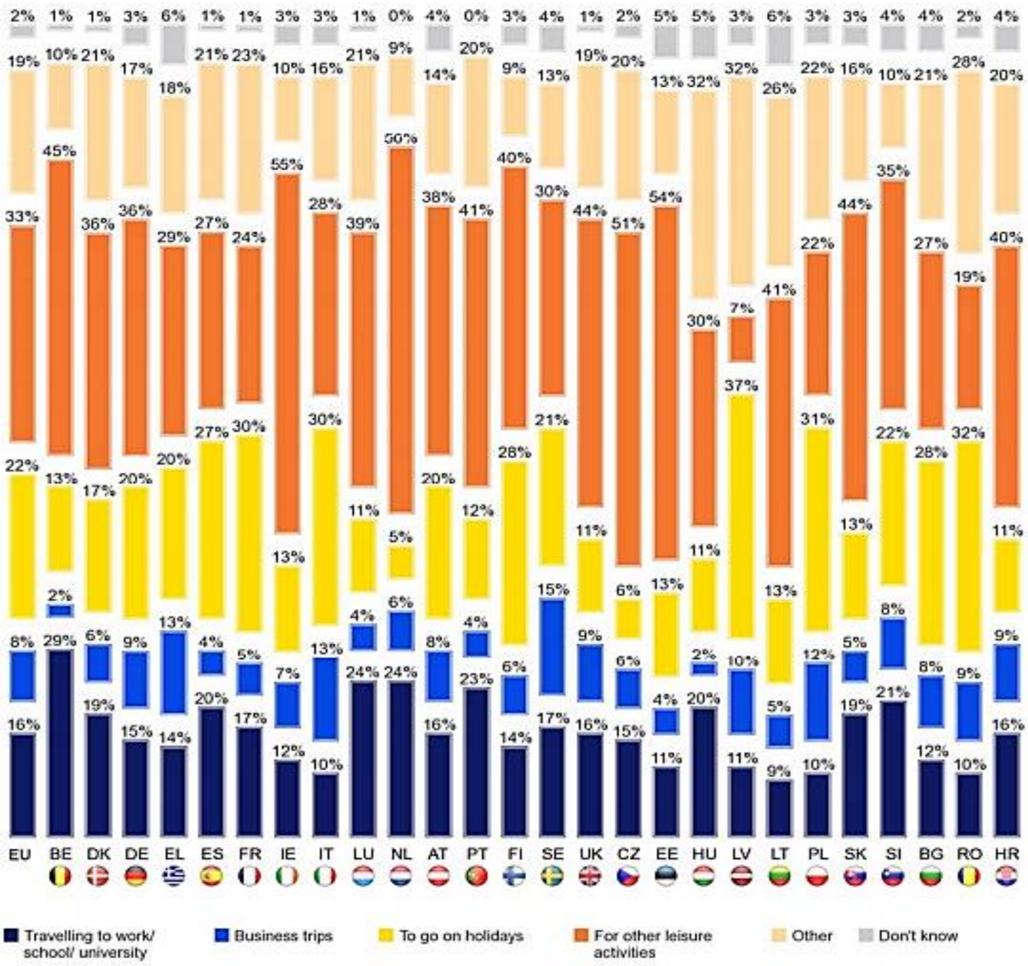
Figure 3 - Passenger railway activity and High-Speed activity as a share of total passenger railway activity (%)



Data on the shares of different travel purposes

There is very little data available for travel purposes for rail transport for all EU countries. In the EU Rail Customer Satisfaction Barometer (TNS Political & Social , 2013) the most frequent purpose of train trips is presented per country, however the results present a relatively high share of leisure trips compared to the national data statistics from the Netherlands and the UK. Figure 4 shows the shares of different purposes in rail travel in the EU (first bar) and the shares for each EU Member State according to the Eurobarometer. The graphs show that leisure and holidays together are responsible for 55% of EU rail travel, according to the Eurobarometer.

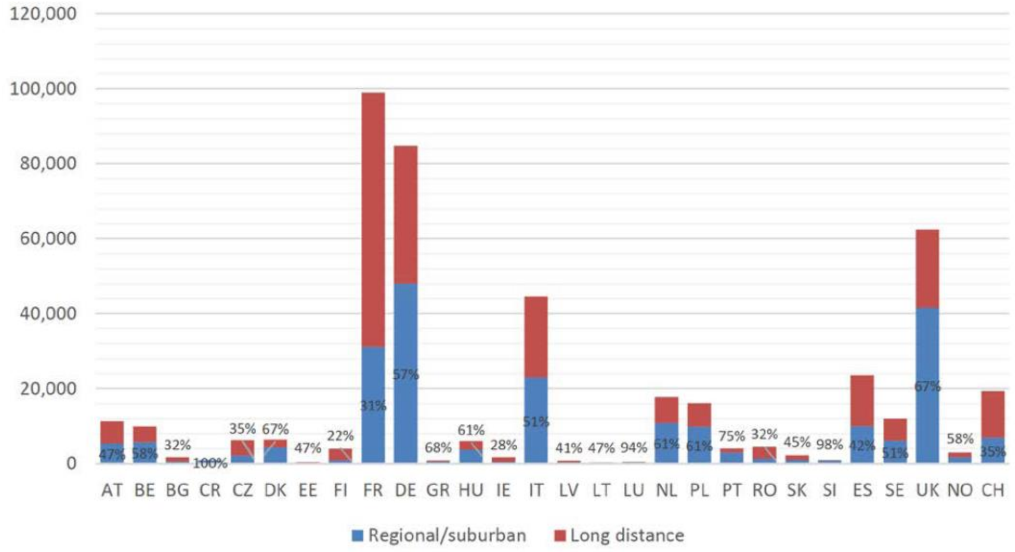
Figure 4 - Most frequent purpose of train trips, per country in the (TNS Political & Social , 2013)



In the UK, over half of all rail journeys were for commuting and education (56%), with smaller shares for leisure (23%), business (10%) and other (10%) according to the UK Department for Transport (DfT , 2017). Data from the national statistical agency in the Netherlands suggest that in that country, commuter transport is by far the largest category of regional and national rail transport: 65% of all regional and national train trips are made with the purpose of commuting (36%) or education (29%). Leisure takes only 32% of all trips and business trips are 4% of all train travel trips (CBS Statline). Data from Dutch Railways NS show that for distances below 10 km, trains have no significant market share.

UITP (2016) reports the distribution of rail trips over regional/suburban and long-distance trains, using a specific definition for regional and suburban railways (RSR): average distance between stations <25 km, commercial speed 40-60 km/h, typical trip time <1h.
They conclude that an EU average of 50% of all rail passenger kilometres is regional and suburban, varying between 22% for the stretched-out network of Finland and 98% for Slovenia, as can be seen in Figure 5.

Figure 5 - Regional and long distance passenger kilometres on railways (UITP, 2016)



2.2 Performance criteria

2.2.1 Modal choice criteria rail travel

The literature review revealed that the criteria listed in Table 4 are the most important ones for modal choice in passenger transport. All criteria found in the reviewed literature are listed in Appendix A. For example, Redman et al., (2013) performed a broad research review into the quality attributes of public transport that attract car users.

Table 4 - Attributes that are important for modal choice according to Redman et al., (2013)

Classification	Attribute	Definition
Physical	Travel time	The time spent for the entire door-to-door travel
	Reliability	How closely the actual service matches the route timetable
	Accessibility	The degree to which public transport is reasonably available to as many people as possible
	Frequency	How often the service operates during a given period
	Price	The monetary cost of travel
	Information provision	How much information is provided about routes and interchanges
	Ease of transfers/interchanges	How simple transport connections are, including time spent waiting
	Vehicle condition	The physical and mechanical condition of vehicles, including frequency of breakdowns
Perceived	Comfort	How comfortable the journey is regarding access to seat, noise levels, driver handling, air conditioning
	Safety	How safe from traffic accidents passengers feel during the journey as well as personal safety
	Convenience	How simple the transport service is to use and how well it adds to one's ease of mobility
	Aesthetics	Appeal of vehicles, stations and waiting areas to users' senses

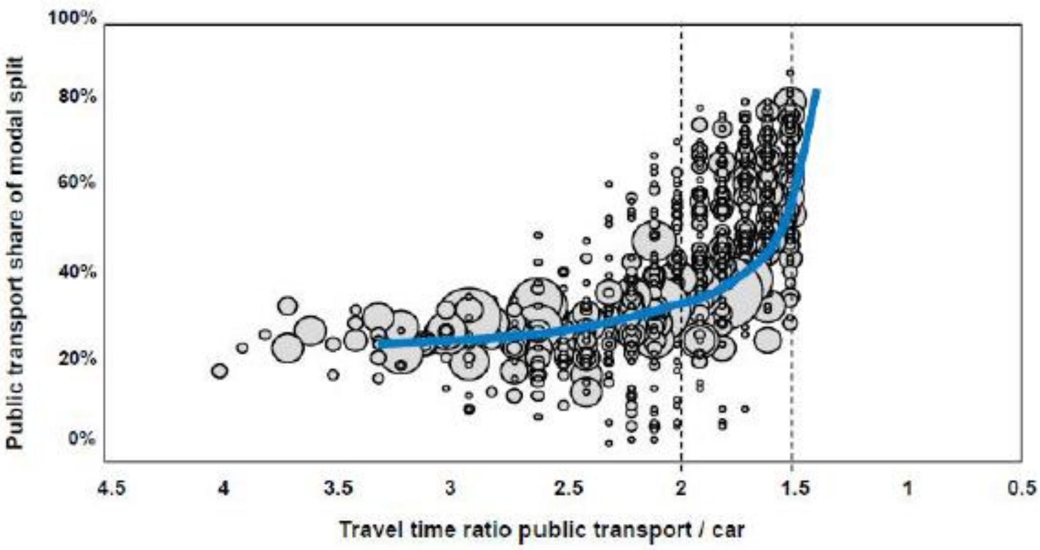
Annex A provides an overview of the criteria mentioned in the studies assessed. From this overview we conclude that the main attributes that they found are travel time, reliability, accessibility, frequency, price and comfort & quality. Below, each of these criteria is discussed, based on findings in literature.

Travel time

The market share of public transport is highly influenced by travel time of public transport vs. alternative modes. For example, Figure 6 shows the travel time ratio of public transport vs. car in Berlin (Rheinhold, 2008). When travel time by public transport is more than two times higher than travel time by car, the market share of public transport drops below 30%. But when travel time by public transport is less than 1.5 times higher than by car, the market share of public transport can grow to over 60%. Also Dutch literature states that travelling by train is competing car when the door-to-door travel time by train is no more than 1.5 as long as the travel time by car (KiM, 2015).

Reducing travel time for train trips can play an important role by increasing rail transport. For example, in the Netherlands rail transport has grown with 25% in the 2005-2016 periods. 10% of the growth can be explained by travel time related factors like travel time reduction (of transport to and from the station), reduction of waiting times and transfer optimisations (KiM, 2018c).

Figure 6 - Travel time ratio for public transport in Berlin (Rheinhold, 2008)



Also for long distance travel, where rail competes with air, travel time is an important criterion. Several sources (UIC, 2018, KiM, 2018a) indicate a strong relationship between rail travel time and market share for long distances related to air travel. Rail can be competitive with air travel when the rail travel time is less than 3h30 minutes (market share > 60%). In fact, rail dominates the market (related to air travel market share > 90%), where rail travel time is less than two hours. For example, the Paris-Brussels route is dominated by rail travel. Where rail travel time is more than five hours, rail becomes a marginal actor compared to air (market share < 20%).

Figure 7 shows the rail market share vs. air market share for long distance-trips in France (UIC, 2018). Figure 8 shows the market share of HSR connections on several city-pairs in Europe and Japan.

Figure 7 - Rail market share (passengers) on the rail+market in France (UIC, 2018)

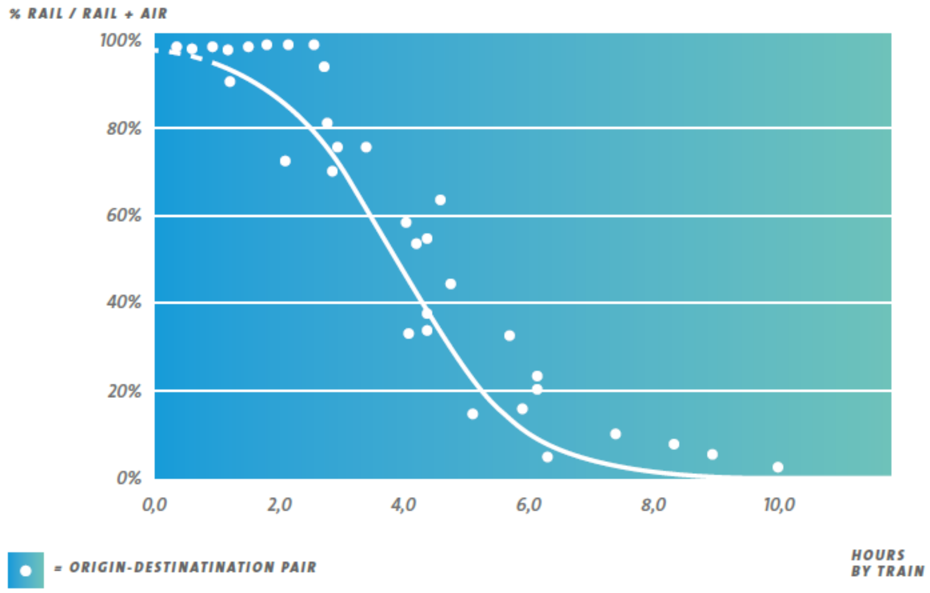
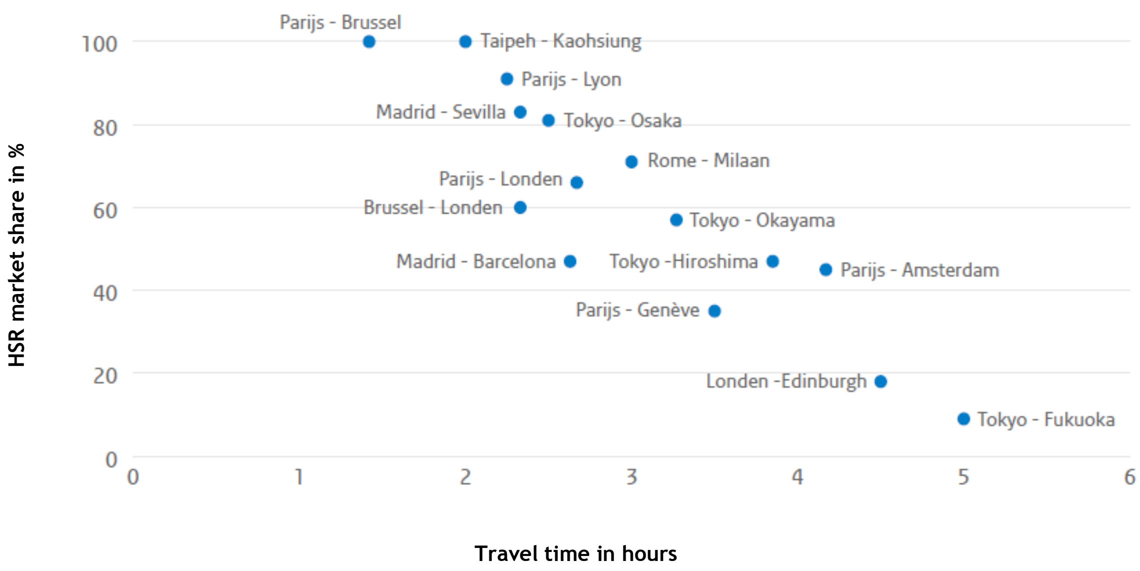


Figure 8 - Market share passenger travelling for HSR-connections between cities, related to train travel time.



Besides the travel times by train itself, also the travel time to and from the railways station and the transfers, waiting time and delays influence the objective travel time.
It is important to emphasize that for the modal choice, it is not just the real travel time the matters, but in particular the perceived travel time (see below).

Reliability

Reliability of travel times is an important factor determining travellers' modal choice. Unexpected delays in public transport and (unpredictable) road congestion are the most important causes of unreliable travel times. High-frequency rail connections improve the travel time reliability because missing a connection does not directly result in large delays. For example, travel cost calculations for transit users on two RER-lines in Paris show that for low-frequent lines frequency improvement has more value to the traveller than reliability improvement (Benezech & Coulombel , 2014).

Accessibility

The existing rail network and the supplied service (connections, frequencies) determine on which relations the train can be attractive. The transport to and from railway stations plays a very important role in the door-to-door travel time of train journeys.

Rail transport can compete well with car trips when the destination can easily be reached from the nearest railway station. For example, for jobs that are within less than 500 metre of main train stations, the share of rail in commuting is significantly higher than for jobs that are located further from railway stations (KiM, 2015).

Also when the destination location is better accessible by train than by car, rail can be the most competitive way of travelling. Mainly in larger cities this is the case when there are significant parking or congestion problems around the destination location. High parking fees, long searching time for parking and extreme congestion are main factors for choosing train instead of car (KiM, 2015).

Frequency

In quality research of public transport, the frequency of service is highlighted as a significant factor determining perceived service quality (Redman, et al., 2013). If a traveller arrives at a random time at their station of departure, the service frequency determines the distribution of waiting times for the first train departure. For high frequency trains, this reduces the need for strict journey planning by travellers, but also the consequence of delays in transport to the station. According to Brons & Rietveld (2009), in some respects, increasing the service frequency is better than reducing the travel time to the station. If the route of the feeder bus to the railway station is shorter, it will reduce the catchment area of the service and possibly the number of rail users. Secondly, increasing the frequency of service will also reduce travel time when including waiting time to the service.

Price

Price is also an important criterion for modal choice. A commonly used measure for expressing the price sensitivity of transport is the price elasticity. A meta-study by Litman (2017) mentions various studies that provide price sensitivity for rail passenger transport. Mayeres (2000) reports price elasticities for rail passenger transport of -0.37 in peak and -0.43 in off-peak hours. This means that a 10% price increase for rail transport in peak hour results in 3.7 less passenger kilometres by rail. So, this study indicates greater price sensitivity for off-peak travel compared with peak travel. For the market segments distinguished in Section 2.1, it means that commuting and business travel is less price sensitive than leisure travel.

Another meta-analysis by PBL and CE Delft (2010), concludes that rail passenger transport is somewhat more price sensitive. The short term price elasticity of rail transport is in the range of -0.3 to -0.7 while the long term elasticity is in the range of -0.6 to -1.1.

All the studies mentioned by Redman et al., (2013) stress that the impact afforded by pricing mechanisms is determined to a great degree by other attributes of public transport service quality such as access, frequency, and speed.

Comfort, convenience and safety

A lot of aspects can influence the quality and comfort the passengers' travel experience. For instance, vehicle condition (e.g. cleanness, silence compartments in the train) and facilities as WiFi or catering can contribute to a pleasant and useful travel time. Also comfort at stations and stops, such as indoor waiting rooms or shops at stations could be useful for the traveller. Other comfort and quality aspects are: travel information (also in case of delays), alternative transport during interruptions, user friendly booking systems and service of personnel.

Also the ease of transfers/interchanges is important. Transfers, waiting time and delays not only influence the objective travel time, but also the perceived travel time of the traveller. For example, waiting time can be experienced twice as long as the objective waiting time, delayed time as three to five times longer (Warffemius et al., 2016, Page 6; KiM, 2015).

A literature review (overview by Wardman, 2014) showed the importance of convenience in public transport. In this research inconvenience variables are valued as multipliers to in-vehicle-time (IVT). The paper shows that most important factors for inconvenience, such as delay, can lead to multipliers to IVT up to five. Figure 9 shows the multipliers for the most important convenience variables.

Figure 9 - Time multipliers for most important convenience issues in public transport (Wardman, 2014)

CONVENIENCE TERM	INDICATIVE MULTIPLIER
Late Time	3.0-5.0
Walking with more than normal effort	4.0
Waiting in Crowded Conditions	2.5-4.0
Walking in Crowded Conditions	2.0-3.5
Walking and Waiting in Normal Conditions	1.75-2.0
Standing (depending on conditions)	1.50-2.0
Headway	0.5-0.8
Displacement Time	0.4-0.6
Interchange Penalties	5-15 mins
On-Vehicle Information	<< 1 min
Off-Vehicle Information	<< 1 min

Also the comfort and service level of the transport to and from railway stations have an effect on the traveller's experience. Furthermore, the real and perceived safety during the entire journey travel are also important for travellers.

Attitude, personal characteristics & environmental awareness

Besides the criteria mentioned above, some literature also mentions the attitude and characteristics of traveller as important parameters.

In all market segments, based on objective, measurable criteria, such as price and travel time, there is more potential for passenger rail than is really used. Subjective criteria, as personal attitude against rail transport, sometimes dominate the travellers' modal choice. However, travel attitudes and behaviours are not necessarily constant over time. In fact, they mutually influence each (Kroesen, et al., 2017). Travel behaviour changes at life events, such as job change or rehousing (De Haas, 2016).

Personal characteristics also influence peoples' travel behaviour and modal choice.
In general, car ownership and higher income decrease the use of public transport and younger people and students use public transport more often than older people (Santos, et al., 2013). Appraisal of some choice criteria depends on the frequency of travelling by train. NS found three decisive criteria where people that are classified as 'car if possible' travellers and 'train if possible' travellers show a significant difference in their modal choice. People in the group 'train if possible' value 'environment', 'useful travel time' and 'pleasant travel time' more than people in the group 'car if possible'. The importance of useful and pleasant travel time is confirmed by the KiM research (KiM, 2015).

Impact of policies

Corporate as well as governmental policies influence indirectly or directly peoples' modal choice. For example, taxation and reimbursement policies influences prices for train tickets and other modes. Also company policies can directly influence the modal choice for business travelling and commuting. When a company decides to book train tickets for specific business trips or provide train cards, employees will be motivated to travel by train more often. Especially for commuting and business, travel policies of employers play an important role in the modal choice.

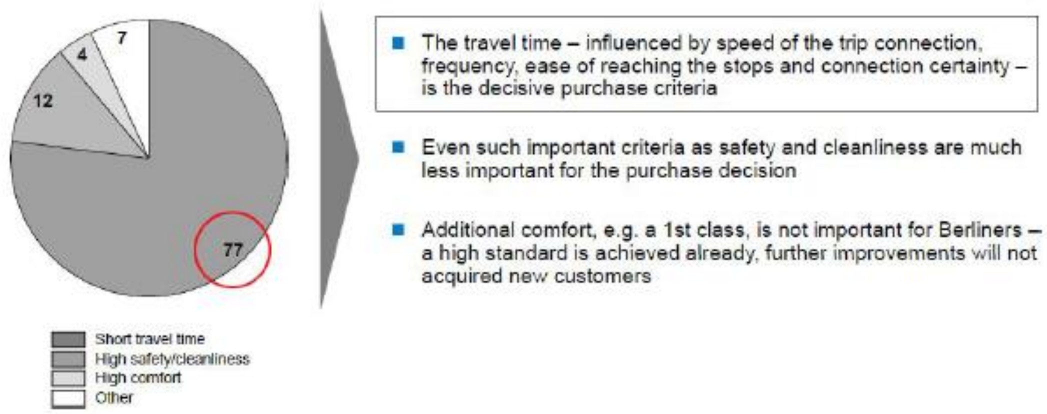
2.2.2 Criteria assessment

In this section, the results of the literature review are provided on the various criteria identified in the previous section and on their relative importance.

Literature review

German research (Rheinhold, 2008) among travellers in Berlin shows travel time (determined by velocity, frequency, accessibility of stops and reliability) as main factor for modal choice, see Figure 10.

Figure 10 - Factors determining purchase decision (%) (Rheinhold, 2008)



Dell'Olio et al., (2011) studied the quality desired by users and potential users of public transport when defining an efficient and reliable system, taking the municipal bus services of Santander (Spain) as a practical example. The users of public transport valued waiting time, cleanliness and comfort the most, but the degree to which they are valued varied according to the type of user. For potential users the most important variables are waiting time, journey time and above all, level of occupancy (comfort). They considered the other variables of little importance.

Dell'Olio et al., (2012) analysed users' preferences concerning the choice between the car and light rail or bus along a congested urban corridor. According to their stated choice experiment, important attributes are trip frequency, fares and parking costs. They show that the potential demand for light rail is higher than for the bus service, but it must guarantee a regular and frequent service, at the same time as charging competitive fares. Moreover, they conclude that it is necessary to act on parking tariffs, introduce higher fuel taxes and a congestion charge.

Chakrabarti (2017) finds that few car owners use transit, and that lack of access to the household vehicle(s) explain choice of transit to a large extent. For the car owners that sometimes use transit, important attributes are: fast (relative to car), frequent and reliable transit service along with fewer transfer requirements. Home and workplace neighborhood density, proximity to transit stop, and availability of rail are other critical facilitators.

Guirao et al., (2016) studies the importance of service quality attributes in public transportation. They conclude that journey time, cleanliness, the possibility of sitting during the journey are important public transport attributes based on a case study in Madrid.

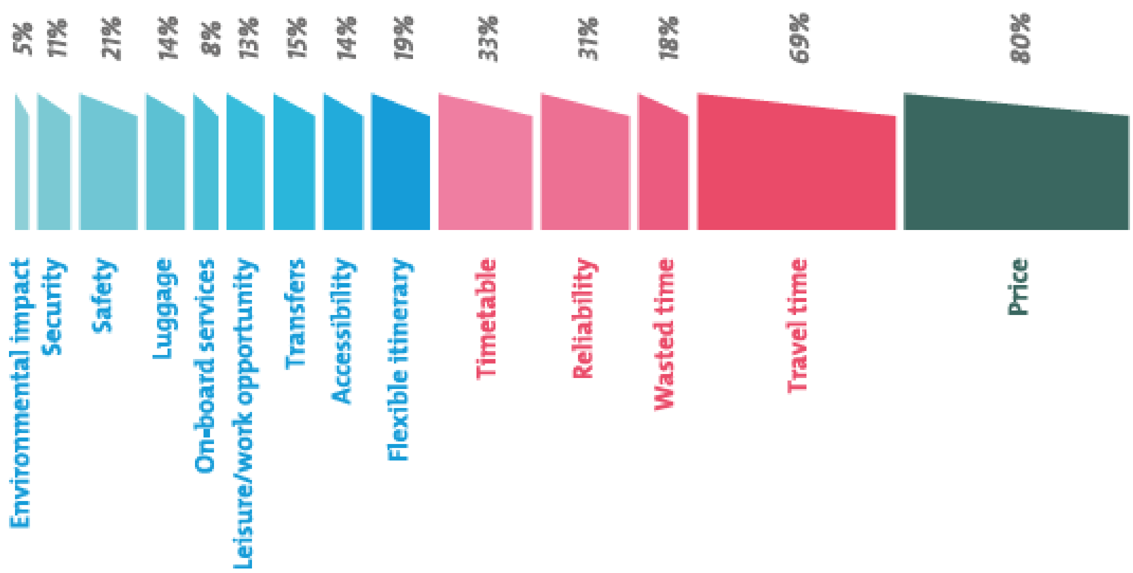
For choosing train versus car problems with car accessibility of the travel destination (high parking fees, high parking searching time, extreme congestion) are the most important factors that determine travellers' choice. Other motivational aspects for choosing the train above the car are usefulness of travel time and avoiding traffic stress factors (KiM, 2015).

In older literature (Bellinger, 1970) passengers mentioned travel time (25.3 %), punctuality (17.9%) and price (10.3 %) as the most important factors for their modal choice, over service and comfort (8.4%), tariff system (5.9%), frequency (5.7%) and number of stops (5.5%).

Customer surveys

A recent UIC questionnaire among 6,000 persons from France, UK and Spain (UIC, 2018) states price as most important factor for modal choice: 80% of the respondents selected price as a relevant modal choice criterion (respondents were asked to select five criteria at the most among 14). Time factors were mentioned as second most, for example travel time (69%), timetable (33%, as a marker for frequency and waiting time) and reliability (31%). Environmental impact (5%) and on-board services (8%)were mentioned least.

Figure 11 - Ranking of criteria in UIC questionnaire (UIC, 2018)



A multivariate analysis of a national passenger survey in the UK (Greeno & Hunt, 2013) shows that punctuality (42%), cleanliness inside train (16%) are the most important factors correlating with overall satisfaction. The way train companies deal with delays (51%) is mentioned as the most dissatisfying factor for satisfaction with the rail journey. Travel time (7%), frequency of service (5%) and value for money (2%) are also satisfying factors, but less important for total satisfaction with the journey. Although this analysis doesn't determine which factors are determinant for modal choice, this survey shows that reliability of time is a very important factor for customers' appraisal of rail trips.

NS customer surveys show time reliability and comfort are most important factors. Top five main factors are reliability (90-95%), ease (85-90%), safety (80-85%), price (55-75%) and speed (60-80%) (% importance) (Brons & Rietveld, 2009).

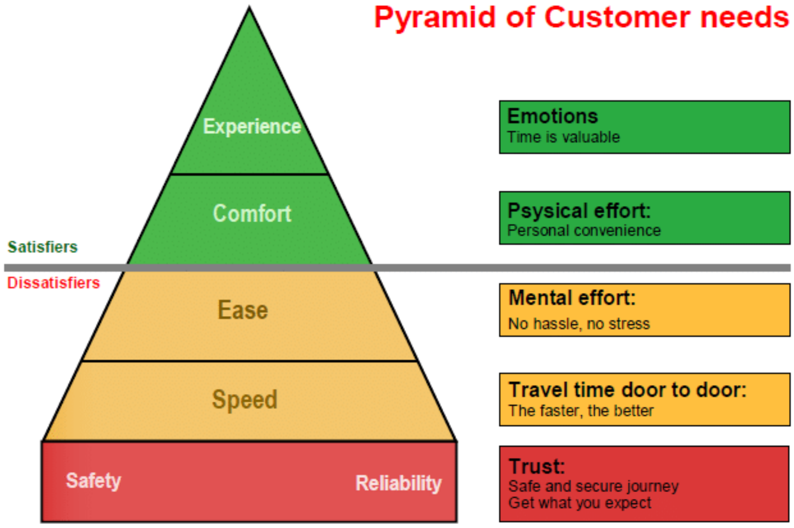
Stress as a factor

Legrain et al., (2015) assessed the stress of commuting, which is caused by an interaction between objective stressors and mediators (time, control, and comfort) and subjective stressors which act as mediators (feelings, desires, and satisfaction). Their results show that driving is the most stressful mode of transportation when compared to others. Stressors are mode dependent. For the car, an important stressor is congestion. Public transit users get stressed dependent on the mode used to get to the station, satisfaction with the time to reach the station (for train riders), and waiting time at the station, and unpredictability. It seems that having 'a plan B' for their commute lessens the stress of their trip. Importantly, stress can be reduced by increasing reliability, but also by information provision regarding delays.

The pyramid of customer needs

Van Hagen & Bron (2014) argues that in order to achieve a true breakthrough in customer satisfaction, railways need to focus more the emotional experience of the customer. He distinguishes between satisfiers (experience, comfort) and dis-satisfiers (safety, reliability, speed, ease) and explains that only satisfiers can truly raise the level of customer satisfaction to a high level. Often, rail operators focus mostly on achieving operational excellence (which is closely monitored by conducting regular customer satisfaction surveys) which leads to raising dis-satisfiers to an acceptable level. Van Hagen & Bron (2014) proposes the 'Pyramid of Customer needs', pointing out the difference between satisfiers and dis-satisfiers.

Figure 12 - Pyramid of customer needs



The base of the pyramid is formed by the basic needs reliability and safety (primarily social safety). Reliability indicates the degree to which passengers experience receiving what they expect. If the service is not available when and where customers expect it, it will result in their being dissatisfied. This means that trains must not only run on time but also that passengers should receive information when they need it and that it is trustworthy. Speed is the principal customer need, i.e. the majority of customers choose as short a travel time between origin and destination as possible. Additionally, the passenger wants the trip to be easy, i.e. convenient and with little hassle. Travel information and signposting are a help and must be seen as logical and unambiguous (Van Hagen & Bron, 2014). Satisfiers are comfort (sheltered waiting, sitting areas, comfortable seats, opportunity for other activities on the train) and experience. The experience is enhanced by architecture, design, cleanliness, used materials and colour, but also (day)light, smell and music can influence the quality of experience.

2.2.3 Differences between market segments and user groups

The importance of the various criteria is likely to differ per market segment. However, the amount of literature found on differences between market segments is limited. Below the main findings are listed.

Wardman (2013) showed that walk and wait multipliers (like mentioned in Figure 9) depends on trip purpose and trip length. Walk and waiting time has slightly more weight in shorter trips and in trips made for leisure, see Figure 13.

Figure 13 - Walk and wait multipliers for various trip lengths and trip purposes (revealed preference, Wardman, 2013)

	BUS				TRAIN			
Distance (Km)	5	25	100	250	5	25	100	250
WALK								
Commute	2.05	1.98	1.91	1.87	1.80	1.73	1.68	1.64
Business	1.85	1.79	1.73	1.69	1.62	1.57	1.52	1.48
Other	2.18	2.10	2.03	1.99	1.91	1.84	1.78	1.75
WAIT								
Commute	1.80	1.73	1.68	1.64	1.80	1.73	1.68	1.64
Business	1.62	1.57	1.52	1.48	1.62	1.57	1.52	1.48
Other	1.91	1.84	1.78	1.75	1.91	1.84	1.78	1.75

Also the value of travel time depends on the travel purpose. As can be expected, the value of time is much higher for business trips than for commuting or leisure (Kouwenhoven, et al., 2015). For a business traveller, the average value of time in the Netherlands is € 19.75 per hour, for commuting € 11.50 and for other travel purposes € 7.00. Although the values for other countries will be different, the ratios between different travel purposes are likely to be similar.

Long distance trips – rail vs. air travel

Specifically for people’s modal choice between train and air travel (so for long distance journeys), KiM (2018a) found the following ranking of criteria:
- travel time;
- number of travel opportunities per day;
- price;
- comfort (reservation system, travel information before and during travelling, luggage handling, comfort at stations/airports, comfort in train/air plane).

Important performance criteria for different user groups

Abenoza et al., (2017) point out that traveller’s behaviour, experience and satisfaction depend on individual attributes, contextual variables and attitudes. They show an overview of attributes that determine travel satisfaction among different user groups:
- Workers: Service attributes such as punctuality, frequency, bus driving security and information service are most important (Guirao, et al., 2016).
- Students: Ease of ticket purchase, on-board security and reliability ((Eboli & Mazzulla, 2009).
- Riders over 65: Comfort (Dell'Olio, et al., 2011).
- Women: Sense of security (Yavuz and Welch, 2010) and cleanliness (Dell'Olio, et al., 2011).
- Leisure travellers in Manchester: Ease is preferred over efficiency measures (Thompson & Schofield, 2007).
- Commuters in Dublin: Reliability of service, waiting times and comfort (Cantwell, et al., 2009).
- Non frequent PT users: Comfort (Dell'Olio, et al., 2011).

2.3 Ranking of criteria

The importance of the different criteria identified in the previous section differs per user and can also vary with trip purpose, length, time and frequency. Table 5 provides an overview of the main criteria and the importance for commuting, business and leisure travellers. The reviewed literature revealed that in general travel time, comfort and travel time reliability are the most important criteria for modal choice, followed by price and frequency. Annex A provides a complete overview of the most important criteria found in the literature.

The literature review revealed some specific assessments of importance of performance criteria for specific user groups, mainly on commuters and leisure. For business trips little literature was available. Based on the literature review and our expertise, we ranked the performance criteria from 1 to 3 +'s. For business, price is less important due to high value of times, while reliability and travel time are ranked highest. Accessibility did not appear frequently in the literature review, but is crucial for door-to-door travel time.

Table 5 - Main criteria influencing modal choice passenger rail transport

Criteria	Commuting	Business	Leisure
Travel time	+++	+++	++
Reliability	+++	+++	++
Comfort	++	++	+++
Accessibility	++	++	++
Price	++	+	++(+)
Frequency	++	++	+
Convenience	+	+	+
Safety	+	+	+
Environment	+	+	+

*For long distance transport, ticket prices are evaluated to be more important than on shorter distance transport.

2.4 Performance of rail passenger transport on the relevant criteria

As we have seen, the most important performance criteria for modal choice of rail are travel time, reliability, accessibility, frequency, price and comfort. Below we discuss the performance of rail for these criteria and also environment (which as we will see can be of importance regarding future trends, see Paragraph 4.1.1) and in most cases the performance compared to competing modes on the criteria identified in the previous section. As accessibility is closely related to travel times, it is not assessed separately.

Travel time

The travel time is determined by vehicle speed, service frequency, and transfers/waiting time. (Steer Davies Gleave, 2016) compares average speeds for European countries between the train and the car. The comparison shows that across all market segments (regional, interurban, international), the travel speed of the train is higher than for cars.
This corresponds to almost all journeys under and over 300 km, as shown in Figure 14 and Figure 15. Especially for journeys over 300 km, the average speed of the train is higher.

Figure 14 - Rail and car average speeds in European countries. Inter-urban trips under 300 km (Steer Davies Gleave, 2016)

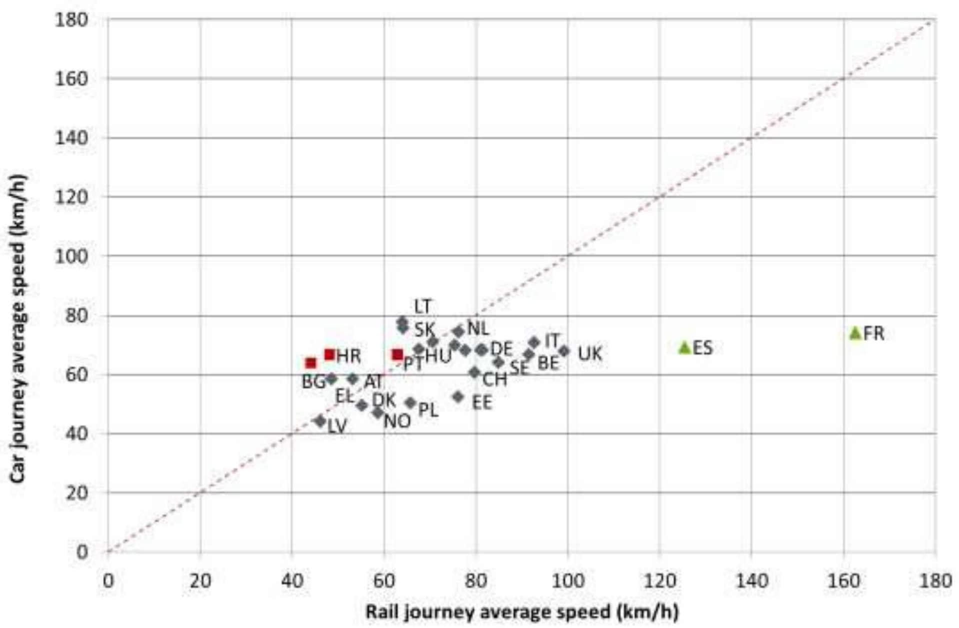
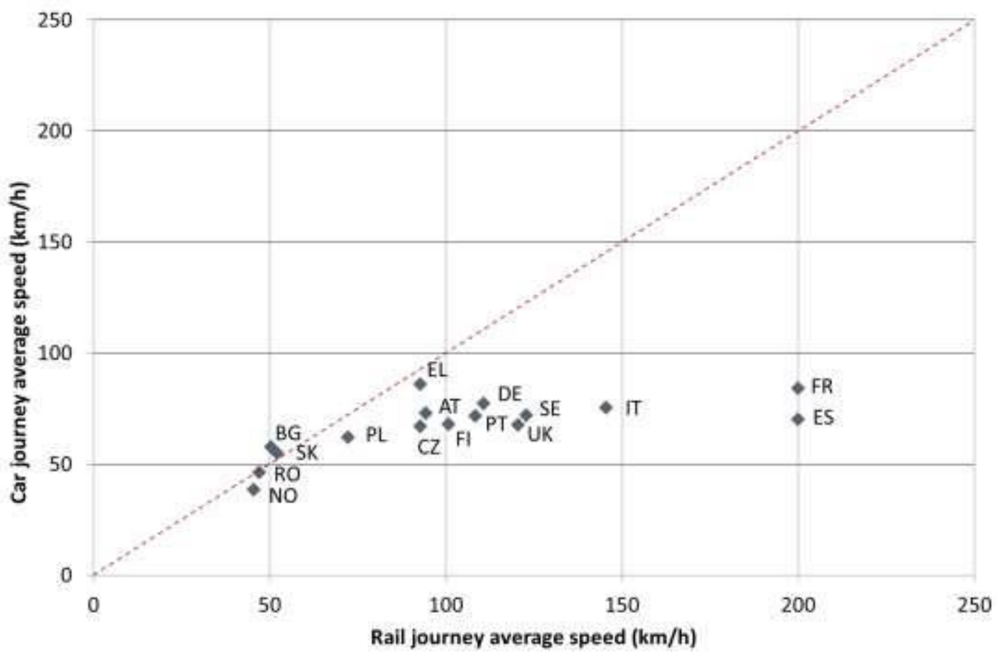


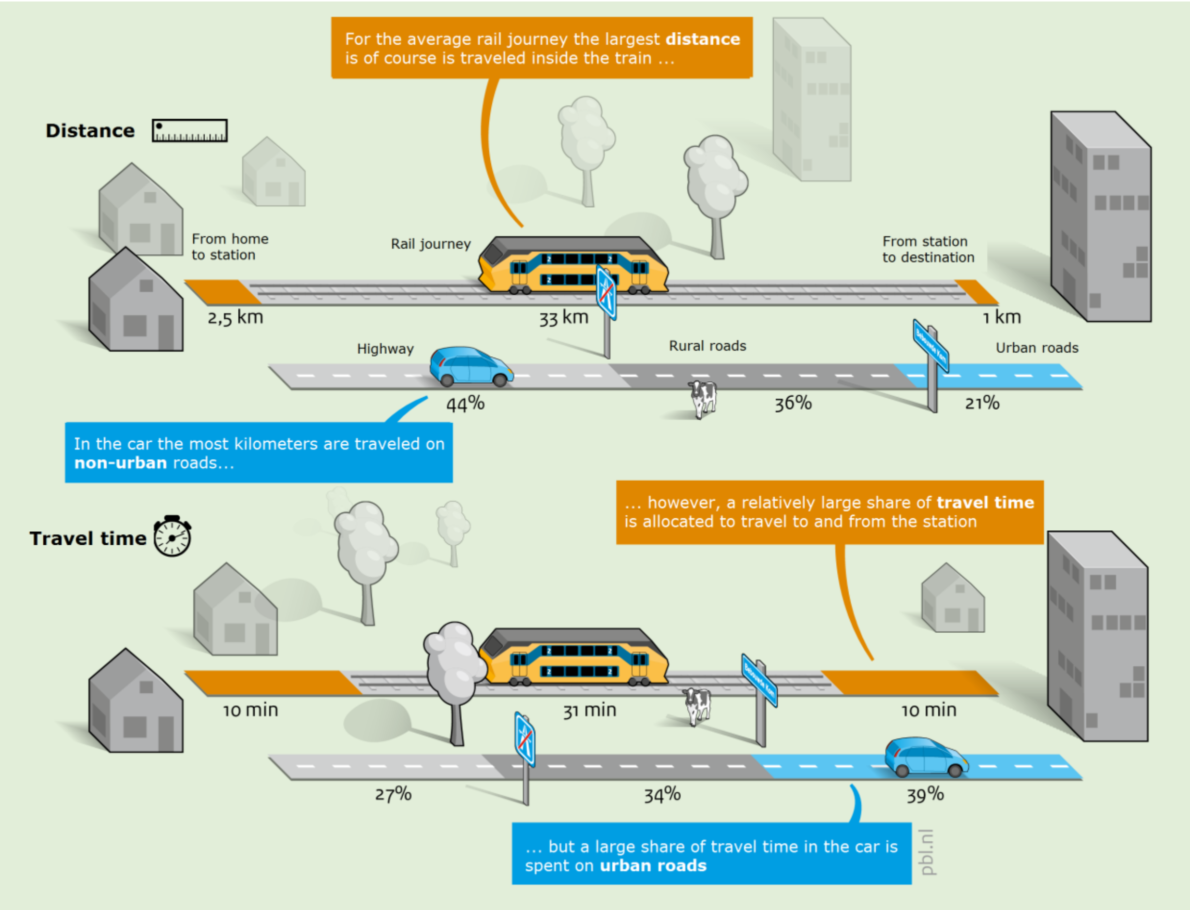
Figure 15 - Rail and car average speeds: Interurban trips over 300 km (Steer Davies Gleave, 2016)



As mentioned in Paragraph 2.2.1, However, it is important to note that not only the speed of the train itself matters. The travel time of public transport is highly dependent on de means of getting to the station and from the station to the destination, as illustrated by

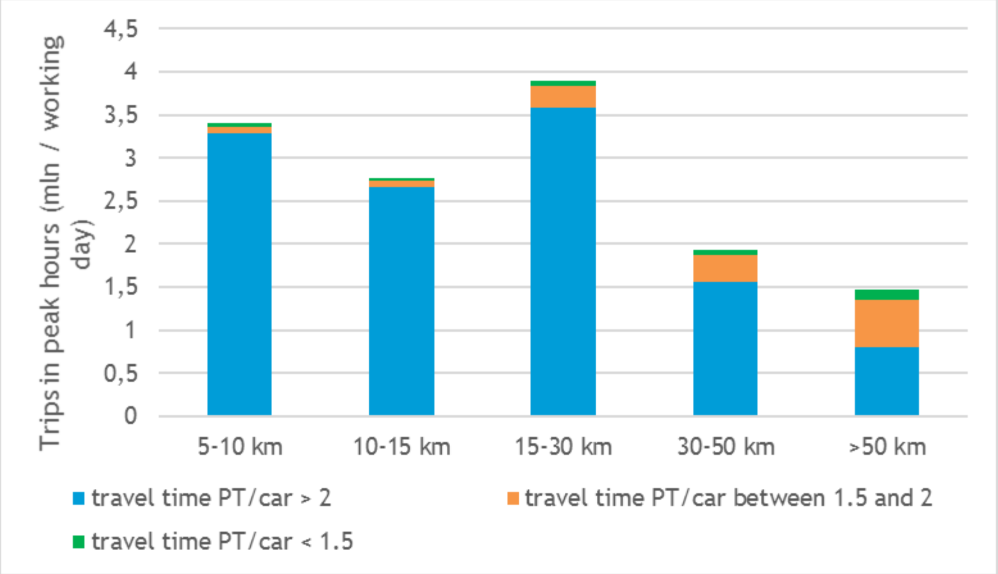
Figure 16. Although most of the kilometres in a rail journey are travelled inside the train, a large share of the travel time is spent waiting and travelling to and from the station.

Figure 16 - Illustration of differences between travel distance and travel time by train and car (PBL, 2015)



Due to travel from door-to-train and train-to-door, the total travel time for the train is in most cases considerably higher than for car travel. As shown in Figure 17, the public transport alternative for most of the car trips in the Netherlands is much slower (often travel time is more than twice as high), especially on short distances. In order to be more competitive, the travel time for the door-to-door rail travel needs to be decreased.

Figure 17 – Number of car trips in peak hours (million per working day) sorted by travel time ratio public transport/car and trip distance (KiM, 2015)



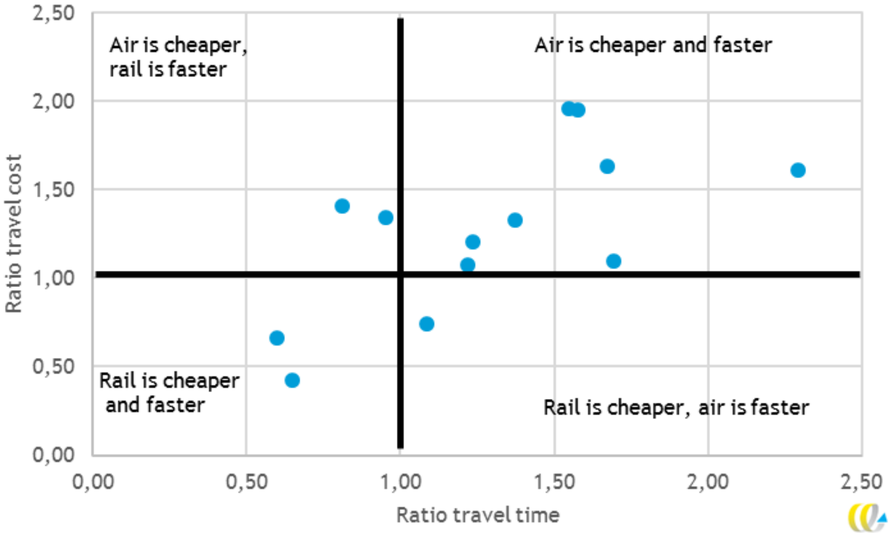
Air travel

Where for relatively short trips the service frequency and door-to-door transport is the dominating factor for travel time, for longer (international) trips the vehicle velocity is more important (KiM, 2018b). In some cases High Speed Trains have a shorter city-to-city travel time than air travel. For example, from Brussels, Paris, London and Frankfurt (amongst others) the high speed train is faster. But in most cases, even for distances below 700 km, door-to-door travel time of direct flights between cities is shorter than for rail transport.

As an example of time and cost comparison, Figure 18 shows the travel time ratios and cost ratios for rail and air transport from and to Amsterdam[1] (figure CE Delft, based on KiM 2018a). From this analysis it can be concluded that it is very dependent on the connection whether or not rail is cheaper and/or faster. In many cases air transport is cheaper and faster.

[1] Amsterdam Airport to/from the cities: London, Berlin, Copenhagen, Paris, Birmingham, Basel, Bristol, Frankfurt, Hamburg, Munchen, Hannover, Brussels, Dusseldorf.

Figure 18 - Ratios for travel time and travel costs between air and rail travel to and from Amsterdam



Improving the HSR network with extra connections can give a reduced travel time by train. For example, travel times to 25 European cities from Amsterdam could become shorter than travel times by air travel[2], where in the current situation this only applies for Paris, Brussel, Frankfurt and Dusseldorf. For such a HSR network not only new infrastructure is needed, but also improving travel comfort and (international) planning (Haskoning, 2018). Similar potential is available for many other large EU cities.

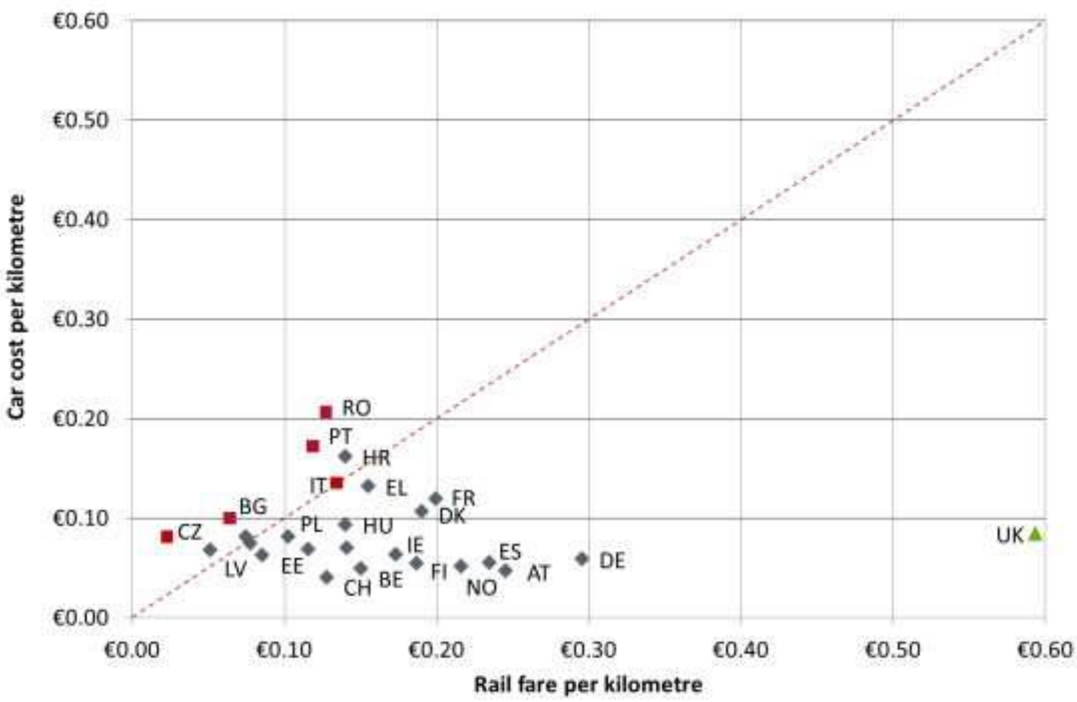
Price

The price of a rail ticket depends on several factors such as subscription structures and in case of a group (or family), the number of travellers. Also prices of other modes depend on many factors, such as taxes, price of car ownership etc. For example, in the Netherlands 65% of train trips are made with some form of subscription (27% student card, NS). In this paragraph, a cost comparison is made between rail and car travel.

Steer Davies Gleave (2016) gathered data on average car and rail ticket costs and travel times for regional trips, interurban trips (under and over 300 km) and international trips. Figure 19 and Figure 20 show this comparison for interurban trips. The car costs shown in these graph, are much lower than the cost usually reported. Car owner organisations like ADAC report car cost of around 40 euroct/km (e.g. for Volkswagen Golf). The main reasons for the very low costs used by Steer Davies Gleeve is that just the marginal cost are shown (i.e. the additional cost of an additional kilometre).

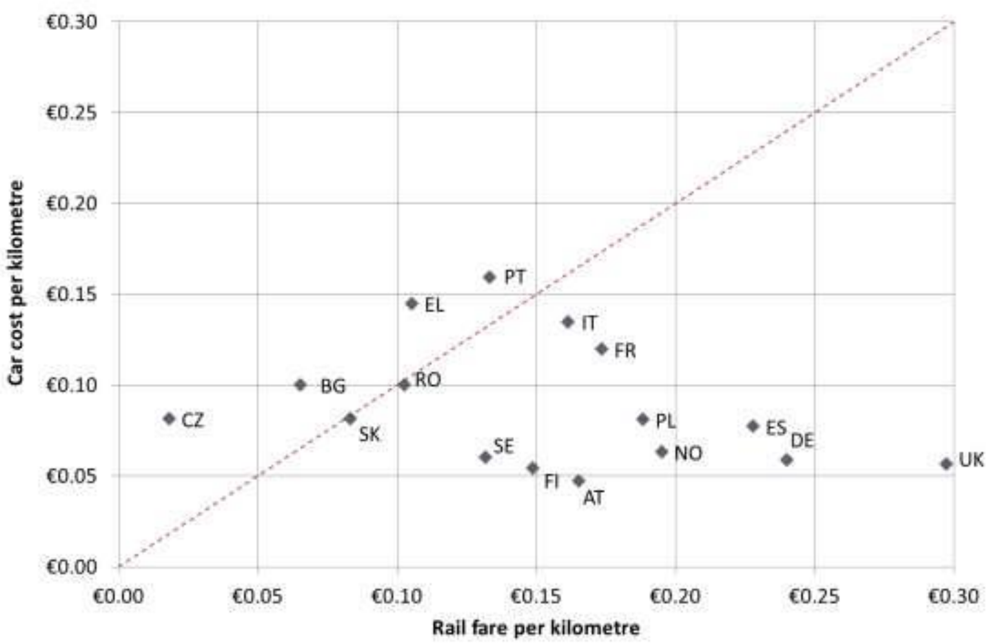
[2] Based on 3.310 km new infrastructure, maximum vehicle velocity 300-350 km/hour and train stops at 200 à 300 km.

Figure 19 - Rail and car costs: Interurban trips under 300 km (Steer Davies Gleave, 2016)



Similar cases are also found in longer distance interurban market (over 300 km) and the international market, where car journeys are all less expensive than rail.

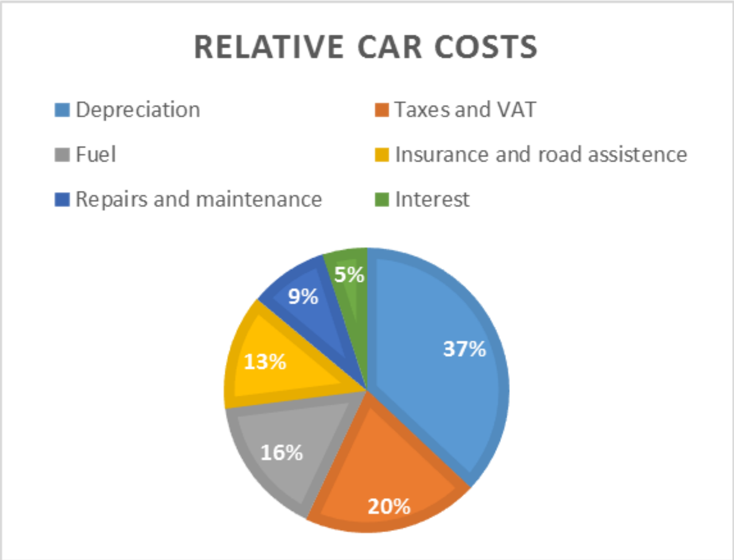
Figure 20 - Rail and car costs: Interurban trips over 300 km (Steer Davies Gleave, 2016)



For most regional and interurban trips under 300 km, rail journeys appear to be more expensive, on a fare per kilometre, than the equivalent journey costs by car.
Several contextual factors have to be taken into account by Steer Davies Gleave, 2016. The car journeys are solo occupant, which has an effect if more people use the same vehicle. With two persons using the same car, the journey price would become half. The same case with a train journey will not yield the same effect and train travel costs may remain the same.

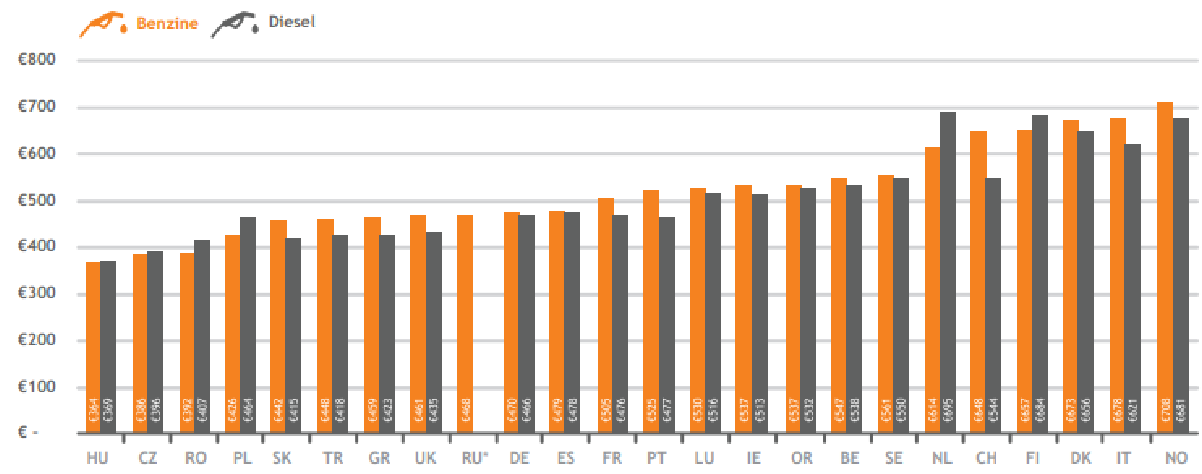
Another key issue to note is the oil price, which was at the time of the study (Steer Davies Gleave, 2016) at a historical low level. A sensitivity test conducted by the study, up to 30% higher oil prices, did increase car travel costs, but did not change the overall conclusions. In most cases, car trips are less expensive than train travel, although in the regional cases the difference became relatively small. A final contextual factor is depreciation, which is not taken into consideration by Steer Davies Gleave. 37% of car travel costs is due to depreciation, see also Figure 21. New vehicles will have higher depreciation than older (second hand) vehicles. In that case, car costs will be lower, although (greater) repairs to older cars may come more frequently.

Figure 21 - Relative costs for car usage for EU member states (for all vehicles using diesel and petrol) (source: LeasePlan, 2017)



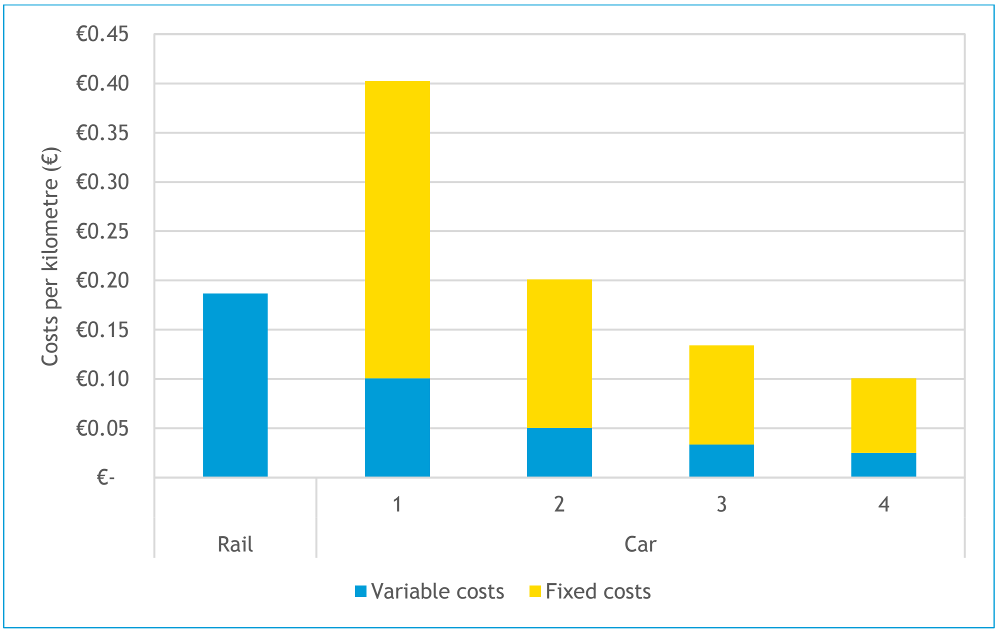
Also, vehicle costs differs greatly in Europe (see Figure 22). For instance, Norway, Italy and the Netherlands have high vehicle costs per month, while eastern European countries are on the other scale of the spectrum.

Figure 22 - Total car costs per month, for mid-class (B- and C-segment, Benzine (Petrol) and Diesel) cars driving 20,000 km's per year, in 24 EU countries (LeasePlan, 2017)Diesel vehicles are almost not used in Russia.



Ticket prices for trains and operational costs for cars are a skewed comparison. Since fuel and repairs and maintenance count for 25% of total car costs, the total costs per kilometre would be a factor four higher if fixed costs are included as is shown in Figure 23.

Figure 23 - Average rail fares (Steer Davies Gleave, 2016) compared to car costs per kilometre for 1, 2, 3 or 4 passengers including fixed costs

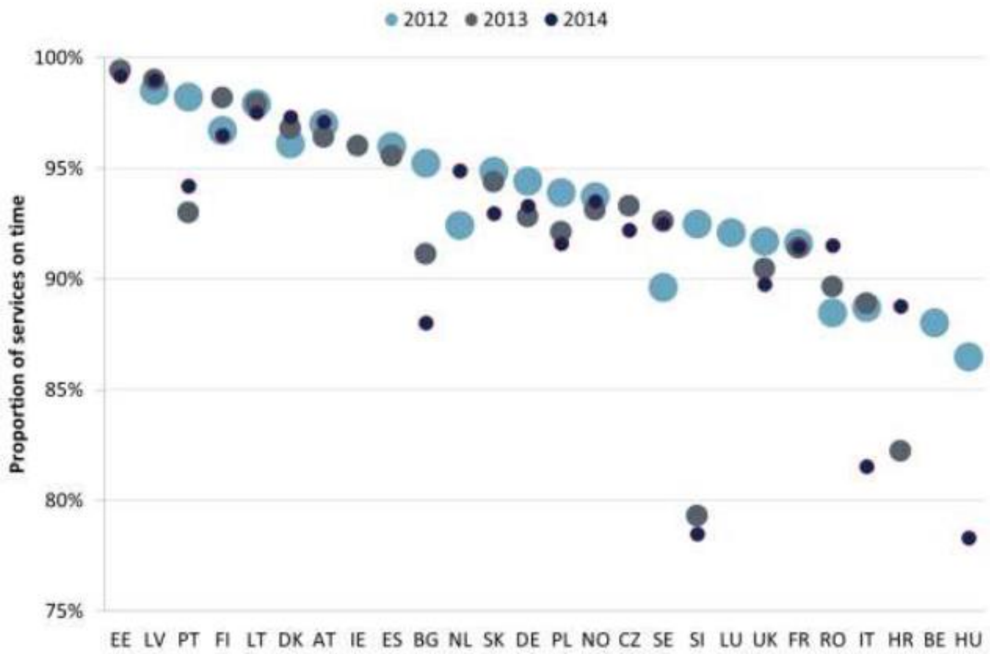


When fixed car costs are included, train fares are less expensive per kilometre than car for most countries in the EU for solo trips. The figure shows that car occupancy is crucial for the car costs. For commuters and business trips, the average car occupancy is just over one, while for leisure trips this is closer to two (Dickinson et al., 2018).

Reliability

As in urban areas the level of road congestion is often high, reliability of travel times can be an important competitive advantage of rail transport. In the case of scheduled transport services, reliability is often referred to as punctuality. The punctuality of rail services in EU Member States was assessed with data from the Rail Market Monitoring Scheme dataset (Steer Davies Gleave, 2016). Almost all countries achieve very high (>90%) punctuality scores, meaning that most trains arrive on-time at the stations.

Figure 24 - Punctuality of regional and local passenger services by Member State (Steer Davies Gleave, 2016)



ProRail/NS (2017) shows that the punctuality of passenger trains in the Netherlands, Belgium, Sweden, Denmark, France, United Kingdom, Switzerland has remained fairly comparable between 2012 and 2015, all achieving levels of 90-98% (measured with a threshold of 5.5 minutes) and averaging 91.2%.

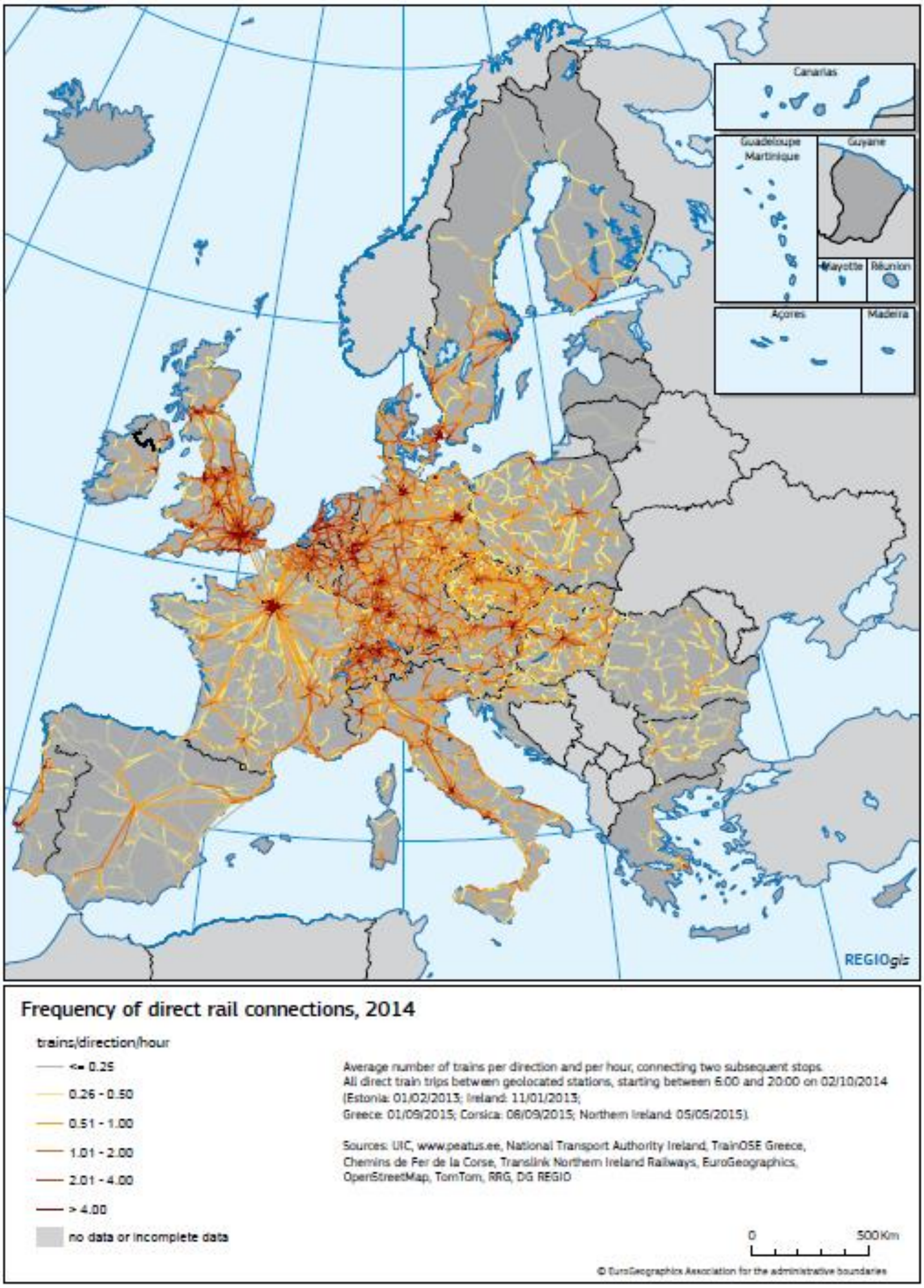
Car journey time reliability data is seldom published and often inconsistent between Member States (Steer Davies Gleave, 2016). However, in terms of delay, The Tomtom traffic index gives an indication of congestion levels, as measured by the average extra travel time percentage compared to free flow levels in the large cities in Europe (see also Text box 1 on Congestion).

Frequency

A key driver for the share of rail transport is the network and frequency of connections. Figure 25 shows the frequencies of connections at the European railway network. When comparing this map with the shares of rail in passenger transport in Figure 1, it becomes clear that all countries with a relatively high share of rail in the modal split (above 8%), have also high rail frequent services.

Also within the various market segments, there are significant differences between countries.
For example, high speed rail transport is strongly concentrated in Western Europe and virtually non-existing in Eastern Europe. The literature review (as presented in Paragraph 2.2) confirms that the speed of transport is for all transport purposes one of the key performance criteria when evaluating the potential of international rail transport. So it is clear that HSR is a precondition for a significant share for rail in international travel.
In general, main cities and agglomerations have a denser network and higher service frequency than rural areas. Trips in, to or from (main) cities dominate the train passenger market. In the Netherlands >50% of the train journeys is from or to the four main cities (KiM, 2015).

Figure 25 - Frequency of direct rail connections



Comfort & quality

The Flash Eurobarometer Survey on Europeans' satisfaction with rail services was conducted in 2012-13 to analyse public satisfaction with a number of features of rail transport. Steer Davies Gleave (2016) used the data to evaluate satisfaction levels related to comfort and quality of rail services, railway stations, ticketing attributes (ease of buying tickets), service frequency, punctuality.

The figures show an extremely high variation within the different countries. Most railways received satisfaction scores of 50-80% for punctuality and reliability. As with all subjective measures, however, it is not clear whether this reflects the quality of the facilities themselves or a disparity between customer expectations and actual performance. As was shown in the paragraph on reliability, punctuality is on a high level in almost all countries, so operators with similar actual punctuality can be given widely different subjective scores.

Less than half of Europeans are satisfied with the levels of cleanliness and maintenance of railway carriages, including train toilets, in their country (48%). Satisfaction is especially low in Romania, Hungary, Italy, Bulgaria and Slovakia. 68% of Europeans satisfied with the provision of information about train timetables and 67% of Europeans satisfied with the ease of buying tickets.

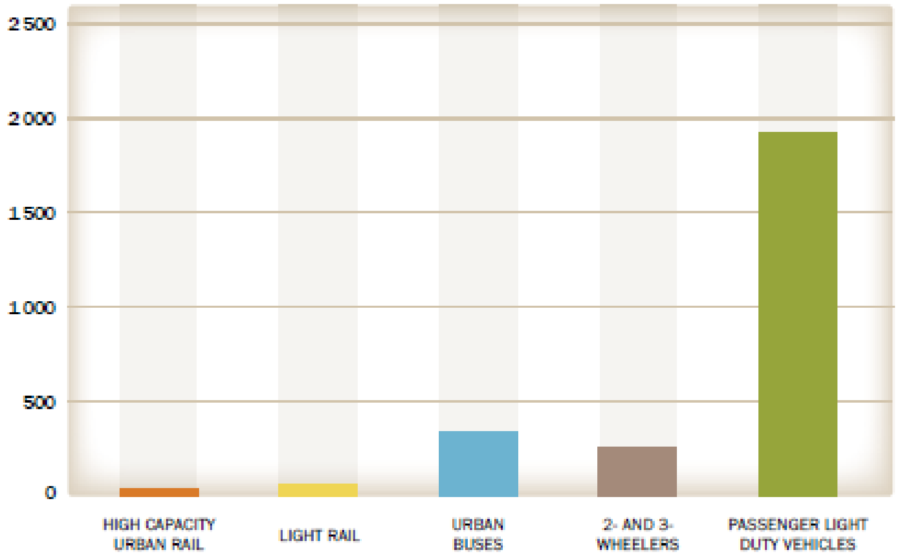
Satisfaction with ease of buying tickets exceeded 50% except in Estonia and was highest in France. However, the satisfaction with through ticketing was often low. A proportion of 55% of respondents score their level of satisfaction with rail services as 'high' or 'good'. There a clear distinction in satisfaction levels between Western and Eastern European Member States. The large differences in customer satisfaction in EU member states indicate that country specific measures are needed to improve comfort and perceived quality performance levels.

Environment

Travelling by train have less negative impacts on the environment than travelling by car or air plane. Rail transport has less emissions of CO_2, nitrogen, fine dust and noise. Rail travel is a sustainable way of transport, because energy consumption and CO_2 emissions per pkm are much lower than emissions of other modes. In Europe more than 60% of the rail network is electrified (IEA/UIC, 2018), which gives opportunities to use renewable energy on short term. In 2015 ca. 20 % of rail transport in EU-28 was energized by renewable energy (IEA ; UIC, 2017).

In cities, high capacity urban rail (including metro-networks) is a very energy-efficient transport mode, which results in low CO_2 emissions compared with other modes. Figure 26 shows the CO_2 emission of several city travel modes.

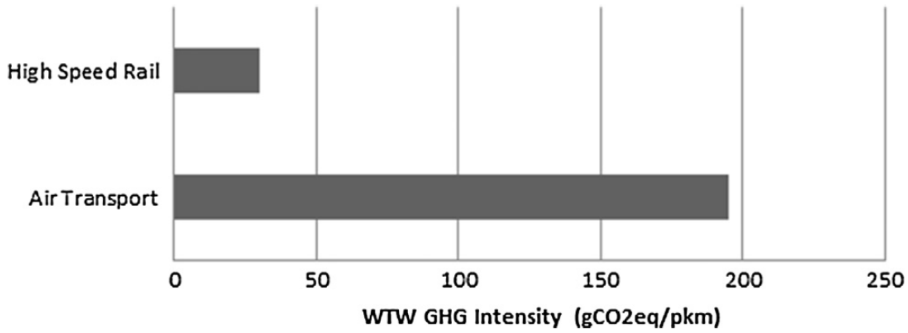
Figure 26 - CO_2 intensity by urban passenger transport mode (gCO_2/pkm, 2015 (IEA ; UIC, 2017)



Also for long distance trips rail travel is the most CO_2 efficient mode. For example, Figure 26 shows the energy consumption and CO_2 emissions for a 600 km trip by plane, car and train. In this case, CO_2 emission of rail travel is 8 times lower than a car trip and more than 11 times lower than air travel. Therefore, a modal shift from other modes to rail travel in short and long distance trips can help the EU to meet sustainable goals of the Paris agreement.

According to D'Alfonso et al., (2016) on average, when taking the Well to Wheel (WTW) emissions from the energy needed to propel the vehicle, high speed rail appears to be more efficient than air transport. They add that including infrastructure manufacture and maintenance carbon emissions into the HSR carbon intensity would add an extra 5 g CO_2/ kpm, which would not drastically change Figure 27.

Figure 27 - GHG benefits of railway versus air transport per passenger-km, EU average (D'Alfonso, et al., 2016)



Improving performance of public transport to attract car users

There is a significant amount of literature on projects, experiments, policies that promote the use of public transport by improving the performance criteria. Redman et al., (2013) selected 74 of those studies and assessed which performance criteria were targeted for improvement to attract car users.

Table 6 - Improvement strategies for attracting car users towards public transport

	Targeted quality attribute						
Improvement strategy	**Reliability**	**Frequency**	**Price**	**Speed**	**Access**	**Comfort**	**Convenience**
Network upgrades		2		2			
Extended service		6			5		
Rail lines replacing bus	9			10			
Underground improvements	3			3			
Integrated public transport systems (quality bus partnership)	7	2	7	8	7	9	9
Price mechanism (discounts, free tickets, integrated ticketing)			14		1		5
Bus rapid transit (BRT)	15	13		16	1	15	8
Improved information							2
Reduced distance between PT nodes					2	2	
Total	**34**	**23**	**21**	**39**	**16**	**26**	**24**

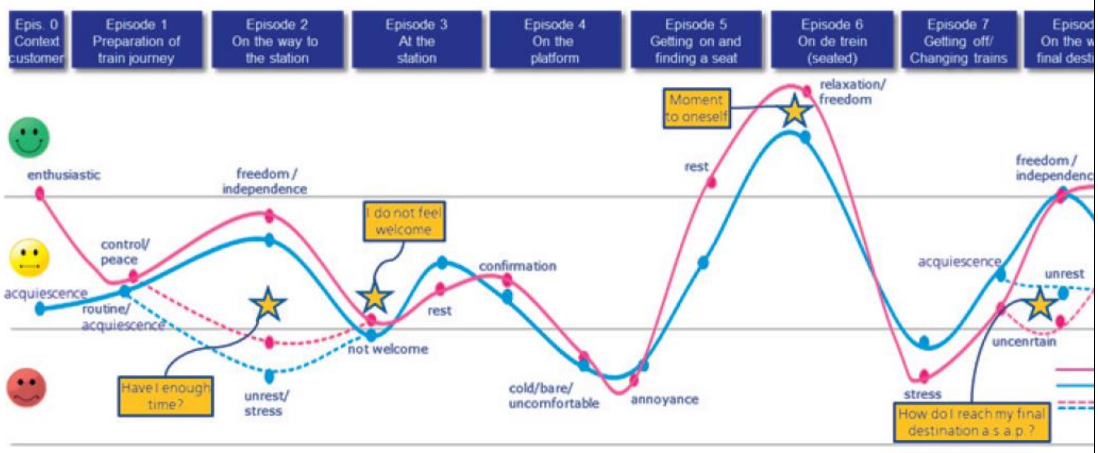
Almost all studies focused on improving physical attributes of public transport services, rather than perceived attributes. Most improvement strategies target several quality attributes simultaneously while service reliability and frequency are important PT attributes in general. Those attributes are most effective in attracting car users and connected to individual perceptions, motivations and contexts.

Redman et al., (2013) conclude that reduced fare promotions and other habit-interrupting transport policy measures can encourage car users to try public transport services initially. However, attributes over and above basic accessibility, reliability and mobility provision, perceived by the target market as important service attributes, must then be provided in sustaining the switch from car use after promotional tactics have expired. Van Hagen et al., (2017) argue that to achieve customer satisfaction, rail passengers experience needs to be improved by enhancing positive emotions during train travel, see Textbox 1.

Textbox 1 - The Power of a Pleasant Train Journey

Van Hagen uses his frame (the pyramid of customers' needs, see Section 2.2.2) to explain the emotional curve that rail passengers experience during their trip. Each traveller has certain needs and expectations regarding the service quality on the different attributes. When the experienced service quality is above expectations this will result in positive, happy emotions, and likewise when it is below expectations it will result in dissatisfaction.

Figure 28 - The emotional curve of train travel, for 'lust and must' customers



Based on train traveller satisfaction surveys, van Hagen (2014) finds that the peak in the emotional curve of train travel is reached when the passenger finds a seat. The curve can be used to make a difference in the travellers experience at four moments: During the access transport (travel information), when passengers arrive at the station (feeling welcome), ensuring that passengers have a seat and when leaving the station. Additionally, they find based on three experiments, that events and promotional actions can be used to generate positive attention for railway services that can be shared with others.
Finally, Van Hagen points out that passengers that enjoy their trip also share their positive experiences on social media and thereby promotional have a larger impact than other travellers on that trip.

3 Freight

In this chapter, the relevant performance criteria for rail freight transport are discussed. First, the relevant market segments are identified in the transport market, and for rail freight transport specific. Next, the performance criteria used by shippers and logistic service providers are listed and assessed resulting in a ranking of the most relevant criteria for market segments that can be identified. Finally the performance of rail and road transport are discussed for the main criteria.

3.1 Market segmentation and market shares

Market segmentation

The market for rail freight transport is by nature limited to routes where rail infrastructure is available or nearby. Due to the need for transhipment and eventually shunting, rail is typically a competitive option only for longer distances.

Freight transport on a national or continental scale can typically be decomposed into groupage (freight sizes of less than a truck load), single wagon/truck load, bulk transport and intermodal transport, see Table 7. Reasoning from the road/rail competition, the following market segmentation is defined.

Table 7 - Market structure freight transport

	Large industrial (bulky) goods shipments	Intermodal container shipments	Single wagonload shipments
National			
Continental			
Intercontinental	X		X

Note: X means a non-existing market.

The above market breakdown is used in monitoring European rail freight corridors. A further detailed market segmentation can be distinguished specifically for the rail freight business, which is presented in Textbox 2.

Textbox 2 - Rail market segments

Rail freight services can be ordered by unit (e.g. wagon or container) or as a full train. The following services are typically offered:

- *block train (typically bulk, e.g. coal, ores, grain or cars);*
  - Ordered by one client on request (can be part of contract), one origin, one destination. No shunting required, no pre- and end haulage.
- *Intermodal trainload (containers);*
  - Assembling of trains needed on rail yards, wagons from different customers. Includes container transport. Trains departs in a predefined schedule. Shuttle principle. Intermodal trains mainly leave from
    EU seaports.
- *Single wagonload;*
  - Groupage of number of wagons from various customers, which are then bundled. In the country of destination, the wagons are distributed again. Mainly relevant in Eastern Europe, and non-existing in other countries. Fixed time schedule, no pre- and endhaulage.

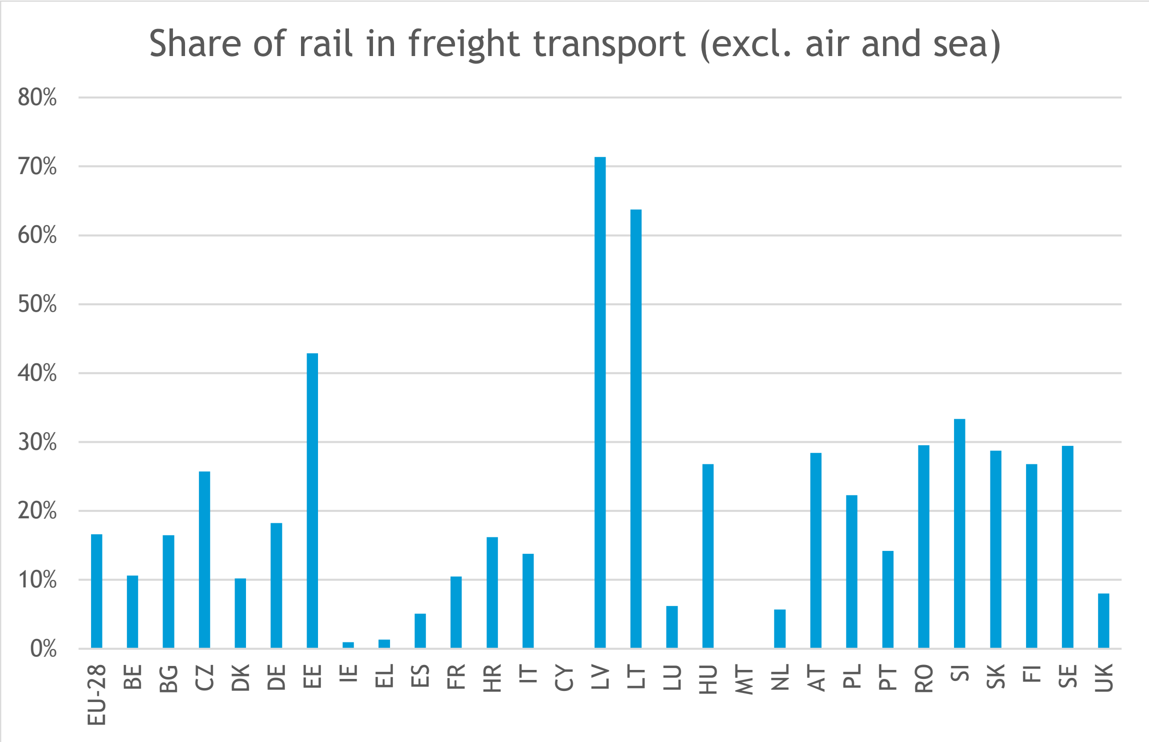
A very small additional category is the rolling highway, which is mainly seen in Alpine countries. Complete trucks are carried by a train. There are however less than 10 'rolling highway' connections in Europe; a very small market segment from European perspective.

Bulk transport is a natural market for rail freight transport on the routes where rail infrastructure is available, as rail can provide a cost effective shipment of goods that typically have a low value (Islam & Zunder, 2018). The market for large scale bulk transport is relatively steady and rail transport has a large market share (TNO, 2017), except in countries where navigable rivers allow the use of inland shipping. This is mainly the Rhine corridor. Large industrial companies with large shipments order their own direct rail service towards or from their customers or import/export hubs. Much bulk transport by road is on short distance (e.g. agricultural products such as potatoes and onions), which does not allow rail transport as a result of lack of rail infrastructure and the small size of shipments.

Size of market segments

The graph below shows the share of rail in the freight transport market in the various EU countries. On average the share of rail in the freight market is considerably larger than in the passenger market. The share is particularly large in some countries which have larger amounts of heavy bulk transport by rail, such as the Baltic states.

Figure 29 - Market share (% of tonne-km) of rail in land-based freight transport in EU Member States (2016)



Source: Pocketbook DG MOVE

Information on the share of market segments identified on EU level for both rail and road transport are rather scarce, since information is typically not available as required for this study. Data by mode of transport are available according to the revised standard goods classification for transport statistics (NSTR). This method does measure which type of goods are transported, but not how goods are transported (e.g. in a container or as wagonload). Data available from the EU rail freight corridors shows that all the markets identified are relevant, as illustrated in Table 8.

Table 8 - distribution of volumes over market segments for two corridors

Type of Cargo/RCF	**RCF3, Scandinavian - Mediterranean** Norway, Sweden, Germany, Austria, Italy	**RCF8, North Sea - Baltic** Belgium, Netherlands, Germany, Czech Republic, Poland, Lithuania	**Weighted average**
Total tonnes (in 1,000 net tonnes)	57,979	35,639	93,618
Intermodal/container	36%	19%	29,5%
Block train	26%	40%	31,0%
Single wagon load	38%	42%	39,5%

Source: (UIC, 2017)

Countries show significant differences in the volume of the single wagon load market. The SWL networks are important in some European countries (e.g. Germany, Belgium, Eastern Europe), but almost disappeared in other countries (Netherlands). In Germany, Austria and Czech Republic SWL has a market share of 35-45%, while in other countries this market is much smaller or not existing. In the countries for which PwC & La Sapienza (2014) reports data, its share (tonne-km) reduced from 50% in 2004 to about 27% in 2011[3].

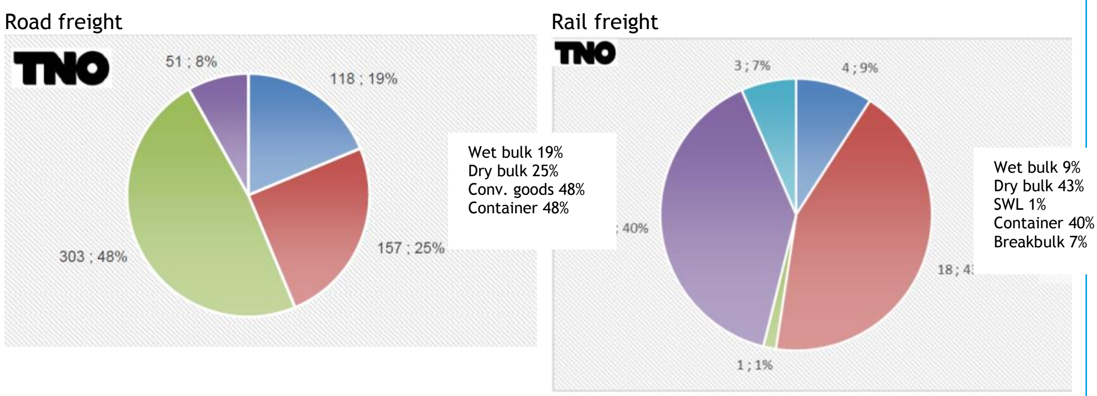
The distribution between national and international transport strongly differs between countries. Germany, Poland and the UK represent the majority of the overall domestic market, while the international market is more equally distributed over Europe, starting amongst others from the large sea ports. Measured in tonnes, the domestic market is the largest, but measured in tonne-km, both markets amount half of the total transport performance (Eurostat; SCI, 2016)

For the Netherlands, more detailed data is available in Textbox 3.

Textbox 3 - Market information for the Netherlands

Figure 30 shows the market segmentation for road and rail freight transport, based on an extensive national dataset. Conventional goods is the largest market, with a share of nearly 48% in 2014 in the Netherlands, measured in tons (Figure 1). The share of conventional goods transported by rail is 1%.

Figure 30 - Breakdown of the Dutch freight market in 2014 (tonnes)



TNO made an analysis on what the future share of rail could be in the Netherlands. TNO concludes that conventional goods is the main market where rail can show growth[4] (31 million tonnes), followed by the import and export of containers (6 million tonnes). Using an average weight of 10 tonnes/TEU results in a potential of 0.6 million TEU. This is supposed by using the principle of generalized costs that not only take the transport costs into account, but also the costs of longer travel times compared to road transport.

[3] Only reflecting a limited number of countries: DE, IT, PL, SL, SK, FL, SE.

[4] The analysis of potential growth was performed under the following assumptions: generalised transport costs, availability of infrastructure, no increase of generalised door-to-door costs, minimum one train per week, 15-30% of the existing road transport remains for urgent shipments. Generalised transport costs do include time costs, which are linked to the deterioration of products. If fresh fish is worthless after seven days, additional transport time goes not without costs.

From the scattered information available, we conclude that the largest market for freight transport is conventional goods, which is mainly continental transport, followed by bulk and container transport.

Potential for growth of rail transport

Conventional goods can potentially be shifted to rail transport, if the distance is long enough. 300 km is the typical distance where rail transport is expected to become competitive. However, this depends on many factors as commodity type, speed of rail service, need for pre- and end haulage, etcetera (TNO, 2011).

The focus of the White Paper goal is the segment of road freight transport covering distances above 300 km. This segment constitutes 11% of tonnes lifted and 56% of tonne-km within road freight. The remaining 89% of the road freight market in tonnes shipped over distances below 300 km. However, the potential over 300 km amounts to about twice the size of the current share of rail transport (Eurostat/Transtools). The EU ratio of shipments over 300 km is 80% road transport and 20% rail transport.

The major groups of goods (NST, 2007) carried by road transport exceeding 300 km are food products (17% tonne-km), agricultural products (10% tonne-km), mixed goods (10% tonne-km), chemical products (9% tonne-km), metal products (9% tonne-km) and wood, paper and pulp (8% tonne-km) (Eurostat, 2012).

Rail transport linking Europa and Asia is upcoming, under the development of the New Silk Route (NSR). Currently rail transport covers a little part of trade turnover between China and EU(28) – or about 500,000 tons (Economist data). Many train services have been set up in recent years. Last year, trains arrived for example in London, Amsterdam and Antwerp.

Variations within the market segments

As for passenger transport, within these markets various sub segments can be defined.

Continental transport needs to be distinct from maritime transport. This distinction is important, because maritime containers are transhipped once for the purpose of rail transportation (inland terminal, transhipment in the seaport is needed anyway). This is often twice for continental transport, where containers are transported pre- and post-rail transportation. In addition, there are often many existing rail services from seaports available, increasing the potential for modal shift.

Also the type of goods may influence the preferences and requirements from the shipper. High value goods (medicines) typically have a higher value of time and reliability than low value goods, resulting in another set of requirements from rail services. An upcoming market is the shipment of reefers, requiring the use of electric power during transport, as well as monitoring and reporting of the conditions during transport.

3.2 Performance criteria

Shippers use certain criteria to determine whether to choose freight transport via road, rail or water. The importance or ranking of these criteria differs per market segment. Modal choice is also strongly influenced by the infrastructure limitations and geographical

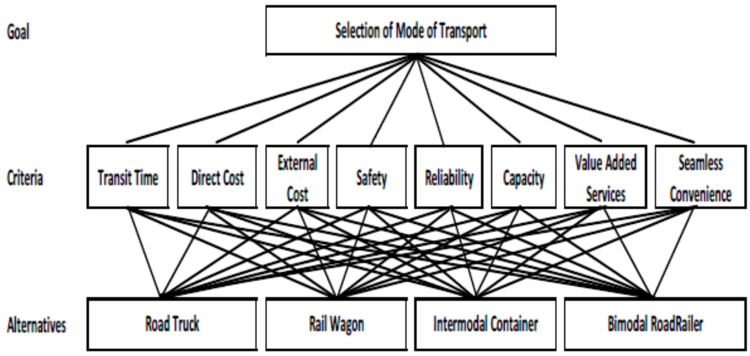
constraints of the location in which the decision is being made (Bury, et al., 2017).
This chapter identifies the criteria used by shippers and presents a ranking of these criteria.

It should be noted that much of the literature illustrating shipper preference is based on stated preference research, which is extremely sensitive to the way questions are pronounced. This implies that the results from research are often difficult to compare.

3.2.1 Rail freight criteria

Work in the field of modal choice and the related fields of route choice and carrier selection has been documented in scientific literature. Criteria are used by the shipper to assess which transport mode is best suited for the particular situation and cargo. What are, for instance, the costs of a particular freight mode and what is the transit time? Figure 30 displays an example of a selection model, where eight criteria are used to determine the appropriate mode.

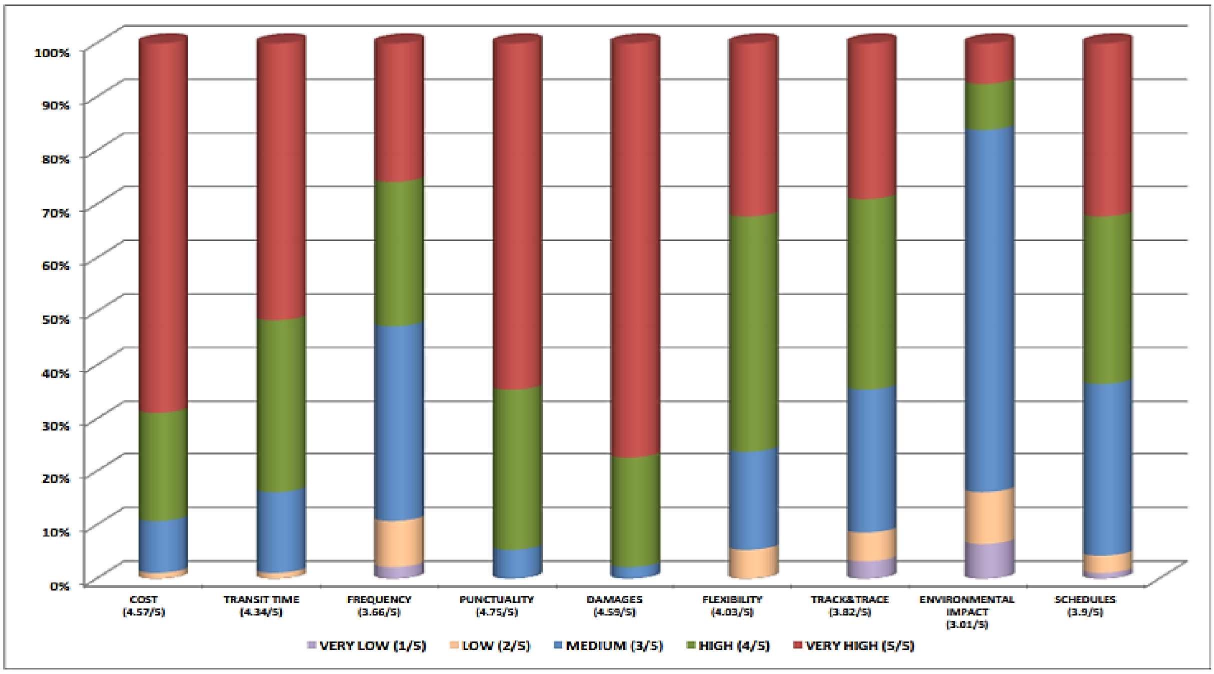
Figure 31 - Model for selection of freight transport mode using criteria (Vashist & Dey, 2016)



Appendix A presents the total list of criteria found identified the literature review, for ten studies. Overall, more than 30 criteria were mentioned in the studies. The criteria most frequently mentioned are direct costs, travel time, flexibility, reliability, frequency, environmental and traceability. Also Bury, et al., (2017) lists popular and less popular criteria, and concludes that costs, distance, transit time, delays, service frequency, controllability and traceability are amongst the important criteria. Other underrepresented criteria in previous modal choice studies are; Pollution, security, claims processing, safety record, image of mode and finances (Bury, et al., 2017).

Selected Preference theory is used to determine the most important attributes or criteria for freight transport mode selection. Figure 31 displays results from such research, from which scores on importance can be concluded.

Figure 32 - Example of Stated Preference theory result, used for selecting freight mode, from Arencibia et al., (2015)

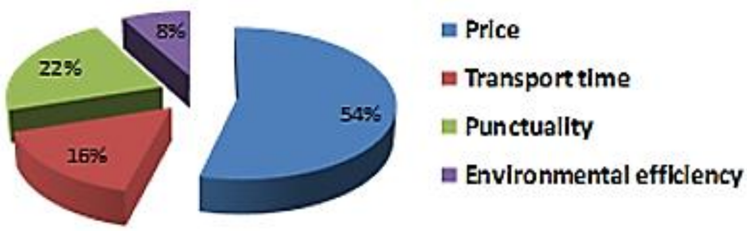


3.2.2 Criteria assessment

A variety of criteria are used to make transport modal choices by shippers. Several studies ranked cost as the most important factor in freight transport mode selection (e.g. Danielis and Marcucci, 2007; Punakivi and Hinkka, 2006; Eng-Larsson & Kohn, 2012; Large et al., 2013; Lammgård & Andersson, 2014), followed by transport time, reliability and the quality of shipping. If the basic delivery conditions on transport quality (limited chance of damage and reliable delivery time) are met, then most modal choices are made on a difference in transport costs (Flodén, et al., 2010). However, cost will often have to be traded against other quality measures, such as transport time, punctuality and frequency (Hanssen, et al., 2012).

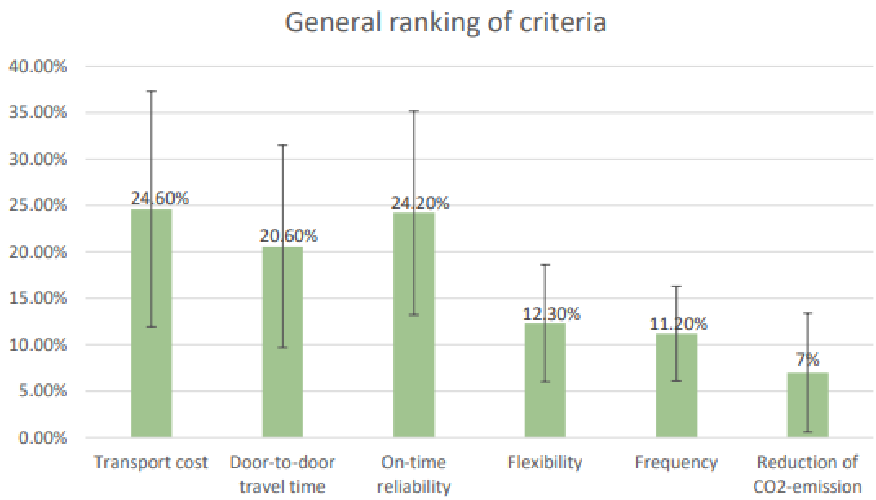
According to a survey done by Lammgård et al., (2013) transport costs rank considerably higher than punctuality, transport time and environmental efficiency. Interestingly, a highly comparable result across these four criteria (51, 23, 18 and 8%) was attained in previous research done in 2003 by the same authors (Lammgård, 2007). This would indicate that the criteria importance or ranking has not significantly changed in ten years.

Figure 33- Stated choice on freight transportation modal (Lammgård, et al., 2013)



Research from Liu (2016) reveals the relative importance of the price, travel time and reliability but concludes that these have almost the same importance, see Figure 34. The Standard deviation in the stated preference results is large. This may be explained by difference in market segment, background of the respondent (academic, shipper, LSP) and the complexity of stated preference research.

Figure 34 - Distinction of transport mode criteria (Liu, 2016)



Another identification of criteria relative importance can be seen in Table 9. In this research case in Europe, maritime container transport costs from Rotterdam to the South of Germany[5] have a far higher importance as criteria than transport time, frequency and additional IT services (as tracking and tracing/ebooking). An increase of the transport rate of 30 euro (~5%) is more important than a reduction of the transport time of five hours, a doubling of the frequency or IT services.

[5] Shippers included in the survey are for example John Deere, Nestle, Robert Bosch, BASF, Daimler, Goodyear, Unilever, STihl, Merck.

Table 9 - Relative importance of factors and benefits of levels for the freight forwarder (TU Darmstadt, 2018). Left table is English translation.

Selected factors	Relative importance	Level	Impact of the level
Transport costs	43%	€ 450	1,28
		€ 480	0,13
		€ 550	-1,41
Transport time	26%	15 hours	0,69
		20 hours	0,24
		40 hours	-0,93
Frequency	18%	2 times/week	-0,56
		3 times/week	-0,03
		5 times/week	0,59
Additional IT services	12%	None	0,27
		eMarketplace	-0,51
		Tracking & Tracing	0,24

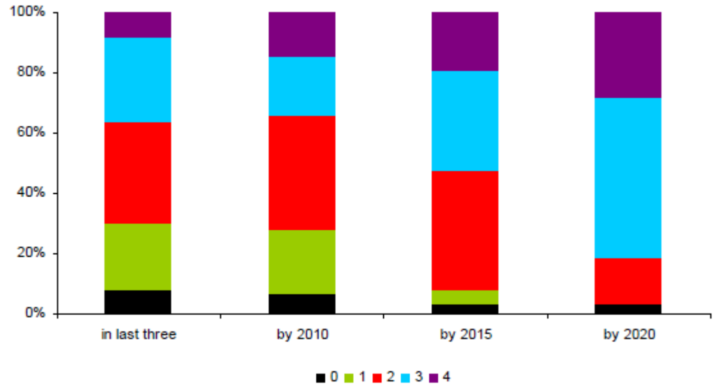
Ausgewählte Faktoren	Rel. Wichtigkeit	Level	Nutzwerte der Level
Transportkosten	43 %	450 €	1,28
		480 €	0,13
		550 €	-1,41
Tranportzeiten	26 %	15 Stunden	0,69
		20 Stunden	0,24
		40 Stunden	-0,93
Frequenzen	18 %	2x pro Woche	-0,56
		3x pro Woche	-0,03
		5x pro Woche	0,59
Zusätzliche IT Dienstleistungen	12 %	Keine	0,27
		eMarketplace	-0,51
		Tracking & Tracing	0,24

Environmental criteria

Platz (2008) mentions that shippers also consider the environmental impact of their mode choice, but only for reasons of marketing or public relations. In general it seems that cost advantages are the main underlying reason for shippers to choose for a more energy efficient and climate smart transport system. Environmental performance as a market criterion itself does not seem to play a very significant role as a driver for change (Conlogic AB, 2013).Furthermore, customers are not willing to pay much of a premium for environmentally friendly transport (Akerman, et al., 2014).

Attitudes towards environmental reasons as a criterion may change in the coming years. Some shippers and forwarders have made sustainability as a company target and expect that the importance will increase in the coming years (Van den Berg, 2014). Survey research done by Piecyk & McKinnon (2009) provides and insight in the distribution of environmental criteria in freight transportation. Increasing emphasis is expected in coming years, growing from 2006 (last three years from 2009) to 2020, as can be seen in Figure 35.

Figure 35 - Impact of climate change concerns on companies' freight transport operations (Piecyk & McKinnon , 2009).
0 is no impact, 4 is large impact.



3.2.3 Differences between market segments

Although in general costs is the most important criterion, speed is a more important selection criterion for industries producing goods with high value/kg ratio and short life cycles (electronics/fashion) than for industries producing less time-sensitive products. Consequently, pharmaceutical trade usually goes from one continent to another by air freight, whereas road freight is the most important mode for transport of construction materials (Punakivi & Hinkka, 2006). In cases of high-value products, the relative costs of transport are low, and consequently other criteria become more important. See Figure 36.

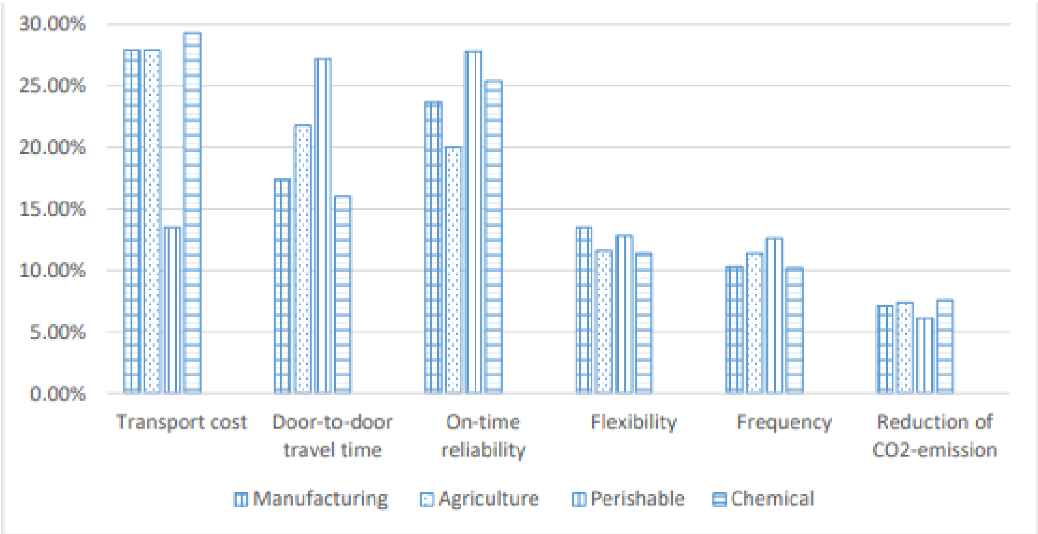
Figure 36 – Ranking of mode election criteria (Punakivi & Hinkka, 2006)

Criteria ranked by importance	**Electronics**	**Pharmaceutical**	**Machinery**	**Construction**
1	Quality	Speed	Price	Price
2	Speed	Convenience	Reliability	Scheduling
3	Price	Safety	Punctuality	Punctuality
4	Convenience	Fluency	Speed	Convenience

Speed is also linked to flexibility. Backorders can be a result from low-speed transportation, as there is a correlation between transit time and the order quantity when replenishing the inventory. A high frequency enables the shipper to adapt to sudden variation of demand, with the benefit of increased flexibility in the supply chain.

Figure 37 shows that perishable goods have a significantly different ranking of criteria than other freight goods. The difference between perishable and non-perishable goods lies in the importance of transport costs and door-to-door travel time. Part of the costs of perishable goods is related to the time dependant value of the goods. The longer the travel time the higher the time costs. Non-perishable goods such as bulk and certain container goods/SWLs regard transport costs as the most important criteria. These goods do not lose value over time as much as perishable goods, so the costs are primarily the transport costs itself. For example perishable goods are particularly time sensitive, with rough assessments indicating price reductions of between 20 and 25% for fresh fish which is delayed in transit by 48 hours (Lervåg, et al., 2001).

Figure 37 - Comparison among four types of commodities (Liu, 2016)



The popularity of truck transportation for perishable goods results primarily from high speed, network connectivity, convenience and flexibility. From this perspective, a distinction can be made on the goods that need to be transported. Time sensitive goods tend to be transported with modes which provide low travel time (high speed), punctuality and flexibility. Rail transport is yet experiencing in this market (Islam & Zunder, 2018). In upcoming market segments rail can find opportunities to capitalize upon. These subjects will be discussed in Chapter 4.

3.3 Ranking of criteria

It is difficult to prioritize the different drivers distinguished in detail, as evidence from literature for ranking is limited. There is, however, significant evidence that direct costs is in general the most important criterion, especially in markets where the time costs and stock costs play a limited role.

In the bulk market cost has absolutely the highest priority. If a set of basic conditions is met, rail transport will be used since the gap in direct costs with road transport is large.

Table 10 presents a selection of the most important criteria which shippers use in considering freight transportation modes, for maritime containers and continental freight. In most cases costs are the predominant factor for users. The criteria are qualitatively judged, based on statements and surveys from literature analysed in the previous section.

Table 10 - Criteria importance ranking for maritime containers and continental freight

Criteria	Perishable goods/high value	Non-perishable goods/low value
Costs	+++	++++
Delivery time	++++	++
Punctuality	++++	++
Flexibility	++	++
Frequency	++	++
Transport safety	++	++
Transport security	++	++
Convenience	++	+
Network connectivity	++	+
Environmental efficiency	+	+

3.4 Performance of rail transport on the relevant criteria

The overall performance of rail freight can be analysed by using the indicated criteria in Table 8. Out of the criteria shippers use to determine their mode of transport the transport costs, delivery time and reliability/punctuality are the most important criteria.

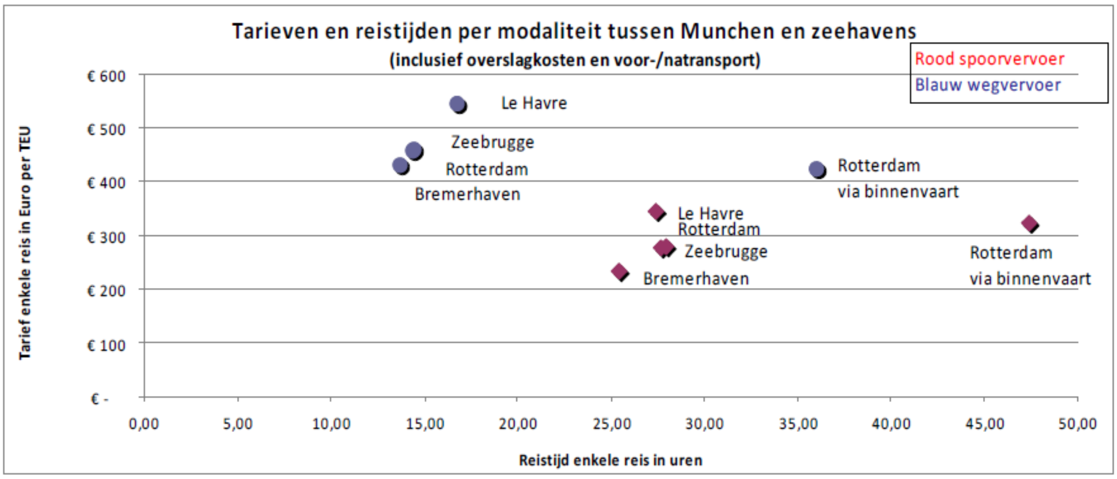
For many commodities and practically all distances below (roughly) 200 km, road transport is superior to rail transport in terms of cost and feasibility (CE Delft, 2011). As discussed before, the tipping point is around 300 kms. In particular, the combination of flexibility, speed, transparency, simplicity and trouble-free border crossing makes road transport, especially on short distances, a mode difficult to compete with. The huge share of road in total inland transport performance in many European countries is a clear illustration of its market dominance (CE Delft, 2011).

Below, the performance of rail transport on the various decision criteria is illustrated, compared with road transport.

Transport costs

Figure 38 shows costs comparisons between road and rail transportation of intermodal containers between Munich and connected seaports. TEU container costs are significantly lower in rail than those of road transport.

Figure 38 - comparison between price and travel time for transport from seaports to Munich (KNV, 2014)



Van den berg (2016) provides an overview of the costs for single and round trips between Rotterdam Maasvlakte II and Nijmegen area (150 km), including handling as depicted in Table 11.

Table 11 - Transport costs including handling (euro)

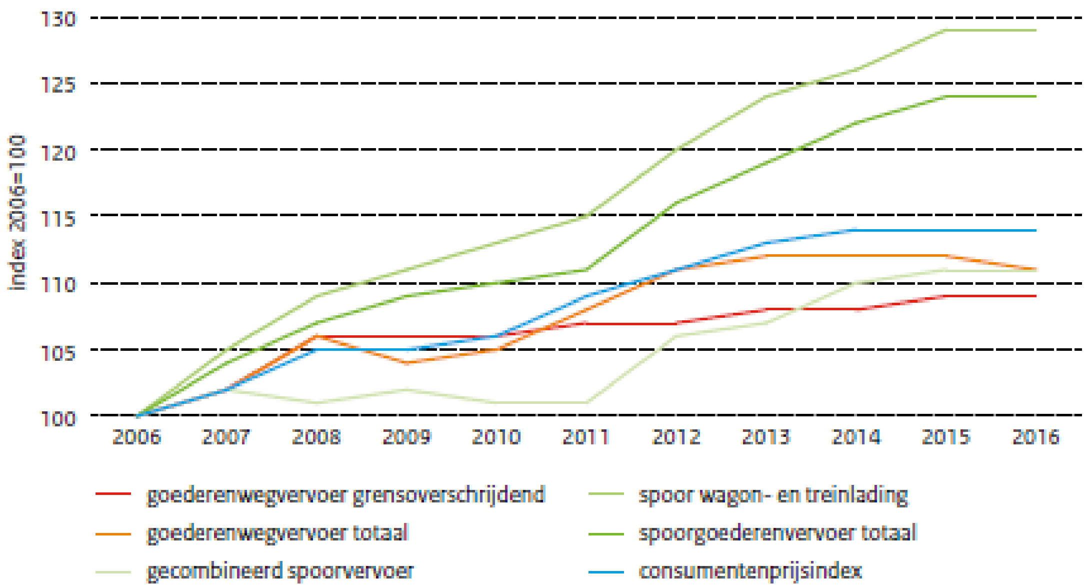
	Single trip		Round trip	
Mode	**20 ft**	**40 ft**	**20 ft**	**40ft**
Road	270	300	360	400
IWW	90-130	110-160	165-180	200-220
Rail	80-110	160	120-220	240-320

Source: Van den Berg (2016)

The cost competitiveness of intermodal transport solutions does to a large extent depend on the costs of pre- and end haulage. This accounts for between 25% and 40% of the total cost of moving an intermodal unit (Kreutzberger, et al., 2006).To make intermodal transport a preferred alternative to road haulage, generalized transport costs would have to be equal or lower (Klink & Berg, 1998), thus the extra costs due to pre- and end haulage as well as transhipments at the intermodal terminals must be offset by the lower costs of the long-haul transport (Bärthel & Woxenius, 2004).

For conventional goods, the cost competitiveness of the single wagon load segment has deteriorated. Figure 39 below shows the price index of the various transport modes. The figure shows the decline of the competitiveness of single wagonload rail freight transport in Germany. Only 25% of the overall costs, including track access charges, are associated with main leg transport (PwC & La Sapienza, 2015). Almost half of the costs are associated with marshalling and distribution. The loss in competitiveness can be explained by the decline of the single wagon load market in many EU countries, putting the train load factors under pressure.

Figure 39 - Trends in competitiveness road and rail freight transport over time in Germany



Note: green (olive) refers to SWL, dark green refers to total rail, blue refers to consumer price index, orange refers to total road transport, red refers to international road transport, grey refers to combined transport.

Punctuality

In research done by PwC & La Sapienza, (2014) a survey revealed that 75 to 90% of SWL trains have less than one hour of delay. UIC (2017) reports a punctuality of between 67% and 78% for the European freight corridors, defined as a delay of less than 30 minutes. One possible reason is that delays can occur due to the lower priority freight trains receive on combined railroads with passenger trains.

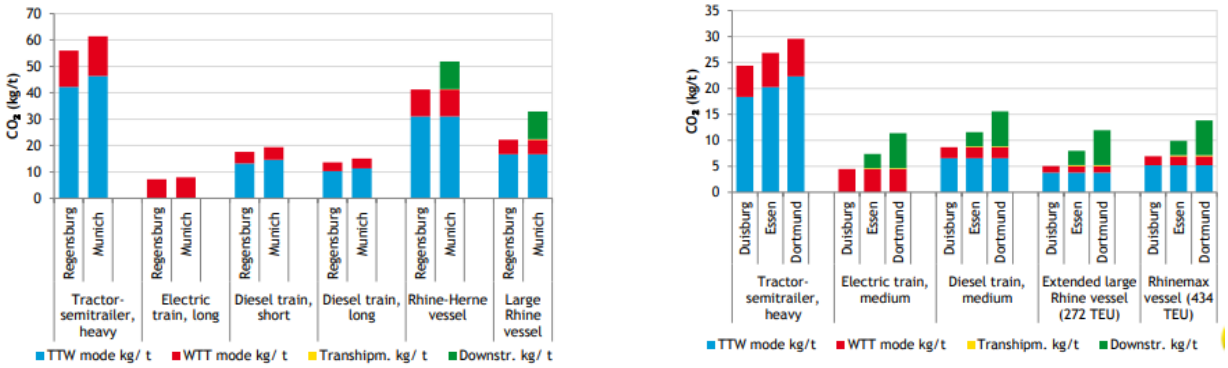
In a case study research by Krüger & Vierth (2015) the 10% longest delays constitute more than half of the total delay time, showing a skewed distribution of transport delays. Since rail transportation has a lower level of on-time reliability, costs associated with delays have to be taken into account. Costs rising from delays are precautionary costs, operational costs and stock-out costs.

The punctuality of road transport is not very different. This was demonstrated by the UK Transport KPI surveys, which analysed the causes of ‘deviations from schedule’ across a sample of 55,820 truck movements in seven sectors (Piecyk & McKinnon , 2009). It found that 26% of these deliveries were delayed, but only 35% of the delays were due primarily to traffic congestion. The average duration of the delay due to traffic congestion was also relatively short averaging 24 minutes, 17 minutes less than the unweighted average for all delays. It should be noted that the road figures also include short distance trips, hindering a fair comparison.

Environmental efficiency

Rail transportation of freight emits less CO_2 per unit of performance than other freight modes. This due to the large scale to which freight is transported and low friction of steel-on-steel. In comparison with inland shipping is rail more energy efficient. Especially with electric trains the differences are relatively large. Figure 40 displays the emission of kg CO_2 per tonne carried. Here bulk transportation by rail shows a significantly lower amount of CO_2 emission. Compared with inland shipping on bulk there is no difference in emissions.

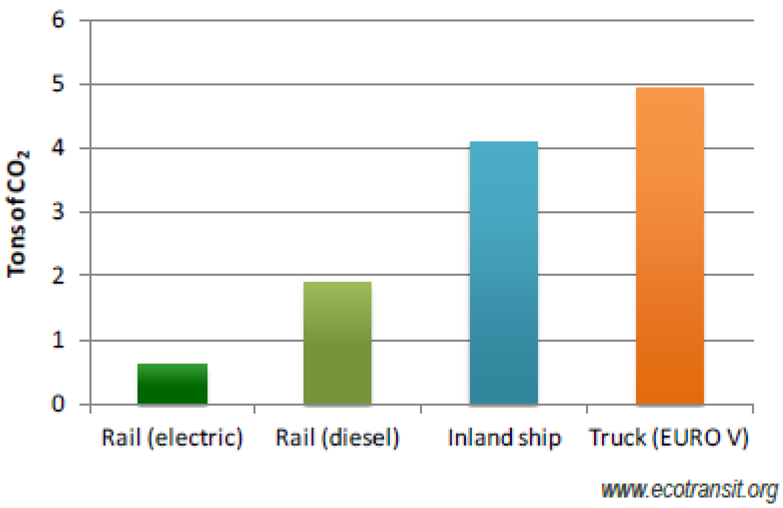
Figure 40 - CO_2 emissions per tonne for medium heavy container (left) and heavy bulk transport (right)



Source: CE Delft, 2016

Figures produced with the Ecotransit tool are comparable. CER (2014) indicates that CO_2 emissions of rail transport are eight time less than by road transport, see Figure 41.
It should be noted, however, that pre- an end haulage can have a significant impact on a door-to-door comparison, as well as the energy source for electricity production.

Figure 41 - Total CO_2 emission of transporting 100 tons of average goods been Basel and Rotterdam



4 Future trends

In this chapter we elaborate on the most important trends in both the passenger (Paragraph 4.1) and freight rail sector (Paragraph 4.2), gathering intelligence from existing academic and corporate publications on the future trends of customers' behaviour in the next decade. We distinguish between exogenous and endogenous trends in the rail sector, with a focus on the period until 2030.

After a description of the trends for the passenger and freight sector, the direction and magnitude of the various trends on the market share of rail transport and the market segment impacted are estimated (Paragraph 4.3). As literature generally does not quantify the expected impact, the qualitative assessment is rather an expert judgement than a science-based analysis.

4.1 Rail passenger market

We distinguish between exogenous and endogenous trends in the passenger transport market, based on a broad review of literature. Exogenous trends are demographic, economic, political trends. Endogenous trends relate to trends within the passenger transport market.

4.1.1 Exogenous trends

Demography

In literature three major demographic trends can be distinguished:
1. Population growth.
2. Ageing population.
3. 'Generation Y or Millennials'.

Population growth is likely to slightly increase the transport market, as more people means more transport demand. EU-28 population is expected to grow by 3% until 2030 (Eurostat). However, also the composition of the population is relevant for transport demand. First, Europe's population is ageing. According to UIC (2015) the number of elderly (including especially 80+) people in industrialised countries will continue to grow during the next decades with increasing public investment in health and care services. The elderly will use trains more frequently in particular in urban areas and for long distance journeys. Litman (2016) notes that although Baby Boom seniors tend to drive more than seniors of previous generations, they drive much less than during their peak driving years, when they were employed and raising children, and use public transit more.

The other relevant demographic trend is 'generation Y or Millennials': The Department of Economic and Social Affairs of the United Nations forecasts a projected increase of almost 0.4 billion population in the 15-34 age group of the world population by 2020. Frost and Sullivan (2010) states that they are the important customers of the future because they are tech-savvy and connected 24/7, demanding and impatient, civic and environmentally friendly. In several Western countries, car use is decreasing among young adults (see for example IFMO 2013, Kuhnimhof et al., 2012a, Kuhnimhof et al., 2012b). This can be explained mainly through situational factors (economic situation and disposable income, life phase, residential location). For the time being there is little evidence that the attitude among young adults changes such that this would lead to less mobility. Moreover, KiM (2014) suggests that young adults still desire a car, but delay the purchase to a later age.

UIC (2015) expects that the lifestyles of younger age groups with fewer car owners will change in that they use multimodal travel options, particularly within cities, including walking and cycling. However, high quality solutions for first and last mile door-to-door long and medium distance travelling need to be provided by the public transport and rail sector (see smart door-to-door mobility). The demographic changes provide opportunities for the rail sector: the increase in transport demand and also by both younger and older generations, who get more familiar with an integrated multimodal transport system.

Urbanisation

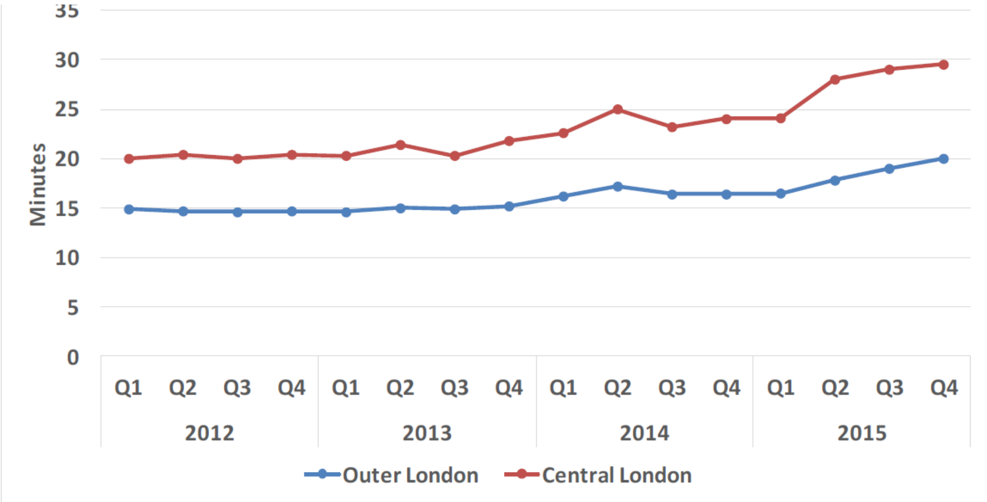
The population is not only expected to grow, also the spatial distribution of the population is expected to change heavily, namely towards a higher rate of urbanisation. In 2018 already 74% of Europe's population resides in urban areas, which is expected to increase by 25 million people to 80% in 2050 (BBVA, 2016).

Textbox 4 - Congestion

Urbanisation has been posing some major challenges to the cities such as the increase in traffic congestion and air pollutant emissions, impacting negatively on the quality of life of citizens. The Tomtom traffic index[6] shows that the level of congestion in European cities is already high and rising. In the EU, there are two megacities (population > 8 million), London and Paris, with average congestion levels of 38-40% (meaning the increase in travel time compared to a free flow situation) and 64-68% at the morning peak. Large cities (population > 800.000) with the highest congestion level are Bucharest, Marseille, Rome, Brussels, Manchester, Athens and Warsaw, all with average congestion levels of over 35% (and 58-90% in morning peak).

Inrix (2016) shows that congestion has increased over time in London, one of the most congested cities in the world. It suggests that congestion is a wider phenomenon and that its intensity will increase.

Figure 42 - Average travel times for a 5-mile trip during daylight hours in London



Source: Inrix, 2016

The Inrix 2015 scorecard scored card concludes that the problem of congestion cannot be solved simply by adding new roads or fixing the pavement on existing ones. If our cities are to enjoy the benefits of growth without experiencing the ill effects of congestion, they will need to invest in smarter solutions.

Urbanisation is therefore an opportunity for public transport. ARUP (2014) predicts that the increasing pace of urbanisation will place added stress on already strained city systems and infrastructure, requiring urban areas to be used far more efficiently. But denser urban areas could also provide opportunities for forms of transport, such as rail, that rely on density to function efficiently. UIC (2015) concludes that the high rate of urbanisation leads to increased passenger rail transport demand within cities but also between cities.
The increased market shares in urban and regional markets can be captured by well integrated public transport involving rail, metro, tram and bus, not just for commuting but also for leisure trips. UIC (2015) expects this trend to accelerate as urbanisation spreads.
To provide sufficient capacity, flexibility and connectivity, in urban areas, the urban and heavy rail are further converging, as well as regional rail into tram-train or metro-train (regional metro) concepts.

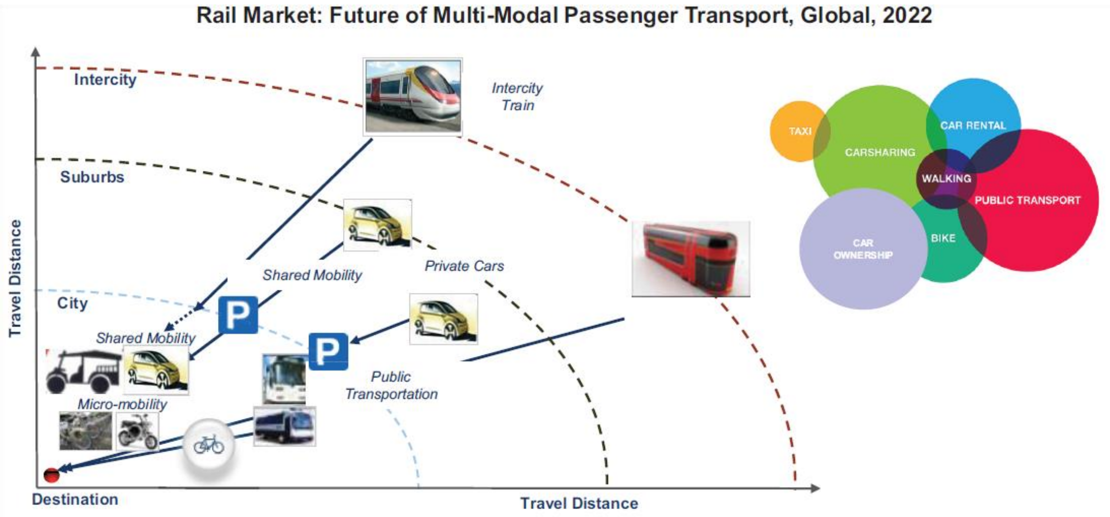
[6] https://www.tomtom.com/en_gb/trafficindex/

A scenario study by (ARE, 2016) for spatial differentiation in Switzerland quantifies the effect of urbanisation on transport volumes and modal splits. The results show shorter trips and higher shares of public transport and non-motorised transport within the cities, but also greater car dependence in rural areas. In the absence of parallel measures to promote public transport in these rural areas, the study finds that this effect could cancel out the effect of urbanisation. Litman (2014) concludes that overall travel demand is likely to decline as more households locate in more compact, multi-modal areas.
This likely results in increased consumer preferences for alternative modes for the car, urban living and walkable communities.

Rail as a backbone for suburban and intercity transport

LivingRail and Spiderplus (2015) suggest that rail modes may serve as a high capacity and reliable backbone transport provider over medium to long distances and on high demand routes (inter-city). But to meet the high expectations of future passengers and freight customers, rail providers thus need to co-operate with other modes or integrate these into their core business models. UIC (2015) formulates an overall vision for the future, 'which foresees passengers to enjoy seamless journeys in a comfortable, valuable, yet affordable, attractive, safe and secure environment, reassured by the availability of real-time traffic and whole-journey information that keeps them abreast of their varying journey options should problems arise with inter-connection with another modes or degraded operating conditions". Frost and Sullivan (2013) also present the future of multi-modal passenger transport with a major role for public transport, especially on the intercity scale, see Figure 43.

Figure 43 - The future of multi-modal passenger transport according to Frost and Sullivan (2013)



Climate action

Climate action is a clear trend, playing a major role in Europe at the moment.
For passenger mobility, three main solutions generally referred to are:

1. Less mobility.
2. Electric mobility.
3. Modal shift.

Climate action is used to stress the importance of modal shift for policy goals such as the Paris Agreement. For passenger transport, the car will likely become gradually less competitive, as energy costs increase, but also due to deliberate public policies to facilitate the transition to sustainable mobility by discouraging car use in cities, with the London congestion charge as an example (Banister, 2008). It should be noted, however, that many studies predict a break-even total cost of ownership for electric vehicles after 2025, due to a sharp decline in battery prices. However, as the cost of acquisition will remain higher, and a recharging network needs to be implemented, car ownership may reduce slightly benefitting public transport.

Public authorities tend to consider electric and hybrid cars as acceptable alternatives in sustainability terms, although this view is controversial (Driscoll, et al., 2012).

UIC (2015) also refers to several sustainable mobility measures as important future trends:

- local climate policy and planning aimed at carbon emission reduction in cities and city regions are causing a modal shift towards rail transport.
- Park and ride and other commuting facilities will be further enhanced so as to reduce car travelling to inner city centres in line with more and more parking and access restrictions to be expected in urbanised areas throughout the world.

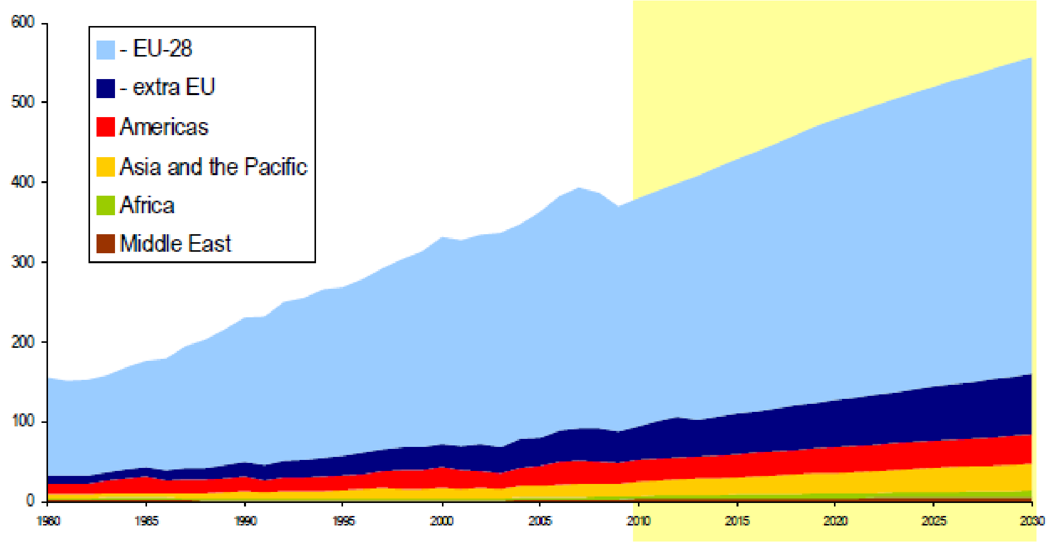
These development strategies are enhancing as well long distance rail services by making car travelling in intercity relation less comfortable, although only electrified rail matches with the sustainability goals.

In the Netherlands, a business initiative has been started to increase the use of rail -as a carbon neutral mode- for business and commuter transport. Around 50 companies with over 250 employees are involved, having the ambition to reduce GHG emission of travel by 50% in 2025. See www.andersreizen.nu/.

Increasing demand for long-distance journeys

The demand for long distance journeys will increase due to increasing leisure time and increased disposable income. The rise of tourism leads to more frequent and shorter holidays at longer distances. International tourism in EU-28 has been growing significantly since the 1990s and is expected to show a steady growth in the next decade, from 286 million travellers in 2010 to 376 million traveller in 2030, a growth of 30% (UNWTO, 2015).

Figure 44 - International tourism by region of origin in EU-28



Source: UNWTO, 2015

As tourism is estimated to account for about 60% of the demand for aviation, being the most frequently used mode for international trips, this poses a threat to sustainability and an opportunity for international rail transport at the same time.

The demand for long distance rail journeys is also already growing in many countries and this growth is expected to increase with further development of the high speed rail network in Europe. The commercial speeds on high speed lines are expected to average up to 300 km/hour allowing up to a 1,000 km distance in a still attractive travelling time of five to seven hours door-to-door. According to UIC (2015), rail experts expect to see substantial revenues of high-speed rail infrastructures attracting private market investments to contribute to their cost and thus relieving public budgets. High speed rail may promote lifestyles in which long distance commuting on a daily, week-end or some days per week frequency become an increasingly common phenomenon.

4.1.2 Sector specific trends

Digitalisation

Flexible ICT solutions

Innovation in ICT is expected to have a large impact on the transport system. ICT (mobile phone, ITS, internet, etc.) enables growing integration between the different transport modes (multi-modality). Also, experts forecast that forms of virtual mobility will develop in the future but will not simply replace physical travel and face-to-face contact, but rather play a complementary role (Aguiléra et al., 2014). As a result, new forms of hybridisation between physical and virtual mobility are likely to emerge or intensify, partly depending on technological and socio-professional innovations but also on social acceptance and finally on local conditions (urban form, cultural dimensions, etc.).
Many experiments are already in place around the world, and especially in developing countries, such as smart work centres, temporary offices for rent in airports and railway stations for mobile professionals, etc. Within the rail market, ICT innovation enables

integrated services for ticketing and traveller information and guidance improvement towards real time level UIC (2015).

Mobility as a service (MaaS)

A major trend mentioned in literature is the digitalisation on the transport market, specifically the shift from vehicle ownership towards Mobility as a Service. Roland Berger and UNIFE (2016) expect the digitalisation on the transport market to lead to seamless intermodal transport, for public transport on a national (rail), regional and urban scale (autonomous buses, shared/autonomous cars, tram, metro, buses, shared bike schemes).

The transition from vehicle ownership towards mobility purchased as a service is sometimes referred to as the 'Netflix for mobility', hinting to an integrated interface in which all of the above mentioned modalities are available and can be accessed. Multiple studies see this as an opportunity for the rail sector, especially in combination with the trends towards an ever higher rate of urbanisation.

Additionally, rail users will expect full functional digital communication and information transmission when travelling by rail, enabled through integrating digital components (computerised equipment, servers, sensors, that are interconnected by open communication networks). The effect is a customer centric approach due to digital applications allowing intermodal planning, booking, and payment.

One of the strongest arguments for promoting MaaS is that it will result in a modal shift. The empirical data from experiments shows that MaaS could, indeed, contribute to such a shift. Experiments –probably attracting particularly interested citizens- show citizens significantly reporting changes in behaviour. It, is, however, too early to quantify the specific impacts (VTT ; AustriaTech ; Chalmers, 2017).

Textbox 5 - MaaS experiments in Vienna

smi)e einfach mobil

www.smile-einfachmobil.at

The aim of the SMILE project was the development and testing of a prototype for a multimodal information, booking and payment system, combined with a personal mobility assistant. The project, in spring 2014, the one year pilot operation amongst 1,000 people started.

The following figures show that the use of the smile app had a significant influence on the mobility behaviour of the users:

- 48 % stated that their mobility behaviour changed through the use of the smile app;
- 55 % stated that they combine different modes of transport more often;
- 60 % stated that they discovered new routes on their leisure trips with the app;
- 69 % said that suggested routes are faster than the ones they used before.

Another aspect is that users of the smile app changed the selection of transport modes:

- 48 % stated that PT is used more often (26 % urban public transport, 22 % regional public transport);
- 10 % used bikesharing more often;
- 4 % used electric carsharing more frequently;
- 4 % used their electric bike more often;
- 21 % of the pilot users stated that they reduced the usage of their private car.

Source: CEDR, 2017

The value of rail travel time

Additionally, mobile ICT devices play an increasingly large role in our everyday lives. For rail transport, these ICT innovations provides the opportunity for more productive time use and this creates a competitive advantage compared to other transport modes, where driver attention is needed (Varghese & Jana, 2018) (Wardman & Lyons, 2016).

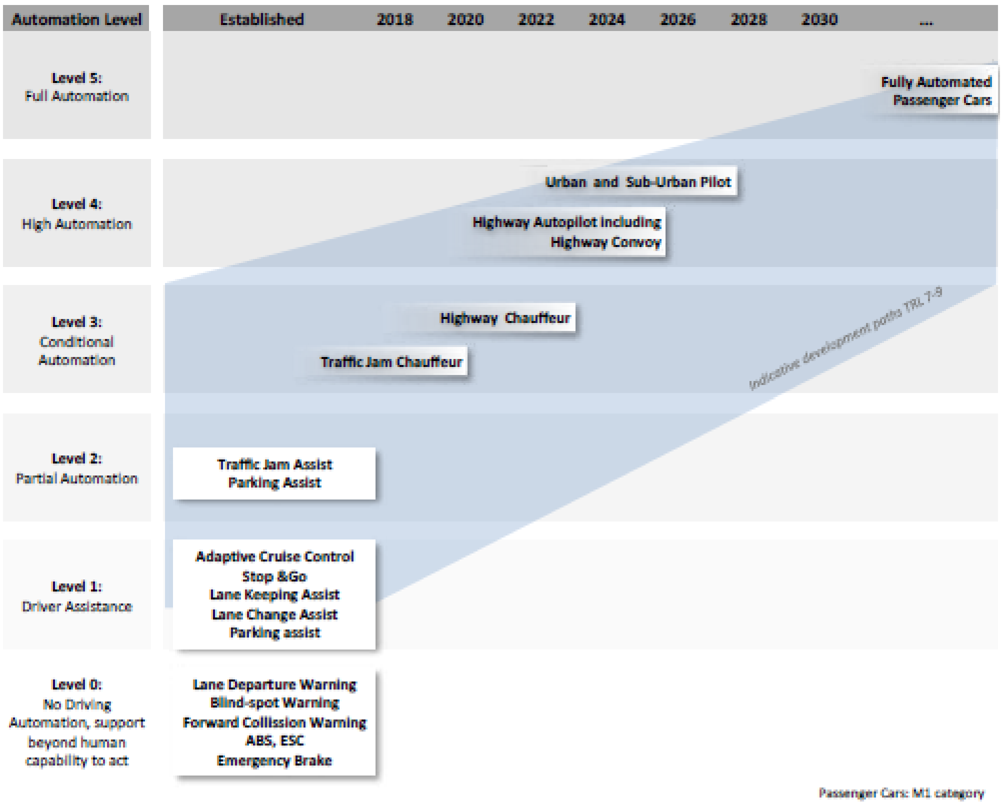
ICT provides the potential for people to spend their travel time in the train productively. Passengers can use their smartphone, laptop, tablet/e-reader for activities during travel that they find useful. Especially for commuters, who can use their train trip to prepare their meetings, read email, and thereby expanding their office to the train. In some companies, employers allow their employees explicitly to use their travel time in the train as working time, thereby shortening their working day at the working location. As a result, the travel time difference between car and train is diminished or turns in favour of the train, which could lead to a large shift in modal choice. However, important conditions for productive travel time such as seat-availability, internet connectivity, overcrowding and delays could threaten the utilisation of this potential. The impact of increased productivity of travel time on modal choice has not been quantitatively assessed yet.

Impact of autonomous vehicles on transport market

UIC (2015) sees semi or fully autonomous and alternatively propelled car systems as a major competitor in 2030 to electrified rail mass transit, if they are able to reach and demonstrate the safety level expected for driverless and public transports. However, in dense and urbanised metropolitan areas rail transit prevents congestion and the consumption of public space needed for moving and parking cars and therefore will retain its major role. The Boston Consultancy Group (2016) also sees AV's as a serious competitor for medium and long distance rail and advises the rail sector to evaluate the impact in different scenario's and to consider establishing a foothold in the AV arena.

Milakis et al., (2015) extensively analysed the potential impact of autonomous vehicles on the transport market and concludes that the impact will be small before 2030, also ERTRAC (2015) expects that autonomous driving will not reach maturity before 2030, see Figure 45. Automatic vehicles will eventually become available and slowly become part of the vehicle fleet. The impact of this on mobility and traffic handling is still very unclear. PBL (2015) assumes in their reference scenarios that full automatic driving around 2050 does not play any significant role, at least not to the extent that it has an impact on transport demand and accessibility.

Figure 45 - The Automated Driving development path for passenger cars



Source: ERTRAC, 2015

Electrification of vehicles

The European Commission has set increasingly strict standards for emissions of CO_2 and pollutants for road vehicles. The strict climate policies will:

- result in higher fuel/car costs and will improve the cost competitiveness of rail;
- strict climate policies will also drive the transport market to develop more energy efficient vehicles, trough more stringent European standards.

When more sustainable cars are more expensive to purchase, this will reduce car ownership and increase public transport demand. However, driving these energy efficient (or electric) vehicles will become cheaper, because their fuel use will be extremely low, impacting the cost competitiveness of rail versus car negatively. Therefore strict climate policies can have different effects.

It is important to note that the trend towards more energy efficient and electric automobiles causes the advantage of rail versus the car in terms of sustainability to decline. In order to stay ahead on this criterion, the rail sector needs to reduce its CO_2 impact through usage of electricity from sustainable sources, phasing out diesel trains and reducing the CO_2 emissions of materials and infrastructure.

Textbox 6 - Electric bikes in the Netherlands

Besides the introduction of electric cars, the share of electric bicycles in the bicycle park is also increasing and new models are being introduced that allow for higher speeds. The electric bicycle has an impact on modal choice and traveling distances as it increases the range of destinations for slow transport modes and also provides the opportunity to consider the bicycle as a modal choice a for a larger group of travellers. PBL (2015) expects the importance of the electric bicycle to increase more and more. This potentially increases the quality and speed of the door-to-door multimodal trip by train for regional or national trips, but requires sufficient bicycle parking spaces near train stations that are preferably secure because of the expensive bicycles.

4.2 Rail freight market

A number of specific trends can be identified that relate to the future prospects for rail freight transport, divided over exogenous trends and sector specific trends.

4.2.1 Exogenous trends

Growth of maritime containers

A number of developments contribute to an increase of trade in maritime containers in Europe, for which the projection for the four major container ports in Europe is indication, as depicted in Table 12. The growth figures have been much lower than expected during the financial crises, and if the growth figures of 10% per year can be met in the next decade is highly unsure. Some ports have adjusted the expectations for growth downwards after the 2008 financial crisis, illustrating that globalisation somewhere stops.

Table 12 - Container throughput in the major NWE ports (mio)

Year	Hamburg	Bremerhaven	Rotterdam	Antwerp
1990	1,9	1,198	3,666	1,549
2000	4,3	2,737	6,290	4,082
2010	7,9 (2,0 rail in 2012)	4,888	11,148 (0.8 rail)	8,468
2020	10,000-12,500			
2030	16,300-20,500			Max. 22,700
2050			20,000	

Source (ISL & IHS, 2015); (Wuppertal institut, 2018)

The following developments contribute to the increase of containers, and are discussed in depth below:
- globalisation and increasing GDP;
- growth of containerisation;
- change in manufacturing and consumption patterns.

Globalisation of the economy and increasing GDP

A first trend is the still ongoing globalisation of the economy, which has induced strong growth of international goods transport. Globalisation manifests itself in the relocation from parts of the production chain (the supply chain) to other countries. Initially from countries to other EU countries, in the past decade also further away, including to China.
An increasing share of the EU economy is dependent on the import and export of goods and

services. Two-third of the growth of rail transport can be linked to globalisation, one third to GDP growth (KiM, 2016) (using the assumption that one percent growth in goods trade leads to 0.67 percent of extra growth in freight transport). Globalisation is expected to continue. However, the current trade barriers being implemented by the large economic world regions are expected to limit world trade. Recent estimations indicate that the import of containers will be less than during the 1990-2010 period, when growth figures were above 10%.

Growth of containerisation

Another linked trend is that industries are adapting their cargo to the container shipping method. For instance, the paper industry has adapted their cargo to the container shipping method by adjusting the size of paper rolls to fit the containers, and agricultural products as unions and seed potatoes can be more easily exported if containerised. Other examples are scrap, waste and timber. By using a container, a door-to-door concept can be more efficient and faster (Notteboom & Rodrigue, 2009). The cargo can be transported directly from the mill to the consignee, or even directly to the consumer.

Change in the manufacturing and consumption patterns in Europe

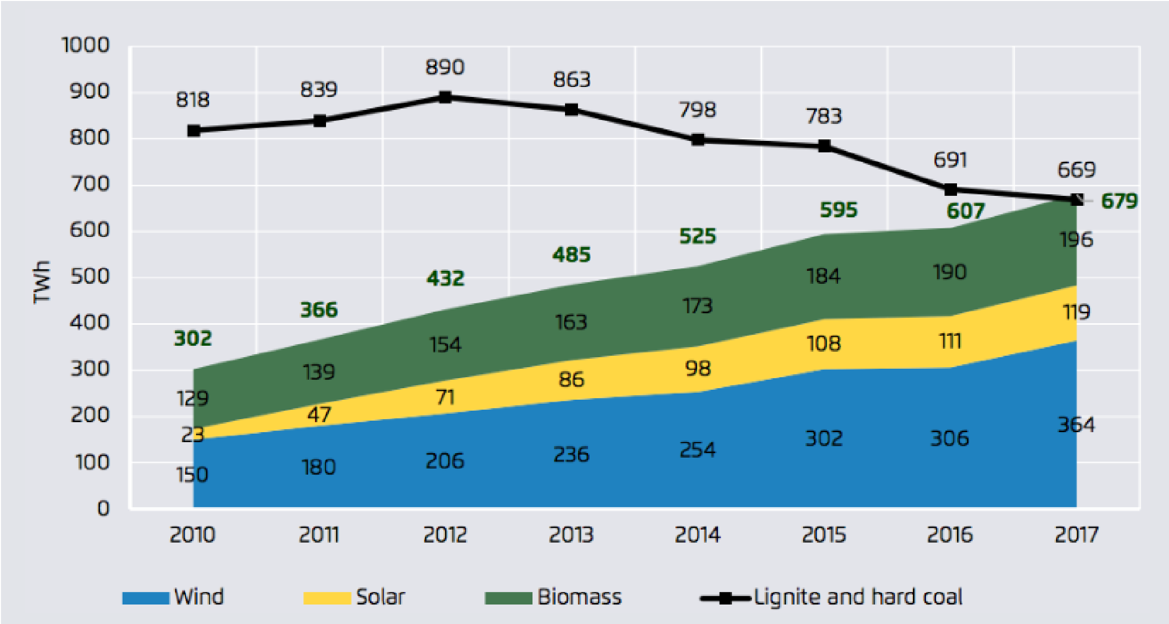
Finally, there is a significant and fundamental change in manufacturing and consumption patterns in Europe, meaning that the share of raw material for heavy manufacturing as a proportion of the total freight transport has declined. By contrast, the share of 'semi-finished' and finished products has increased. The increase has been in a market in which rail freight transport is traditionally weak, as these products require short and accurate transit times and shippers are used to receive offers for door-to-door delivery (Islam & Zunder, 2018). Today, the focus is even more on low-density-high-value (LDHV) goods as Europeans consume more luxury goods like electronics and conditioned goods as exotic fruits (Notteboom & Rodrigue, 2009). This implies that rail needs to be able provide the required services to these markets in order to gain market share. See also Section 4.2.2.

Climate action

The phase-out of coal for power generation

Climate policy is becoming more and more important in Europe of today. While the impacts in the transport and logistics sector are still relatively limited, both power generation and passenger transport will show significant changes in the next decade.

Figure 46 - EU power generation from wind, solar, biomass and coal (2017)



Source: Sandbag, 2017

The use of coal for power generation will phase out, drastically reducing the need for hinterland transport of coal. Coal comprised around 10% of rail freight transport tonne-km in 2014 in Europe (KiM, 2017a) (SCI , 2016). The closure of coal fired power plants has started already, supported by a sharp decline in the costs of generation of sustainable electricity. Germany is the most important market in this respect, and the political discussion on an end date for coal is ongoing. Fossil liquid fuels used in transport will be phased out, starting with passenger transport that consumes two-thirds of all fossil fuels. 95% of the mineral oil imports are used to produce transportation fuels. The demand will be reduced as it is most likely that passenger cars and light trucks will be electrified in the period towards 2030. This electrification could originate from battery electric vehicles, plugin hybrids and hydrogen powered vehicles. Also the (potential) rise of bio LNG powered vehicles could further transform the current fleet of passenger cars towards more sustainable drivelines. Multiple countries have formulated goals for a ban of the purchase of conventionally fuelled passenger cars by the 2030 decade.

Especially the phase out of coal will be an important loss for rail freight market. At the same time, transportation of sustainable fuels (such as (bio-)LNG or hydrogen) could present a potential new market, although this development is still uncertain.

Climate policies

At the same time, climate policies are a key chance for rail transport, as rail transport is the only transport mode that can offer climate neutral transport. Although the current demand for climate neutral transport is still limited, as available evidence shows, other research shows that climate is an upcoming discerning criterion. However, it is difficult to assess when climate will become a relevant performance criterion for the majority of the market. First evidence of frontrunners investing in climate neutral transport on markets where rail is a candidate can be seen on shipper level. Examples are the green corridor initiated by Heineken or carbon neutral transport of beer between its Zoeterwoude-brewery and the Port of Rotterdam, the initiative for a CO_2 neutral rail terminal in the Dutch green port and investment into 10 electric inland vessels. Not all these examples can be directly turned into potential for rail, but illustrate the change in mind-set that is ongoing. Also Van den Berg & De Langen, 2017 and Kudla & Klaas-Wissing (2012) illustrate that sustainability will become more important, based on a survey under shippers. TNO (2017) has analysed the potential for modal shift for CO_2 reduction in the Netherlands (and international transport on Dutch territory) by selecting road transport trips that have a rail terminal both at origin and destination of the trip, only for containerised and dry bulk cargo. This leads to a potential of 12% of trips and potentially saving up to 0,8 Mton of CO_2, only in the Netherlands.

In the longer term (2030), zero emission trucks may also be a solution to meet the demand for climate neutral transport, but this requires a new expensive infrastructure (motorway electrification or fast charging stations for example) that is not yet available.

In recent years road freight transport has benefitted from reduced fuel prices, while rail transport could not, further affecting the competitiveness of rail transport (KiM, 2016). Most studies assume that for the decade to come, fossil fuel prices will rise again, leading to improved cost competitiveness for electrified rail transport. The PRIMES energy model (E3M-Lab of ICCS-NTUA, et al., 2016) used by the European Commission assumes for example an increase of real fuel prices of 15% until 2025 and 25% until 2035.

Modernisation of transport services

Digitalisation in the transport market
Digitalisation is transforming many industries today and the logistics industry is no exception. As technology becomes more advanced, customers expect a higher level of service including e.g.:
- easy and flexible booking;
- electronic consignment notes; and
- tracking and tracing.

The many modes of transport in intermodal freight contribute to a complex and dynamic supply chain and information has become a vital part in efficient supply chain management. Since companies in the maritime and road transport segment are making large investments in IT solutions with fully integrated view of real-time information across the supply chain, rail freight transport needs to offer high quality IT services that improve transparency, in order to meet a baseline customer satisfaction requirement. Such services are currently not available in all countries and typically not on international corridors, but should be seen as a prerequisite (Platz, 2008) (PwC & La Sapienza, 2015). Various surveys indicate the need for better digital solutions and the increased attractiveness of rail transport under increased digitisation (PwC & La Sapienza, 2015) (UIC, 2017).

Door-to-door transport services required

Since the 1970s, containerised/unitised cargo and door-to-door (rather than terminal-to-terminal) transport service have become a widely accepted, normal phenomenon. Rail has been slow to respond to such changes, for example by failing to co-operate with transport chain partners to offer a door-to-door service. Research (Islam & Zunder, 2018) recommends that technical solutions, such as automated transhipment and temperature controlled systems, are required for rail freight services for LDHV goods, but that they must be complemented by collaborative operational solutions and viable service planning for an intermodal rail transport service to be reliable and competitive with road transport.

Problems in the road transport market

Increasing road congestion

The strong growth of transport movements after the recovery of economic crisis have led to renewed discussions about congestion. For the Dutch motorway network, the number of travel time losses is projected to increase by 38% in the 2015-2021 period (KiM, 2016). Also, TomTom data for Antwerp, Rotterdam and Hamburg show travel times increase up to 50% during the morning rush hours (TomTom, 2016). All the large ports in Europe are trying to anticipate and prevent congestion, amongst others by easing the movement of individual containers between ports in order to create larger shipment sizes, setting contractual objectives for terminals, and by developing inland corridors. In their combat to congestion, the rail freight sector will find ports on their side as rail is being seen as an alternative to road transport.

Congestion is also occurring in the ports, mainly as a result of the significant increase of trade and the size of ships. If containers miss their intermodal service or the service is delayed, the supply chain becomes unreliable. Inland navigation mainly suffices from this in-port congestion, which provides an opportunity for rail.

The reefer market is relatively small but growing, following the societal trend of consuming more fresh (exotic) products. It may be a potential growth market for rail, if rail operators can anticipate the demand for reefer transport, including the supply of power during transport and monitoring on-the-way performance. Co-operation between stakeholders in ports (e.g. storage), rail operators and intermodal reefer services is required. However, it should be noted that speed is an important requirement in this market segment. Conditioned transport is therefore not only a chance for maritime container transport, but also for single wagonload (SWL) transport.

Truck drivers

For the past 15 years, the trucking industry has seen an increasing shortage of truck drivers, directly impacting the delivery of day-today items. Almost 30% of people employed in the transport sector are over 50, and will be retiring in the coming 10 to 15 years, according to IRU. The road transport sector has been less successful than many other sectors in recruiting younger workers, partly due to the sector’s negative image for employment.

On the longer term, the need for truck drivers may be reduced due to the implementation of platooning and automated driving. Multi-brand platooning is planned by the truck industry to be implemented around 2025. Technology will not be decisive, but legislation will. Autonomous driving, a follow up of –leading to a major reduction in transport costs- is not expected before 2030 (ERTRAC, 2015).

4.2.2 Sector specific trends

Rail's respond to required changes

Decline of SWL network

The share of rail freight transport in Europe is under pressure, mainly due to the decline of single wagon load transport (SWL). Some European countries have shown growth over the last years, while others saw a reduction of rail freight transport. It should be noted that the decrease of the size of shipments in 'just-in-time' (JIT) logistics supply regimes, requiring flexibility and timely delivery, are not beneficial for SWL rail transport, as road transport generally performs better on these criteria (PwC & La Sapienza, 2015).
Too many delays and the non-availability of tracking and tracing are also indicated as reasons for a decrease in the competitiveness of rail in single wagon load market. Although increasing the market share of SWL again will be a difficult job, the potential market is large (TNO, 2017).

Trailers-on-train

One of the alternatives to a single wagon load network is the 'trailers-on-train' concept. The concept is commercially applied on a number of links in Europa, amongst others companies as Cargobeamer and Lohr started a number of years ago. These concepts provide flexibility as standard trailers can be put on a train without lifting, and there is no need for a rail network connection for companies.

Cross border transport difficulties remain hindering speed and capacity increase

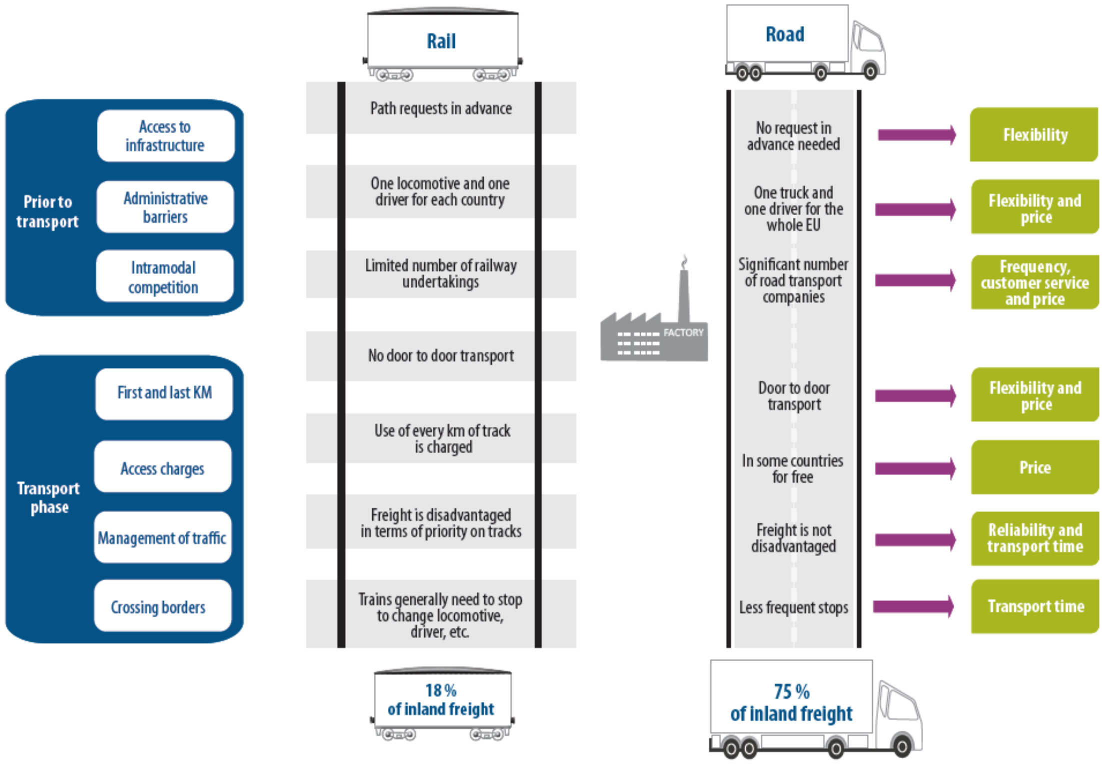
While cross-border transport is a chance for rail transport in a globalising world and also a large share of its market (50% expressed in tonne-km), the speed of rail transport is still low. While speed and just-in-time deliveries have become more important, the rail sector has not managed to improve the speed over the last decade. The EU Court of Auditors report an average speed of international rail transport of 18 km/h, but also speeds of 50 km/h have been reported for the rail freight Rhine-Alpine corridor. Low speeds can be explained by the weak co-operation between national infrastructure managers and the need for train formation on marshalling yards, locomotive/driver change (ECA, 2016).
Other factors hindering interoperability are:

- different signalling systems;
- different electrification systems;
- differences in train length and axle load;
- lack of a standard European gauge;
- need for national safety certificates in each country for rail freight wagons;
- the need for the train driver to speak the national language.

Although some of the constraints above have been addressed in the revised TEN-T regulation, international freight rail transport likely will not benefit before 2030, because of the timelines set for implementation. The freight rail liberalisation planned long ago has not yet completely been implemented.

Road transport does not suffer from these disadvantages. Since travel time is one of the three major shipper decision criteria, reducing the border crossing difficulties and other interoperability problems would significantly improve the competitive position of rail.
It should be noted, however, that solving interoperability problems does not necessarily reduce costs. The Dutch shipper organisation reports an initial increase of costs (KNV, 2014) because of investments to be made (e.g. ERTMS).

Figure 47 - Comparison of some of the challenges faced by rail freight transport, compared to road (ECA, 2016)



One of the options to make rail transport more cost competitive is to utilise longer trains (740 m), making rail transport more profitable. This requires, however, investments and tuning between EU countries. For the Rhine-Alps corridor only, the investments have been estimated at 130-200 Mio euro.

The New Silk route

The maritime and rail New Silk Route, also called the 'Belt and Road Initiative' (BRI), has a geographical scope that includes 65 countries which jointly account for some 60% of global Gross Domestic Product (GDP) and 30% of the world's population, providing a significant opportunity for rail operators.

Maritime and rail transport should be treated as complementary rather than competitive. Sea transport from China to Europe takes about 30-40 day, which is too long for many goods. Rail transport needs only 11-14 days and is much cheaper than air transport. Agricultural products from the EU enjoy a high credibility and interest of Chinese consumers, which could be a potential (new) market. Predicting the effect of the BRI on the transport network is particularly challenging, as there is no clear definition or programme

for the BRI. In addition, it is not possible to distinguish trade specifically generated by the BRI from wider trade between the Far East and Europe. Rail transport, in the framework of the BRI, could increase export opportunities and price competitiveness of EU agricultural products. However, there are many challenges for China and the other countries involved, among which rough terrain, persistent regional conflicts and thriving corruption.
One example is the Russian ban of fruits and vegetables from the EU, hindering the transfer of these products.

A study by Steer Davies Gleave (2018) found that as a result of improved services attributed to the BRI, around 2.5 million TEUs could transfer from maritime and 0.5 million TEUs from air transport to rail by 2040. This is equivalent to 50 to 60 additional daily trains between Europe and the Far East, or 2 to 3 trains per hour, in each direction. Rail services can be expected to target higher value and more time-sensitive goods than current maritime transport (Steer Davies Gleave, 2018).

UIC (2017) is less optimistic and estimates the potential at 0,8 Mio TEU in 2030, illustrating the large uncertainty. The trade was 0,1 Mio TEU in 2017.

4.3 Synthesis

In Table 13, all the trends identified in this chapter are brought together and assessed by the consultants team qualitatively on how the trend impacts the rail market share (trough the shipper/traveller decision in case of a performance criterion) and the expected impact of the trend.

The impact of a trend identified on the development of the market is estimated as negative, neutral or positive. Next, the expected impact of a trend is assessed as low, moderate or high. The combination of high impact and positive or negative development are particularly interesting, as they can be classified as an opportunity or threat for rail transport.

Table 13 - Trends with largest impact on the rail passenger market in the coming decade

Trend	Performance indicator impacted by trend/ Exogenous trend	Potential development of market share of rail	Expected impact of trend	Impacted rail market segment
Demography	Exogenous trend	+	Moderate	Mainly regional/all
Urbanisation	Exogenous trend	+	High	Mainly regional/all
Climate action	Exogenous trend	+	Moderate/high	All
Increasing demand for long-distance journeys	Exogenous trend	+	High	International /leisure
Digitalisation	Comfort and quality Transport to and from railway stations Travel time	+	High	Regional and national/business and commuter
Autonomous transport		-	Low	Regional and national/all
Vehicle electrification		+/-	Low	Regional and national/all

The following trends are expected to have the greatest impact on rail:
- Urbanisation, linked to congestion, is a major trend for rail. Rail is expected to benefit from increased urbanization in suburban regions and between cities, which is linked to lower levels of car ownership and a decline of accessibility by private car.
- Although it is not expected that the hierarchy of transport modes will change radically in the future, researchers foresee a trend towards greater hybridisation of transport modes, through the use of digital services (MaaS), though depending on local conditions.
- An increasing demand for intra-EU leisure trips provides the opportunity to increase its market, especially in the context of the increased (political) attention for reducing the carbon footprint of transport.
- There is increasing attention on reducing the emissions of business transport of companies, and climate policies are expected to steer towards carbon neutral transport, where rail has the best starting point. However, it should be noted that diesel powered rail could be disadvantageous in this respect.

Table 14 - Trends with largest impact on the rail freight market

Trend	Performance indicator impacted by trend/Exogenous trend	Potential development of market share of rail	Expected impact of trend	Impacted rail market segment
Continuance of cross-border difficulties	Transport time	-	High	(Maritime) containers
Single wagonload market decline	Transport costs/overall market potential	-	High	Single wagon load
New Silk route	Exogenous trend	+	Moderate	(Maritime) containers
Trailer-on-train concepts		0/+	High	Single wagon load
Phase-out of coal transport	Exogenous trend	-	High	Bulk transport
Incomplete digitalisation of rail	Convenience	-	Moderate	(Maritime) containers
Growth of containerisation	Exogenous trend	0	Moderate	(Maritime) containers
Increasing road congestion	Exogenous trend	+	Low	(Maritime) containers
Climate policies	Exogenous trend	+/0	Moderate	Maritime containers

Three future trends may impact the rail freight market negatively and are expected to have a high impact:
- Phase-out of coal transport;
- SWL network decline; and
- remaining cross-border difficulties.

Opportunities for rail freight transport can be found in new and upcoming markets:
- growth in maritime containers;
- transport of conventional goods in conventional trailers;
- the rise of New the Silk Route;
- the need for low-carbon freight transport.

Overall, it will require significant efforts for rail freight transport to provide a competitive and modern rail service that meets the needs of the logistic markets. On the other hand, the conventional goods market is large, and if rail can catch a share of the transport on longer distances, the potential impact can be big. Conditions for success are low transhipment costs and a competitive speed.

5 Conclusions

Increasing the market share of rail transport, in specific markets where rail can compete with its competitors, can potentially contribute to improved accessibility, reduce road congestion and at the same time reduce the environmental burden and climate impacts of transport. In order to understand where the market opportunities for rail are and under which conditions rail can increase its market share, an analysis was made of market segmentation, customers modal choice decision criteria, relevant exogenous and sector specific trends, and ultimately, areas where new opportunities for rail will come up or threats where the rail sector needs to react upon.

5.1 Passenger transport

5.1.1 Performance criteria ranking

Many performance criteria are assessed in the literature review. In Table 15 the ranking of performance criteria for rail passenger transport for different trip purpose is shown.

Door-to-door travel time, reliability and comfort are in all market segments the most important criterion for modal choice. Commuters rank travel time and reliability highest. For commuters and leisure travellers price is also important, while this is not the case for business travellers.

Table 15 - Ranking of performance criteria for rail passenger transport for different trip purposes

Criteria	Commuting	Business	Leisure
Travel time	+++	+++	++
Reliability	+++	+++	++
Comfort	++	++	+++
Accessibility	++	++	++
Price	++	+	++(+)
Frequency	++	++	+
Convenience	+	+	+
Safety	+	+	+
Environment	+	+	+

*For long distance transport, ticket prices are evaluated to be more important than on shorter distance transport.

The evaluation of performance criteria shows that rail can be especially competitive on trips with distances between 10 and 700 km, especially on costs. The speed of the train is competitive as well, but travellers compare door-to-door travel time and transfer times and intermodal connectivity have a large impact on the total travel time. Likewise, rail competitiveness increases when road travel time reliability is poor due to congestion. Rail‘s reliability is very high in almost all member states. However, the perceived quality of rail services (in terms of reliability, cleanliness, ticketing and other comfort factors) varies highly between member states, suggesting that improvement strategies should be country or situation specific.

Many improvement programs for public transport focus on improving physical attributes of services, rather than perceived attributes. Fare promotions and other habit-interrupting transport policy measures can succeed in encouraging car users to try the train. However, in order to sustain the switch from car use after promotional tactics have expired, the train travellers experience has to be improved above the level of the basic needs of accessibility and reliability. New focus on and a better understanding of customer needs can increase rail customer satisfaction levels. For example, Van Hagen et al., (2017) propose motivational theories to enhancing positive emotions during train travel.

5.1.2 Future trends relevant for rail passenger transport

Based on a broad analysis, the following trends are expected to have the greatest impact on rail passenger transport in Europe:
- urbanisation and congestion (all market segments, regional mainly);
- mobility-as-a-service (all market segments, regional mainly);
- increased demand for intra-EU leisure trips;
- environmental awareness.

Rail can in particular be competitive in cases where car transport does not perform well (e.g. because of congestion, parking problems, etc.), so mainly in/to/from urban areas. Therefore, urbanisation gives opportunity for growth of rail, but requires a high level of integration with other modes, such as walking/cycling, bus/tram/metro and private car or new shared car service concepts. In dense urban areas, a flexible multimodal transport system is envisioned with rail as a backbone.

This trend is strengthened by the rise of MaaS that allows access to a low threshold integrated interface providing information on intermodal trips as an alternative to passenger car trips. Seamless switching between modes, an important decision criterion identified, contributes to the potential growth of rail, as door-to-door travel time is decisive in some markets in the choice for a certain mode.

Another trend allowing rail to increase its share is an increase in the number of leisure trips. Between 2010 and 2030 the number of intra-EU trips is expected to increase by 30%. However, ticket prices for international rail transport are often above the prices of air tickets. This, while ticket prices for leisure trips are highest on the ranking of decision criteria for mode choice. High speed rail connections are needed to make rail transport competitive to air transport.

Environmental/climate awareness will provide opportunities for the rail sector, especially through expected stricter environmental policies at the EU and national level that discourage car use. However, stricter environmental policies will also lead to more electrification of automobiles, which are also perceived to be sustainable while they do not fix all challenges in dense urban areas (such as scarcity of public space, safety and congestion).

5.2 Rail freight

5.2.1 Performance criteria ranking

Although a large number of criteria are mentioned in the literature, only a handful of criteria really play a role in decision making by shippers or logistics service providers.
The vast amount of literature available illustrates the major importance of costs as a modal

choice criterion in the freight transport sector. Only in cases of high value goods transport or goods (e.g. electronics) that relatively soon lose value like conditioned goods, cost is not the single most important decision criterion. In those cases transport time and on-time reliability are also more important.

Table 16 - Criteria importance ranking for maritime containers and continental freight

Criteria	Perishable goods/high value	Non-perishable goods/low value
Costs	+++	++++
Delivery time	++++	++
Punctuality	++++	++
Flexibility	++	++
Frequency	++	++
Transport safety	++	++
Transport security	++	++
Convenience	++	+
Network connectivity	++	+
Environmental efficiency	+	+

Today, growth of import of maritime containers can to a larger extent be explained by the focus on low-density-high-value goods as electronics and conditioned goods. This implies that for rail to gain market on this segment, it has to offer the required services in that market, as delivery time, punctuality and technical services as plug-in power and track and trace.

5.2.2 Future trends relevant for rail freight

Based on an analysis of trends, three future trends may impact the rail freight market negatively and are expected to have a high impact:
- Phase-out of coal transport for power generation (bulk market segment).
- SWL network decline (conventional goods market).
- Remaining cross-border difficulties (mainly intermodal transport/single wagon load).

Due to climate policies that are being developed by European governments, the use of coal for power generation has reduced over the last years, 25% since 2012. Coal transport accounts for about 10% of the European rail performance (tonne-km). This is expected to reduce significantly in the next 10 years. Rail transport has not yet felt this trend, because the share of coal imported has increased over time since the 1980's.

The share of rail freight transport in Europe is under pressure, mainly due to the decline of single wagon load transport (SWL), which is typically around 1/3 in size of the overall market in the EU. The decrease of the size of shipments in 'just-in-time' (JIT) logistics supply regimes, requiring flexibility and timely delivery, are disadvantageous for SWL rail transport, as road transport generally performs better on these criteria (PwC & La Sapienza, 2015).

This inability to compete with road transport can be explained by low speeds measured, caused by persistent interoperability problems, especially outside the European rail freight corridors. Adressing of these bottlenecks is expected to last until 2030. Reducing the border crossing difficulties and other interoperability problems would significantly improve the competitive position of rail.

Opportunities for rail freight transport can be found in new and upcoming markets:

- growth in maritime containers (intermodal transport);
- transport of conventional goods in conventional trailers (conventional goods, trailer-on-train);
- the rise of New the Silk Route (container/intermodal);
- the need for low-carbon freight transport (all).

Most of the opportunities above result from exogenous trends. Maritime containers will continue to grow, although to a lesser extent than in previous decades and the opening of the New Silk route provides opportunities for the European rail freight market. The need for low-carbon transport, which is hardly demanded today by freight customers, is expected to increase. Rail is in a competitive position, although variations in the extent of network electrification are considerable between countries. Trailer-on-train is a concept that may require more attention as a result of a stronger demand for low-carbon transport in the next Post Paris decade and increasing shortage of truck drivers and increasing road congestion.

Overall, it will require significant efforts for rail freight transport to provide a competitive and modern rail service that meets the needs of the logistic markets as a significant share of the market is impacted by the challenges mentioned. On the other hand, the conventional goods market is large, and if rail can catch a share of the transport on longer distances, the impact can be big. Conditions for success are low transhipment costs and a competitive and reliable speed.

6 References

Abenoza, R., Cats, O. & Susilo, Y., 2017. Travel satisfaction with public transport: Determinants, user classes, regional disparities and their evolution. *Transportation Research Part A: Policy and Practice,* Volume 95, pp. 64-84.

Agora Energiewende and Sandbag , 2018. *The European Power Sector in 2017, State of Affairs and Review of Current Developments,* London ; Berlin: Sandbag ; Agora Energiewende.

Aguiléra, A. & Grébert, J., 2014. Passenger transport mode share in cities: Exploration of actual and future trends with a worldwide survey. *International Journal of Automotive Technology and Management,* 14(3-4), pp. 203-216.

Akerman, J. et al., 2014. *TRANSFORuM Roadmap Long-distance Freight,* Cologne / Köln: Rupprecht Consult.

ARE, 2016. *Transport Outlook 2040 : Development of passenger and freight transport in Switzerland,* Bern: Federal Office for Spatial Development ARE.

Arencibia, A. I., Feo-Valero, M., García-Menéndez, L. & Román, C., 2015. Modelling mode choice for freight transport using advanced choice experiments. *Transportation Research Part A: Policy and Practice,* Volume 75, pp. 252-267.

ARUP, 2014. *Future of rail 2050,* London: ARUP.

Banister, D., 2008. 'The sustainable mobility paradigm'. *Transport Policy,* 15(2), pp. 73-80.

Bärthel, F. & Woxenius, J., 2004. Developing intermodal transport for small flows over short distances. *Transportation Planning and Technology,* 27(5), pp. 403-424.

BBVA, 2016. *European urbanization trends, Urbanization report,* Madrid: BBVA Research.

Bellinger, B., 1970. *Bellinger, 1970. Optimale Fahrpreise kommunaler und gemischtwirtschaflichter Unternehmungen im Öffentlichen Personennahverkehr,* Berlin: s.n.

Benezech, V. & Coulombel , N., 2014. The value of service reliability.. *Transportations Research Part B: Methodological,* Volume 58, pp. 1-15.

Boston Consulting Group, 2016. *Will Autonomous Vehicles Derail Trains?,* Seattle (USA): Boston Consulting Group.

Brons, M. & Rietveld, P., 2009. Improving the Quality of the Door-to-Door Rail Journey: A Customer-Oriented Approach. *Built Environment vol 35, no1.,* 35(1), pp. 122-135.

Bury, A., Paraskevadakis, D., Ren, J. & Saeed, F., 2017. A framework for use in modelling the modal choice decision making process in North West England's Atlantic Gateway. *Logistics & sustainable transport* , 8(1), pp. 19-30.

Cantwell, M., Caulfield, B. & O'Mahony, M., 2009. Examining the factors that impact public transport commuting. *Journal of Public Transportation,* 12(2), p. 1–21..

CE Delft, 2011. *Study on the projected effects on GHG emissions and transport volumes* , Delft: CE Delft.

CE Delft, 2014. *Externe en infrastructuurkosten van verkeer,* sl: sn

CE Delft, 2016. *STREAM Freight Transport 2016,* Delft: CE Delft.

CE Delft, 2018 (in publication). *Roadmap duurzaam OV en spoor (in Dutch) =Roadmap towards zero-emission public transport in 2050,* Delft: CE Delft.

CE Delft, 2018. *CO_2-effect van Anders Reizen,* Delft: CE Delft.

CER ; UIC, 2014. *Rail transport and environment : facts and figures,* Paris: UIC ; CER.

CER, 2017. *Annual Report 2017 ,* Bruxelles: CER aisbl.

Chakrabarti, S., 2017. How can public transit get people out of their cars? An analysis of transit mode choice for commute trips in Los Angeles. *Transport Policy,* Volume 54, pp. 80-89.

Conlogic AB, 2013. *Företagens logistikanalyser – åtgärder för bättre resurseffektivitet och mindre miljöpåverkan.* [Online]
Available at: https://trafikverket.ineko.se/Files/sv-SE/10558/RelatedFiles/2013_095_Foretagens_logistikanalyser_atgarder_for_battre_resurseffektivitet_och_mindre_miljopaverkan.pdf
[Accessed 2018].

D'Alfonso, T., Jiang, C. & Bracaglia, V., 2016. Air transport and high-speed rail competition: Environmental implications and mitigation strategies. *Transportation Research Part A: Policy and Practice,* Volume 92, pp. 261-276.

Danielis, R. & Marcucci, E., 2007. Attribute cut-offs in freight service selection. *Transportation Research Part E: Logistics and Transportation Review,* 43(5), pp. 506-515.

De Haas, M., 2016. *Travel pattern transitions : A study on the effects of life events on changes in travel patterns,* Delft: Technische Universiteit Delft.

Dell'Olio, L., Ibeas, A. & Cecin, P., 2011. The quality of service desired by public transport users. *Transport Policy,* 18(1), pp. 217-227.

Dell'Olio, L., Ibeas, A., Dominguez, A. & Gonzalez, F., 2012. Passenger preference analysis: Light rail transit or bus versus car. *Transport,* 27(3), pp. 276-285.

DfT , 2017. *National Statistics: Rail factsheet: 2017 : An overview of key statistics on the rail industry in Great Britain,* London: Department for Transport (UK).

Dickinson, J. E. et al., 2018. Lift-share using mobile apps in tourism: The role of trust, sense of community and existing lift-share practices. *Transportation Research Part D: Transport and Environment,* 61, Part B(June), pp. 397-405.

Dobruszkes, F., 2011. High-speed rail and air transport competition in Western Europe: A supply-oriented perspective. *Transport Policy,* 18(6), pp. 870-879.

Driscoll, P., Theodórsdóttir, Á., Richardson, T. & Mguni, P., 2012. 'Is the future of mobility electric? Learning from contested storylines of sustainable mobility in Iceland'. *European Planning Studies,* 20(4), pp. 627-639.

E3M-Lab of ICCS-NTUA, et al., 2016. *EU Reference Scenario 2016 : Energy, transport and GHG emissions, Trends to 2050,* Brussels: European Commission (EC).

Eboli, L. & Mazzulla, G., 2009. A new customer satisfaction index for evaluating transit service quality. *Journal of Public Transportation,* 12(3), pp. 21-38.

EC, 2016a. *Report from the Commission to the European Parliament and the Council : Fifth report on monitoring development of the rail market {SWD(2016)427 final}, COM(2016)780 final,* Brussels: European Commission (EC).

EC, 2016b. *Towards regional and urban indicators on rail passenger services, using timetable information,* Brussels: European Commission (EC) Directorate-General for Regional Policy.

ECA, 2016. *Rail freight transport in the EU : still not on the right track,* Luxembourg: European Court of Auditors .

EEA, 2011. *The European Environment - State and Outlook 2010: Assessment of Global Megatrends,* Copenhagen: European Environment Agency (EEA).

Eng-Larsson, F. & Kohn, C., 2012. Modal shift for greener logistics : the shipper's perspective. *International Journal of Physical Distribution and Logistics Management,* 42(1), pp. 36-59.

Eom, J., Schipper, L. & Thompson, L., 2012. We keep on truckin': Trends in freight energy use and carbon emissions in 11 IEA countries. *Energy Policy,* 45(June), pp. 327-341.

ERRAC, 2017. *Rail 2050 Vision - Towards a competitive, resource efficient and intelligent Rail Transport System for 2050,* Paris: ERRAC, the European Rail Research Advisory Council.

ERTRAC, 2015. *Automated Driving Roadmap,* Brussels: ERTRAC.

Ewing, R. & Cervero, R., 2010. Travel and the built environment: a meta-analysis. *Journal of the American Planning Association,* 76(3), pp. 265-294.

Feo-Valero, M., García-Menéndez, L. & del Saz-Salazar, R., 2016. Rail freight transport and demand requirements: an analysis of attribute cut-offs through a stated preference experiment. *Transportation,* 43(1), pp. 101-122.

Flodén, J., Bärthel, F. & Sorkina, E., 2010. *Factors influencing transport buyers choice of transport service : A European literature review. Paper presented at the 12th WCTR, July 11-15, 2010, Lisbon.* Lisbon, s.n.

Fries, N., 2013. *Carrier or Mode? - The Dilemma of Shippers' Choice in Freight Modelling : Travel Survey Metadata Series 43,* Zürich: Institute for Transport Planning and Systems (IVT); ETH Zürich.

Frost and Sullivan , 2013. *Rail Outlook Study 2013-2022 : Paradigm Shift Towards Intermodal Mobility Boosts Growth in All Rail Segments,* s.l.: Frost and Sullivan .

Gärling, T. & Schuitema, G., 2007. Travel demand management targeting reduced private car use: effectiveness, public acceptability and political feasibility. *Journal of Social Issues,* 63(1), pp. 139-153.

Gonzáles-Savignat, M., 2004. Will the high-speed train compete against the private vehicle?. *Transport Reviews,* 24(3), pp. 293-316.

Greeno, D. & Hunt, R., 2013. *National Passenger Survey : Train Operating Company Multivariate Analysis Report, Passengerfocus,* London ; Manchester: Transportfocus.

Guirao, B., García-Pastor, A. & López-Lambas, M., 2016. The importance of service quality attributes in public transportation : narrowing the gap between scientific research and practitioners's needs. *Transport Policy,* Volume 49, pp. 68-77.

Hanssen, T., Mathisen, T. & Jørgensen, F., 2012. Generalized transport costs in intermodal freight transport. *Procedia-Social and Behavioral Sciences,* Volume 54, pp. 189-200.

Haskoning, 2018. *Vergelijk vliegen met treinreizen voor korte afstanden - en hoe we vaker voor de trein kunnen kiezen (in Dutch) = Comparison of air and rail travel for short distances : and how we could choose the train more frequently,* Amersfoort: Royal HaskoningDHV.

IEA ; UIC, 2017. *Railway Handbook on Energy Consumption and CO2 emissions,* Paris: International Energy Agency (IEA) ; International Union of Railways (UIC).

IFMO, 2013. *Mobility Y' – The Emerging Travel Patterns of Generation Y,* Munich: Institute for Mobility Research (ifmo).

ISL & IHS, 2015. *Prognose des Umschlagpotenzials und des Modal Splits des Hamburger Hafens für die Jahre 2020, 2025 und 2030 , Band 1: Umschlagpotenzialprognose,* Bremen: ISL Institut für Seeverkehrswirtschaft und Logistik.

Islam, D. & Zunder, T., 2018. Experiences of rail intermodal freight transport for low-density high value (LDHV) goods in Europe. *European Transport Research Review,* Issue June, pp. 10-24.

ITF, 2014. *A vision for railways in 2050,* Paris: International Transport Forum (ITF), OECD.

Janic, M., 2008. An assessment of the performance of the European long intermodal freight trains (LIFTS). *Transportation Research Part A: Policy and Practice,* 42(10), pp. 1326-1339.

KiM, 2014. *Niet autoloos, maar auto later. Voor jongvolwassenen blijft de auto een aantrekkelijk (in Dutch) = Not car-less but car later. For young adults, the car stays an attractive perspective,* Den Haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

KiM, 2015. *Uitwisseling gebruikersgroepen 'auto-ov',* Den Haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

KiM, 2016. *Marktontwikkelingen spoorgoederenvervoer 2005-2016,* Den Haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

KiM, 2017a. *Stabiele beelden verdiept. Trends in beleving en beeldvorming van mobiliteit,* Den haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

KiM, 2017b. *Ontwikkeling van de modal split in het goederenvervoer,* Den Haag: Kennisinstituut van Mobiliteitsbeleid (KiM).

KiM, 2018a. *Substitutiemogelijkheden van luchtvaart naar spoor,* Den Haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

KiM, 2018b. *De keuze van de reiziger,* Den Haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

KiM, 2018c. *Verklaring van de ontwikkeling van het ov-gebruik in Nederland over 2005-2016,* Den Haag: Kennisinstituut voor Mobiliteitsbeleid (KiM).

Klink, H. v. & Berg, G. v. d., 1998. Gateways and intermodalism. *Journal of Transport Geography,* 6(1), pp. 1-9.

KNV, 2014. *Aanvalsplan Spoorgoederenvervoer, Strategie en ambitie Spoorgoederensector,* s.l.: Werkgroep Aanvalsplan Spoorgoederenvervoer (WAS).

Kouwenhoven, M. et al., 2015. De waarde van betrouwbare reistijden in personenverkeer en -vervoer in Nederland. *Tijdschrift Vervoerswetenschap,* 51(1), pp. 17-48.

Kreutzberger, E., Konings, J. & Aronson, L., 2006. Evaluation of the cost performance of pre- and post-haulage in intermodal freight networks. In: B. Jourquin, P. Rietveld & K. Westin, eds. *Towards better performing transport networks.* Abingdon (UK): Routledge - Taylor & Francis Group, pp. 256-284.

Kroesen, M., Handy, S. & Chorus, C., 2017. Do attitudes cause behavior or vice versa? An alternative conceptualization of the attitude-behavior relationship in travel behavior modeling. *Transportation Research Part A: Policy and Practice* , 101(July), pp. 190-202.

Krüger, N. & Vierth, I., 2015. Precautionary and operational costs of freight train delays: a case study of a Swedish grocery company. *European Transport Research Review, 7(1), 6.,* 7(1), pp. 1-6.

Kudla, N. L. & Klaas-Wissing, T., 2012. Sustainability in shipper-logistics service provider relationships: A tentative taxonomy based on agency theory and stimulus-response analysis. *Journal of Purchasing and Supply Management,* 18(4), pp. 218-231.

Kuhnimhof, T. et al., 2012b. Men Shape a Downward Trend in Car Use among Young Adults : Evidence from Six Industrialized Countries. *Transport Reviews,* 32(6), pp. 761-779.

Kuhnimhof, T., Buehler, R., Wirtz , M. & Kalinowskad, D., 2012a. Travel trends among young adults in Germany : increasing multimodality and declining car use for men. *Journal of Transport Geography,* 24(september), pp. 443-450.

Lammgård, C., 2007. *Environmental Perspectives on Marketing of Freight Transports : The Intermodal Road-Rail Case,* Göteborg: School of Business, Economics and Law, Göteborg University.

Lammgård, C. & Andersson, D., 2014. Environmental considerations and trade-offs in purchasing of transportation services. *Research in Transportation Business & Management,* Volume 10, pp. 45-52.

Lammgård, C., Andersson, D. & Styhre, L., 2013. *Purchasing of transport services : a Survey among major Swedish Shippers.* [Online]
Available at: https://www.chalmers.se/sv/centrum/northern-lead/transportinkopspanelen/Documents/Lammg%C3%A5rd%20et%20al_NOFOMA.pdf
[Accessed 2018].

Landex, L., 2012. Reliability of Railway Operation. In: *Proceedings from the Annual Transport Conference.* Aalborg: Aalborg Universitet. Trafikforskningsgruppen.

Large, R., Kramer, N. & Hartmann, R., 2013. Procurement of logistics services and sustainable development in Europe: Fields of activity and empirical results. *Journal of Purchasing and Supply Management 19(3): 122-133.,* 19(3), pp. 122-133.

LeasePlan, 2017. *Totale autokosten per maand (Total car costs per month).* [Online]
Available at:
https://www.leaseplan.nl/documents/10182/128541/Car+Cost+Index+Europa+2017/70f3f6e0-c475-4253-95bf-6051574dbb63
[Accessed 2018].

Legrain, A., Eluru, N. & El-Geneidy, A., 2015. Am stressed, must travel: The relationship between mode choice and commuting stress. *Transportation Research Part F: Traffic Psychology and Behaviour,* Volume 34, pp. 141-151.

Lervåg, L.-E., Meland, S. & Wahl, R., 2001. *Utvikling av NEMO/REGO Parameterverdier (In Norwegian) = The development of NEMO/REGO - Parameter values,* Trondheim: SINTEF Bygg og miljø.

Litman, T., 2016. *The Future Isn't What It Used To Be : Changing Trends And Their Implications For Transport Planning,* Victoria, BC. (CA): Victoria Transport Policy Institute.

Litman, T., 2017. *Understanding Transport Demands and Elasticities : How Prices and Other Factors Affect Travel Behavior,* Victoria, BC. (CA): Victoria Transport Policy Institute.

Liu, W., 2016. *Determining the Importance of Factors for Transport Modes in Freight Transportation,* Delft: Technische Universiteit Delft.

LivingRAIL ; SPIDER PLUS, 2015. *Rail towards 2050 : Vision and Roadmap for Sustainable Mobility (Collaborative brochure of the research projects LivingRAIL and SPIDER PLUS),* Karlsruhe: Fraunhofer Institute for Systems and Innovation Research ISI.

Mann, E. & Abraham, C., 2006. The role of affecting UK commuters' travel mode choices : An inpretative phenomenological analysis. *British Journal of Psychology,* 97(2), pp. 155-176.

Mayeres, I., 2000. "Efficiency Effects of Transport Policies in the Presence of Externalities and Distortionary Taxes. *Journal of Transport Economics and Policy,* 34, part 2(May), pp. 233-260.

Milakis, D. et al., 2015. *Development of automated vehicles in the Netherlands: scenarios for 2030 and 2050,* Delft: Delft University of Technology.

Mulholland, E. et al., 2018. The long haul towards decarbonising road freight : A global assessment to 2050. *Applied Energy,* Volume 216(C), pp. pages 678-693.

Nordenholz, F., Winkler, C. & Knörr, W., 2017. Analysing the modal shift to rail potential within the long-distance passenger travel market in Germany. *Transportation Research Procedia,* Volume 26, pp. 81-91.

Notteboom, T. & Rodrigue, J.-P., 2009. The future of containerization: Perspectives from maritime and inland freight distribution. *GeoJournal,* 74(1), pp. 7-22.

OPTIMISM , 2012. *List of potential Megatrends influencing transport system and mobility behaviour. , Deliverable D.3.2, Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility (OPTIMISM),* Brussels: European Commission.

Paulley, N. et al., 2006. The demand for public transport : The effects of fares, quality of service, income and car ownership. *Transport Policy,* 13(4), pp. 295-306.

PBL & CE Delft, 2010. *Effecten van prijsbeleid in verkeer en vervoer : Kennisoverzicht,* Den Haag: Planbureau voor de Leefomgeving (PBL).

PBL, 2015. *De Toekomstverkenning Welvaart en Leefomgeving : Cahier Mobiliteit (in Dutch) = Prosperity and Environment , Mobility,* Den Haag: Planbureau voor de Leefomgeving (PBL).

PBL, 2015. *Veel kilometers buiten de stad.* Den Haag: Planbureau voor de Leefomgeving (PBL).

Piecyk, M. & McKinnon , A., 2009. *(2009). Environmental Impact of Road Freight Transport in 2020. Full Report of a Delphi Survey.,* Edinburgh: LRC, Heriot-Watt University.

Platz, T., 2008. *Market perspectives for inland waterway shipping in intra-European intermodal transport. Paper presented at the European Transport Conference 2008, proceedings.* s.l., s.n.

Port Authorities PoR, 2015. *Container Throughput Hamburg - Le Havre Range, Timeseries, 1985-2014,* Rotterdam: Port of Rotterdam.

ProRail ; NS, 2017. *International Benchmark 2011-2015,* s.l.: ProRail ; NS.

Punakivi, M. & Hinkka, V., 2006. Selection criteria of transportation mode: A case study in four finnish industry sectors. *Transport Reviews,* 26(2), pp. 207-219.

PwC & La Sapienza, 2015. *Study on Single Wagonload Traffic in Europe – challenges, prospects and policy options,* Luxembourg: Publications Office of the European Union.

Redman, L., Friman, M., Gärling, T. & Hartig, T., 2013. Quality attributes of public transport that attract car users: A research review. *Transport Policy,* Volume 25, pp. 119-127.

Rheinhold, T., 2008. More passengers and reduced costs. The optimalization of the Berlin transport network. *Journal of Public Transportations,* 11(3), pp. 57-76.

Roland Berger ; UNIFE, 2016. *World rail market study 2016,* München: Roland Berger GmbH.

Santos, G., Maoh, H., Potoglou, D. & von Brunn, T., 2013. Factors influencing modal split of commuting journeys in medium-size European cities. *Journal of Transport Geography,* 30(June), pp. 127-137.

Scheiner, J., 2010. Interrelations between travel mode choice and trip distance: trends in Germany 1976-2002. *Journal of Transport Geography,* 18(1), pp. 75-84.

SCI , 2016. *European Rail Freight Transport Market : Developments – Volumes - Players,* Hamburg et al.: SCI Verkehr GmbH.

Sessa, C. & Enei, R., 2009. *EU Transport GHG: Routes to 2050?. Paper: EU transport demand : Trends and drivers,* London: AEA ; EC.

Sichelschmidt, H., 1999. The EU programme "trans-European networks": a critical assessment. *Transport Policy,* 6(3), pp. 169-181.

Steer Davies Gleave, 2015. *Study on the Cost and Contribution of the Rail Sector, final report,* Brussels: European Commission Directorate General for Mobility and Transport.

Steer Davies Gleave, 2016. *Study on the prices and quality of rail passenger services,* Brussels: European Commission (EC).

Steer Davies Gleave, 2018. *Research for TRAN Committee : The new Silk Route opportunities and challenges for EU transport,* Brussels: European Parliament (EP), Policy Department for Structural and Cohesion Policies.

The European Rail Research Advisory Council, 2012. *Encouraging modal shift (long distance) and decongesting corridors.* [Online]
Available at: http://errac.org/publications/errac-work-package-02-encouraging-modal-shift-long-distance-and-decongesting-transport-corridors/
[Accessed 2018].

Thompson, K. & Schofield, P., 2007. An investigation of the relationship between public transport performance and destination satisfaction. *Journal of Transport Geography,* 15(2), pp. 136-144.

TNO, 2011. *Modal Shift Target for Freight Transport Above 300 km: An Assessment, Discussion Paper – 17th ACEA SAG Meeting –.* [Online]
Available at: https://www.acea.be/uploads/publications/SAG_17.pdf
[Accessed 2018].

TNO, 2017. *Modal shift van weg naar spoor Potentie tot 2050 en effect op CO2-uitstoot (in Dutch) = Modal shift from road to rail, potential towards 2050 and CO2-effects. Dutch: ,* Den Haag: TNO, Earth, Life & Social Sciences.

TNS Political & Social , 2013. *Europeans' satisfaction with rail services,* Brussels: European Commission (EC).

TomTom, 2016. *Trafic Data Antwerp, Rotterdam and Hamburg, data sheets, 2013,2014, 2015,* s.l.: TomTom.

TU Darmstadt, 2018. *HiRo – Marktpotenzial von Containertransporten aus dem südwestdeutschen Hinterland : Auszug aus dem Forschungsbericht des Fachgebiets Unternehmensführung und Logistik, Nr. 26,* Darmstadt: Technische Universität Darmstadt .

UIC, 2015. *Global Vision for Railway Development,* Paris: International Union of Railways (UIC) .

UIC, 2017. *Combined Transport in Europe,* Paris: International Union of Railways (UIC) .

UIC, 2018. *High Speed Rail, fast track to sustainable mobility,* Paris: International Union of railways (UIC).

UITP, 2016. *Regional and Suburban Railways - Market Analysis Update,* s.l.: Union Internationale des Transports Publics (UITP).

UN, 2018. *2018 Revision of World Urbanization Prospects,* Washington DC: United Nations (UN), Desa.

UNWTO, 2015. *International tourism trends in EU-28 member states - Current situation and forecast for 2020-2025-2030,* Madrid: World Tourism Organization (UNWTO).

Van den Berg, R., 2015. *Strategies and new business models in intermodal hinterland transport.,* Eindhoven: Technical University Eindhoven.

Van den Berg, R. & De Langen, P. W., 2017. Environmental sustainability in container transport: the attitudes of shippers and forwarders. *International Journal of Logistics Research and Applications,* 20(2), pp. 146-162.

Van Hagen, M. & Bron, P., 2014. Enhancing the Experience of the Train Journey : Changing the Focus from Satisfaction to Emotional Experience of Customers. *Transportation Research Procedia,* 1(1), pp. 253-263.

Van Hagen, M., De Bruyn, M. & Ten Elsen, E., 2017. The Power of a Pleasant Train Journey. *Transportation Research Procedia,* Volume 26, p. 177–186.

Varghese, V. & Jana, A., 2018. Impact of ICT on multitasking during travel and the value of travel time savings: Empirical evidences from Mumbai, India. *Travel Behaviour and Society,* Volume 12, pp. 11-22.

Vashist, J. K. & Dey, A. K., 2016. Selection Criteria for a Mode of Surface Transport: An Analytic Hierarchy Process Approach. *Amity Global Business Review ,* 11(Februari), pp. 86-95.

VTT ; AustriaTech ; Chalmers, 2017. *Mobility As A Service For Linking Europe MAASiFiE : Deliverable Nr 4 – Impact Assessment,* Brussels: Conference of European Directors of Roads (CEDR).

Wanders, G., 2014. *Determining shippers' attribute preference for container transport on the Rotterdam – Venlo corridor,* Delft: TU Delft.

Wardman, M., 2013. *Value of Time Multipliers: A Review and Meta-Analysis of European-Wide Evidence. Paper Presented at Transportation Research Board 92nd Annual Conference, 2013-1-13 to 2013-1-17,* Washington DC: s.n.

Wardman, M., 2014. *Valuing convenience in public transport : Roundtable Summary and Conclusions,* Paris: OECD, International Transport Forum.

Wardman, M., Chintakayala, V. & Jong, G. d., 2016. Values of travel time in Europe: Review and meta-analysis. *Transportation Research Part A: Policy and Practice,* Volume 94, pp. 93-111.

Wardman, M. & Lyons, G., 2016. The digital revolution and worthwhile use of travel time: implications for appraisal and forecasting. *Transportation,* 43(3), pp. 507-530.

Warffemius, P. et al., 2016. *The value of comfort in train appraisal. Paper for the European Transport Conference (ETC), Barcelona,* s.l.: s.n.

Wuppertal institut, 2018. *Deep Decarbonisation Pathways for Transport and Logistics Related to the Port of Rotterdam,* Wuppertal: Wuppertal Institut für Klima, Umwelt, Energie gGmbH.

Yavuz, N. & Welch, E., 2010. Addressing fear of crime in public space : gender differences in reaction to safety measures in train transit. *Urban Studies* , 47(12), p. 2491–2515.

A Modal choice criteria passenger rail transport

Modal choice (performance) criteria		Redman, 2013	Brons, 2009	Reinhold, 2008	Bellinger, 1970	UIC, 2018	Greeno & Hunt, 2013	KiM, 2015	KiM, 2018a[7]	Dell'Olio et al., 2011	Dell'Olio et al., 2012	Chakrabarti, 2017	Guirao et al., 2016
Time	Travel time (door-to-door)	x	x	x	x	x	x	x	x	x		x	x
	Wasted time					x							
	Waiting time	x						x		x			
	Speed	x		x									
	Parking searching time							x					
	Road congestion							x					
Reliability	Reliability/ punctuality	x	x		x	x	x					x	X
	Connection certainty			x									
	Vehicle condition/frequency of breakdowns	x											
	Handling of delays						x						
Accessibility	Access	x			x	x		x				x	
	Ease of reaching stops			x									
	Transfers					x		x					
	Flexible itinerary					x							
	Timetable					x							
Frequency	Frequency	x		x	x		x				x	x	
	Number of travel opportunities per day								x				
Price	Price	x	x		x	x	x		x		x		
	Parking fees							x			x		
	Fuel taxes										x		
	Congestion charges										x		
Comfort & Quality	Comfort	x		x	x				x				
	Comfort at stations								x				
	Comfort in train								x				
	Access to seat	x								x			x
	On-board services					x							

[7] Scope of this study is specific for long distance trips (rail vs. air travel).

Modal choice (performance) criteria	Redman, 2013	Brons, 2009	Reinhold, 2008	Bellinger, 1970	UIC, 2018	Greeno & Hunt, 2013	KiM, 2015	KiM, 2018a[7]	Dell'Olio et al., 2011	Dell'Olio et al., 2012	Chakrabarti, 2017	Guirao et al., 2016
Cleanliness			x			x			x			x
Leisure/work opportunity					x							
Air conditioning	x											
Noise levels	x											
Driver handling	x											
Convenience	x	x		x								
Ease of transfers/ interchanges												
Travel information before travelling								x				
Travel information during travelling								x				
Reservation system								x				
Luggage handling					x			x				
Aesthetics of vehicles, stations and waiting areas	x											
Safety (related to accidents)	x	x	x		x							
Security/personal safety	x				x							
Environmental Impact					x							

B Complete list rail freight criteria

Modal choice (performance) criteria	**Bury et al., 2017**	**Vashist & Dey, 2016**	**Elbert, 2018**	**Liu, 2016**	**CE Delft, 2011**	**Piecyk & McKinnon, 2009**	**Lammgard et a., 2013**	**ERRAC, 2012[8]**	**Arencibia et al., 2015[9]**	**Feo-Valero et al., 2016[10]**
Administration	x					x				
Direct cost	x		x	x	x	x	x	x	x	x
External cost		x			x					
Inventory costs					x					
Handling costs					x	x				
Delays	x									
Traceability	x		x		x			x	x	x
Controllability	x							x	x	
Value Added Services	x	x								
Transit time	x	x	x	x	x	x	x		x	x
Lead time					x					
Just in time					x					
Frequency	x		x	x	x			x	x	x
Distance	x									
Capability	x	x								
External impacts	x									
Security	x				x					
Finances	x									
Damage/Loss	x								x	x
Claims Processing	x									
Flexibility	x			x	x	x		x	x	x
Certification	x									
Safety Record	x									
Image of Mode	x									
Market Considerations	x									
Location	x					x				
Destination					x	x				
Relationships	x									
Previous Experience	x									
Company Policy	x									
Cargo characteristics	x				x					
Inventory	x									
Safety		x			x			x		
Reliability/punctuality		x		x	x	x	x		x	x
Capacity		x			x			x		x
Seamless convenience		x				x		x		

8 The European Rail Research Advisory Council, 2012.
9 Arencibia, et al., 2015.
10 Feo-Valero, et al., 2016.

Modal choice (performance) criteria	Bury et al., 2017	Vashist & Dey, 2016	Elbert, 2018	Liu, 2016	CE Delft, 2011	Piecyk & McKinnon, 2009	Lammgard et a., 2013	ERRAC, 2012[8]	Arencibia et al., 2015[9]	Feo-Valero et al., 2016[10]
Mode attribute		x								
Availability		x								
Environmental				x	x		x		x	x
Destinations					x					
Social costs					x					
Accessibility (terminals)								x		
Transparency/simplicity					x					
Interoperability					x			x		
Congestion (rail infra.)						x				
Less-than-train-load ability								x		
Schedules (documentation)									x	x

C Rail customer satisfaction figures

The following figures are taken from Steer Davies Gleave (2016). The source is Flash Eurobarometer 382a analysis. Note: “high” and “good” satisfaction scores combined.

Figure 48 - Eurobarometer scores: railway stations and rail services (2012-2013)

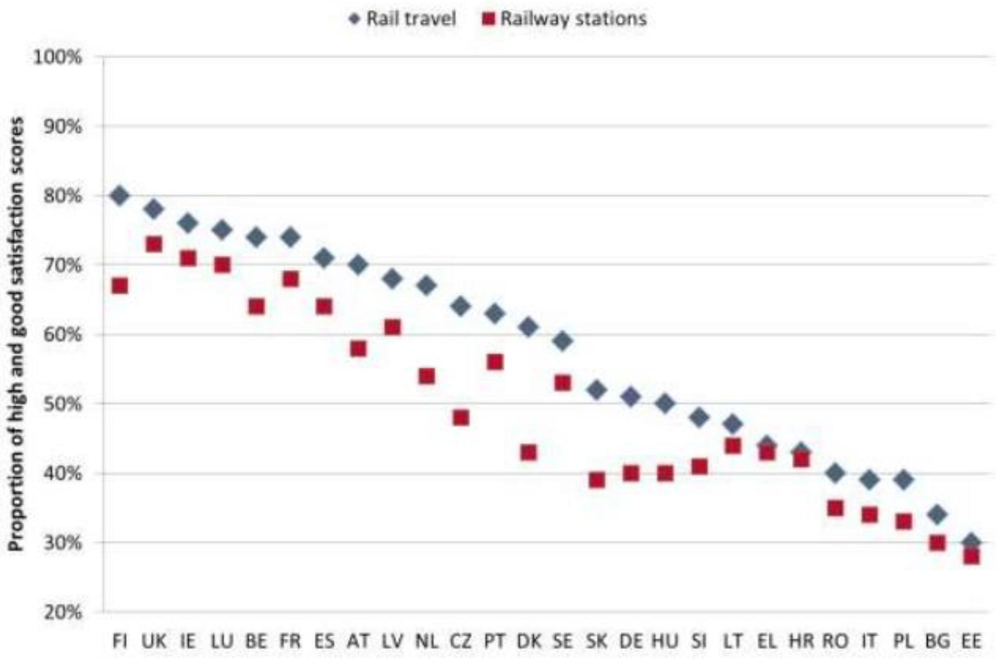


Figure 49 - Eurobarometer scores: ticketing attributes (2012-2013)

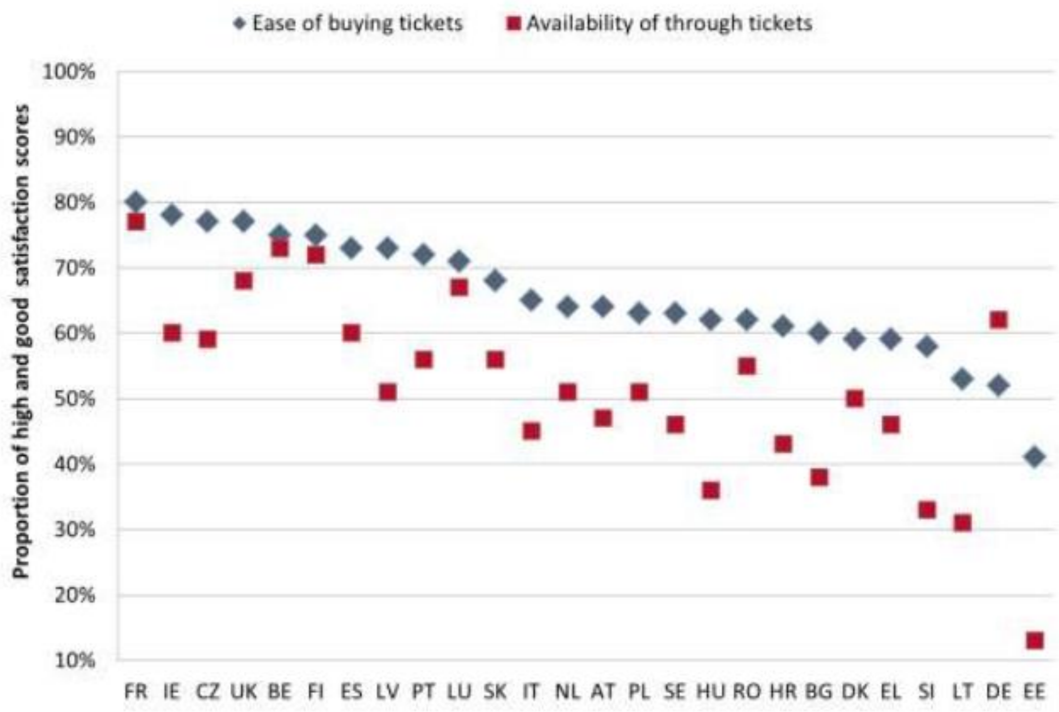


Figure 50 - Eurobarometer scores: frequency and punctuality and reliability (2012-2013)