TEXTE
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Executive summary

Options for action for an ecological design of long-distance mobility in passenger and freight transport

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List of abbreviations

BRKG	Bundesreisekostengesetz - Federal Travel Expenses Act
CO_2	Carbon dioxide
COVID-19	coronavirus disease 2019; Coronavirus-Krankheit-2019
DLR	Deutsches Zentrum für Luft- und Raumfahrt e. V. – German Aerospace Center
e.g.	for example
et al.	et alii (and others)
e. V.	eingetragener Verein – registered association
FB	Fachbereich - department
f., ff.	following pages
GmbH	Gesellschaft mit beschränkter Haftung – limited company
HH	household
ISSN	International Standard Serial Number
KIT	Karlsruhe Institute of Technology
km	kilometers
MiD	Mobilität in Deutschland – Mobility in Germany
n	sample size
PDF	Portable Document Format
pkm	passenger kilometers
t	ton
TTS	TRIMODE Transport Solutions GmbH
UBA	Umweltbundesamt – German Environment Agency

Preliminary note

Greenhouse gas emissions from transport are mainly determined by long-distance traffic between conurbations in passenger transport and traffic hubs in freight transport. In the course of the project "Options for action for an ecological design of long-distance mobility in passenger and freight transport", strategies and solutions were identified that effectively reduce the greenhouse gas emissions caused by long-distance transport.

According to the "Action Program Climate Protection 2020" of the German Federal Government, long-distance passenger transport is to be made more climate-compatible on the one hand, and rail freight transport is to be strengthened on the other. With regard to these two goals, the research project provides findings for the further design of both sustainable passenger mobility and sustainable freight transport and provides the basis for the development of environmental policy options in long-distance transport.

Although long-distance mobility in passenger transport is characterized by continuing growth, the data basis for describing and explaining it is still fragmentary. In freight transport, on the other hand, the focus so far has been primarily on the infrastructural supply side with regard to shift potentials from road to rail, while there are still research gaps in the identification and analysis of demand-side requirements of shippers and carriers.

Given the very different structure of passenger and freight transport - and thus also the possible, specific solutions - both transport sectors are investigated independently of each other, but in a similar way by means of systematic literature research followed by empirical analysis and final formulation of recommendations for action.

Part A – Passenger transport

1 Background

Long-distance mobility in passenger transport is characterized by continued growth. While transport growth in everyday mobility has slowed down considerably or even stagnated, the dynamic growth in long-distance passenger mobility continued unabated until the start of the COVID-19 pandemic. Though long-distance journeys are comparatively rare compared to everyday trips, the environmental impacts are particularly severe due to the corresponding high mileage, which is also generated almost exclusively by motorized means of transport.

Despite the fact that long-distance mobility accounts for a considerable share of total mobility, there are gaps in both the state of knowledge and the data available for describing and explaining it. Given the objective to identify options for action for an ecological design of long-distance mobility, this project aims to develop a data basis for a detailed description of the long-distance mobility of individuals. A dedicated survey is used to investigate decision-making related to long-distance mobility. Finally, taking into account the empirical results, options for action to influence long-distance mobility are derived.

In this project, the term 'long-distance' is used to refer to trips with a one-way distance between origin and destination of at least 100 km. In order to obtain a picture of long-distance mobility as comprehensive as possible and to derive specific options for action, both private and business trips of different durations (with and without overnight stays) are taken into account. The focus is on the mobility of the domestic population, thus including not only journeys within Germany, but also abroad.

2 Literature and data

Based on a comprehensive literature review, determinants and drivers are described that have an influence on long-distance mobility. On the one hand, this serves to identify relevant characteristics for the investigation of different groups of travelers and, on the other hand, to determine areas of action for the final derivation of options for action. The main characteristics used to describe long-distance mobility according to the literature are age, occupational status, income, education and gender. Drivers on the demand side are thus rising incomes, increasing occupation and higher levels of education. Other driving trends include urbanization, the emergence of multi-local lifestyles, changing work patterns and socialization. On the supply side, both the expansion and diversity of services (including expansion of the network of federal roads and highways, deregulation of transport markets) and the reduction of barriers to travel (for example, easier information procurement and booking options) are to be mentioned.

In addition to the literature review to identify determinants and drivers, a synthetic compilation of available data on long-distance mobility was carried out. On the one hand, these are data and findings from mobility surveys. In this regard, the data set of the Germany-wide survey "Mobilität in Deutschland 2017" (MiD) (Eng. "Mobility in Germany") is the most comprehensive source of data on the transport demand of the domestic population. Besides everyday travel, it includes long-distance travel by means of an additional survey module on overnight trips. On the other hand, data and information are available from official statistics. Many of them follow the territory principle and cover, for example, trips inside Germany of both the residential population and foreign tourists. Therefore, such data and information are not directly compatible with results from mobility surveys that follow the residence principle.

The result of the compilation of data and information shows that none of the available data sources, neither those from the transport sector nor those from a tourism perspective, provides a comprehensive overall picture of long-distance mobility. The generation of a consistent demand picture thus requires a methodological approach that brings together the central, complementary data bases in a single model.

3 Fusion model for the determination of the quantity structure

The modeling of the domestic population's mobility is essentially based on the results of the Germany-wide survey MiD 2017, supplemented by other official statistics. Even if the MiD is in principle suitable for measuring total (long-distance) transport demand, data must be processed for the purpose of this project and calibrated using key figures from transport statistics. Both the merging of the various data sources and the calibration are carried out within the framework of a 'fusion model' derived from the passenger transport calculation model for the statistical pocketbook "Verkehr in Zahlen" (Eng. "Transport in Figures"). The modeling was done in synergy with the project "Klimawirksame Emissionen des deutschen Reiseverkehrs" (Eng. „Greenhouse gas emissions of the German tourism mobility"), which was carried out in parallel for the German Environment Agency.

The processing of MiD primarily involves an integration of the trips and journeys reported in the different survey modules (trip diary of the reporting date module, journey module). Basically, long-distance trips are recorded in both modules, but with different levels of detail and for different groups of respondents. Different steps of processing are necessary because, among other things, the journey module only covers trips with overnight stays undertaken by individuals aged 14 and older, or because outward or return trips of multi-day journeys may be captured by both modules. Components of the processing are therefore the elimination of doubly recorded trips, the imputation of missing data on the means of transport and the distance traveled, the imputation of overnight trips by children, and a reweighting.

Several parameters of passenger transport demand are used for calibration. These include parameters from the statistical pocketbook "Verkehr in Zahlen" (Eng. Transport in Figures) published by the German Federal Ministry of Transport, information on motor vehicle use from the driving performance survey "Fahrleistungserhebung 2014", demand figures and transport performance of public transport from the German Federal Statistical Office, and passenger figures at German airports from the German Federal Statistical Office and the German Airports Association (G. Arbeitsgemeinschaft Deutscher Verkehrsflughäfen).

The resulting fusion data set enables various and flexible analyses. The weighting included allows the calculation of the annual transport performance of the domestic resident population. Based on the distance traveled, this is divided into everyday mobility (less than 100 km) on the one hand and long-distance mobility (100 km or more) on the other. If this distinction is applied to the fusion model, the key figures are as shown in Table 1. It becomes clear that long-distance mobility (trips ≥ 100 km) plays only a minor role in terms of travel volume, accounting for 1.7% of all trips, but explains a large share of travel performance with a share of 46.3%.

Table 1: Long-distance mobility of the domestic population (travel volume and travel performance) based on the fusion dataset

Key figure	Trip distance ≥ 100 km (share)	Trip distance < 100 km (share)	Total
Travel volume	1.589 billion trips (1.7%)	93.113 billion trips (98.3%)	94.702 billion trips
Travel performance	702.386 billion pkm (46.3%)	815.421 billion pkm (53.7%)	1,517.806 billion pkm

Source: own calculation based on the fusion dataset

With regard to mode choice, it can be seen that the individual motorized transport dominates both everyday and long-distance mobility (Table 2). Other modes of transport are used almost exclusively either for everyday travel or for long-distance travel. Thus, the modes "walking" and "cycling" are primarily present in everyday mobility, while the airplane and the ship play a role almost only for long-distance mobility.

Table 2: Results of the model calculations – travel performance of long-distance and everyday mobility broken down by mode of transport

Travel performance of the domestic residential population	Walking	Cycling	Motorized individual transport	Public transport	Airplane	Ship	Other/ not specified
[billion passenger kilometers]	[billion passenger kilometers] [%]						
Long-distance mobility as of 100 km Total: 702.4 46.3%	0.0 0%	1.2 3%	315.3 34%	70.1 40%	290.7 100%	13.8 95%	11.2 43%
Everyday mobility up to less than 100 km Total: 815.4 53.7%	35.8 100%	41.6 97%	618.4 66%	104.1 60%	0.0 0%	0.7 5%	14.9 57%
Total mobility: 1,517.8 100%	35.8 100%	42.8 100%	933.7 100%	174.2 100%	290.7 100%	14.5 100%	26.1 100%

Reference year 2017

Source: own calculation based on the fusion dataset

The results for transport performance broken down by trip purpose show that vacation trips with a minimum duration of 5 days and business trips with overnight stays are almost exclusively trips with a minimum distance of 100 km (Table 3). These decisively contribute to long-distance transport performance. For trips to educational institutions and to work, 7% of the travel performance can be attributed to long-distance mobility.

Table 3: Results of the model calculations – travel performance for long-distance and everyday mobility broken down by type of journey

Travel performance of the domestic residential population	Vacation journeys (5+ days)	Short vacation journeys (2-4 days)	Trips to educational institutions/ to work	Day trips and trips on reporting day[1]	Business journeys with overnight stay	Business journeys without overnight stay
[billion passenger kilometers]	[billion passenger kilometers] [%]					
Long-distance mobility as of 100 km Total: 702.4 46.3%	313.4 100%	91.0 98%	18.2 7%	90.5 17%	121.2 100%	68.2 34%
Everyday mobility up to less than 100 km Total: 815.4 53.7%	0.4 0%	2.1 2%	236.3 93%	442.8 83%	0.3 0%	133.4 66%
Total mobility: 1,517.8 100%	313.8 100%	93.1 100%	254.5 100%	533.2 100%	121.6 100%	201.6 100%
Breakdown of purposes within long-distance mobility **Total: 702.4** **100%**	**313.4** **45%**	**91.0** **13%**	**18.2** **3%**	**90.5** **13%**	**121.2** **17%**	**68.2** **10%**

[1] Day trips and trips conducted on the reporting day include the trip purposes shopping, errands, leisure as well as pick-up and drop-off.

Reference year 2017. Due to rounding totals may not sum up exactly.

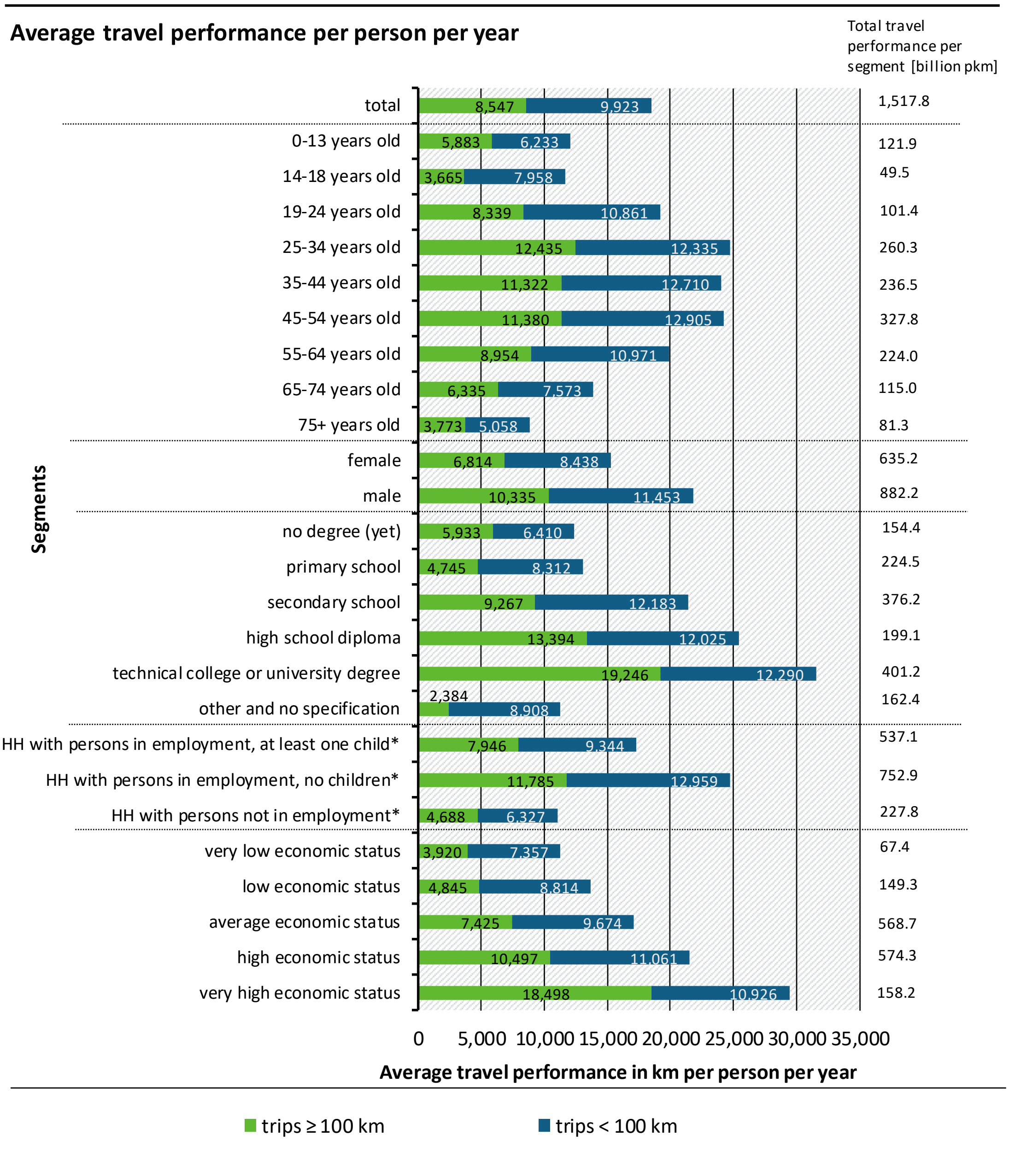
Source: own calculation based on the fusion dataset

In order to derive options for action and the potential impact, it is necessary to examine and describe various demand segments (groups of travelers, modes of transport and trip purposes).

On average, an individual conducts 19.33 long-distance trips per year, with business trips with and without overnight stays as well as outings without overnight stays dominating the travel volume. With regard to the use of transport modes, the relevance of motorized individual transport becomes clear: While public transport is equally used for all trip purposes, airplanes are mainly used for longer vacation trips and for business purposes. The transport performance results in approximately equal parts from the individual motorized transport (3,863 km per person) and air travel (3,538 km per person). With regard to air travel, it should be emphasized that a small number of trips (1.5 one-way trips or 0.75 journeys by air per person per year) is responsible for this high average transport performance, about half of which is accounted for by vacation trips with at least four overnight stays. Overall, annual long-distance travel per person averages 8,547 km, which is 46.3% of the total individual travel of 18,470 km.

A look at the average travel performance of different groups of people shows that different groups of middle-aged people, men and highly educated people in particular account for most of the kilometers traveled (Figure 1), as do employed people without children and households with a high economic status.

Figure 1: Results of the model calculations – Average travel performance of long-distance and everyday mobility per person per year broken down by traveler's characteristics



*HH = households

Source: own calculation based on the fusion data set

The increase in average travel performance that rises along with economic status (the higher the status, the higher the travel performance) results primarily from an increase in travel performance by air.

4 Empirical findings

Since none of the available data sources, neither the ones from the transport sector nor those from the tourism perspective, provide a consistent overall picture of long-distance travel, a complementary online survey was designed. Questions on decision-making related to long-distance travel, differentiated according to various behavioral dimensions and segments of long-distance mobility, were paramount to the survey. These questions were embedded in the collection of an overall quantitative overview of the different travel types.

A total of 1,002 individuals (net sample) were surveyed who had made journeys with a one-way distance of 100 km or more in a retrospective observation period of up to one year. Respondents with a high level of long-distance mobility should have above-average representation in the survey to reflect their strong influence on the overall long-distance travel.

Traveling is characterized by a typical seasonality in the course of the year. In addition, the recording of trips made some time ago, with all the associated considerations, deliberations and decisions, is dependent on the limited and also selective memory of the respondents. Therefore, the retrospective reporting periods were staggered according to the type of journey to be reported: The greater the number of overnight stays in the course of a journey, the longer the respective reporting period. First, however, the past 12 months were to be recapitulated in their entirety. Only then were a maximum of two individual trips to be reported in more detail.

The survey followed a modular scheme: Following the query of selected personal characteristics to control the sample, a rough recording of the travel volume (number of trips) for an entire year was carried out, differentiating between private and business trips, in each case with or without overnight stays.

Detailed questions on individual trips were nested within questions on general travel behavior and related framework conditions, on secondary residences and related commuting behavior, on commuting to work or education, and on the socio-demographics of the respondents and their households. The core of the survey, however, was about decision-making in the context of specific travel events (decision criteria, attitudinal statements about destination and mode choice, personal mindset towards the environment).

The results of the empirical investigation provide a number of starting points for recommendations for action.

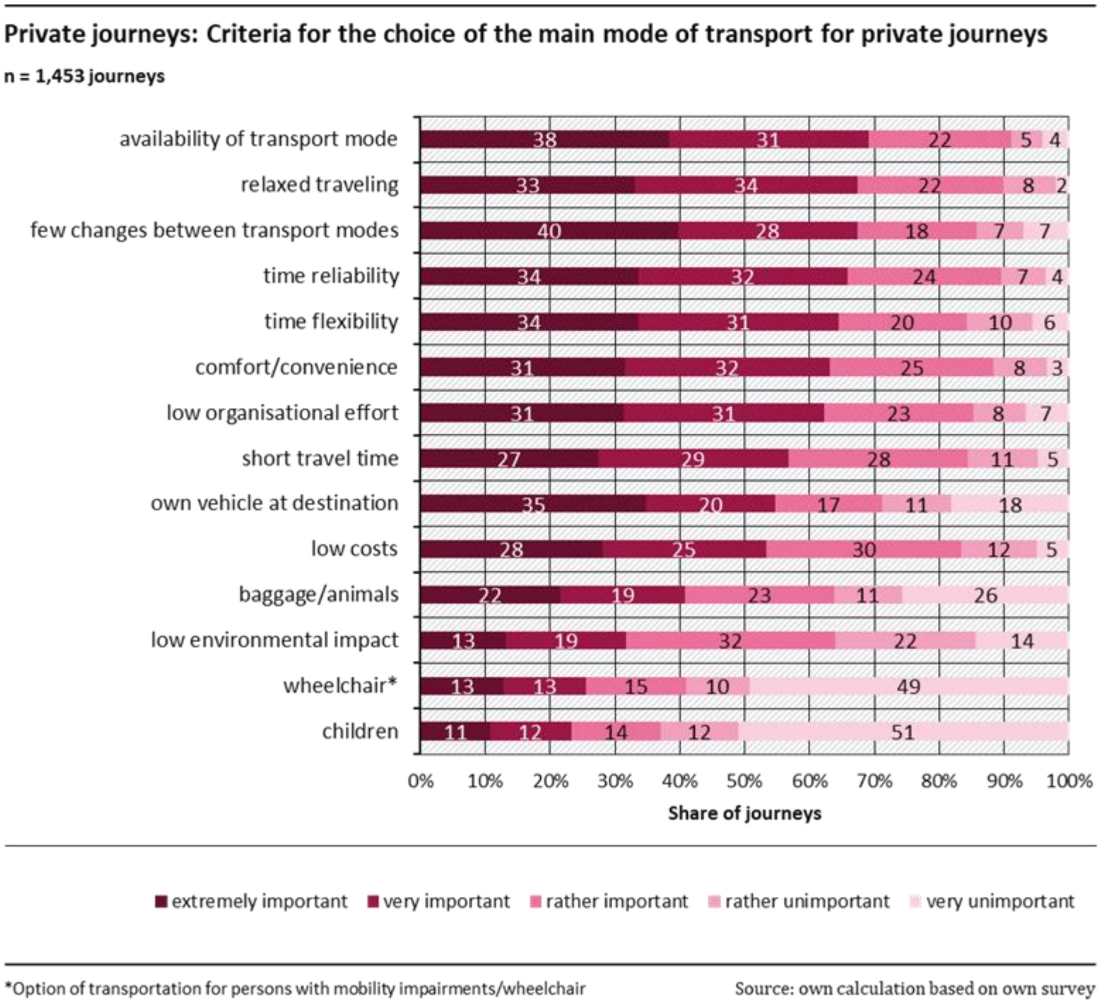
There is a tendency to travel abroad, especially on vacation, but this does not necessarily mean longer distances. However, the time spent traveling plays a rather subordinate role. It is a possibility that therefore longer distances are also readily accepted, thus shorter travel times tend to be omitted as a decision argument.

Similarly, environment-related arguments do not promise to gain any momentum: Despite the general awareness of many people, the resulting environmental impact of their own travels is either played down or readily accepted. In this context, even indirect measures such as climate compensation payments show little potential. The extremely low utilization of these compensation measures to date implies that they tend not even to be used as a 'fig leaf'. However, this also illustrates a certain ignorance of the environmental impacts. Thus, for private trips (as well as for business trips), a low environmental impact plays a rather subordinate role compared to other criteria when choosing the main mode of transport (Figure 2).

The effectiveness of financial incentives, on the other hand, appears to be of slightly greater importance, but it is questionable whether all cost components – be it the cost of travel or those related to the stay at the destination – have an equal influence on decision-making with respect to the development of travel demand.

There is little evidence for control measures with regard to possible changes in the choice of destination: It can be assumed that the travelers are largely committed to their destination (region), and that this is well justifiable, at least from a subjective point of view. Only a small proportion of respondents were willing to head for another (possibly closer) destination, in which case they still tended to stay within the originally targeted region.

Figure 2: Criteria for the choice of the main mode of transport for private journeys



The same applies by and large to the choice of transport mode, where there is also a low propensity to change. At least the use of rail is considered more frequently, so that in combination with service improvements, for example, there is potential for a shift away from the private car and air travel.

Against the background of the current pandemic, it is completely open which role the option not to travel will play in the future. In principle, before the outbreak of the pandemic, the option of foregoing a trip and realizing the purpose of the trip in some other way was judged to be virtually non-existent. The most likely area for change would be in the professional context, especially after practical experience with permanent "substitutes" such as work from home, web-conferencing and other forms of digital communication.

Regardless of the presumably changing relevance and quantity of work-related travel, it is just in the professional context that business travelers have considerable individual flexibility with regard to mode choice, which, however, can only have an effect in combination with corresponding regulations of labor law (e.g. 'travel time = working time').

The most promising parameters would be travel time reliability and flexibility of transport modes, which are of great importance for both private and business travelers. Improvements in these areas, combined with minimized organizational effort for planning and booking trips, would be compelling incentives that could help transit operators retain their existing customer base and attract new ones.

5 Recommendations for action

The starting points for the elaboration of measures are, on the one hand, findings on already discussed, tried and tested measures, on the customers' socio-demographic and socio-economic characteristics, attitudes and decision-making processes and, on the other hand, the respective quantitative relevance of different groups of travelers or types of journeys.

The vast majority of conceivable measures are usually directed only at very specific target groups or areas of transport demand. A central target group are travelers, who directly determine the demand arising from their decisions. Another target group comprises individuals, organizations and companies that set the framework conditions for travel demand and thus also determine it. In the broadest sense, the state in its function as legislator also is part of this target group, as it is responsible for the legal and regulatory framework.

Whether a measure can be effective at all in the intended sense crucially depends on whether the target groups addressed have sufficient options and freedom to act. Hence, it must be assumed that even within the aforementioned groups, individual subgroups are subject to different framework conditions and have different needs, requirements and levels of authority. This applies at all levels, be they different travelers (for example, private versus business travelers), different transport providers (for example, primarily publicly financed municipal transport operators versus privately operated airlines or long-distance bus operators), or different government agencies (for example, local municipalities versus the federal government). This inevitably means that conflicting interests of different target groups may have to be considered. When deriving measures, it must also be taken into account that they may also result in opposite, so-called rebound effects.

Based on the findings documented in the literature and the results of the empirical analyses, measures are presented that show potential for sustainable change in long-distance mobility.

The spectrum of possible interventions towards a sustainable change in long-distance mobility is very broad, ranging from monetary measures to the targeted influence of individual modes of transport or travel segments, the large sphere of digitalization that is effective in all areas of society, all the way to communication strategies, mobility culture, and individual socialization (Table 4).

Table 4: Overview of areas of action and individual measures (selection)

Area of action	Individual measures (selection)
Monetary approaches (pricing, budgeting, compensation)	▪ CO_2 pricing ▪ Implementation of individualized CO_2 budgets ▪ Modification of policies and taxation related to company cars ▪ Implementation of a mandatory CO_2 compensation regime
Influencing (= reducing) air travel	▪ True-cost pricing ▪ No reduction of access barriers ▪ More efficient organization of air travel
Strengthening vacation destinations 'nearby'	▪ Orientation of the incurred costs according to travel distance ▪ Establishment and strengthening of local tourism ▪ Broadening the range of the domestic tourism portfolio
Influencing (= reducing) individual motorized transport	▪ Application of demand-/time-based tolling scheme to long-distance transport infrastructure (passenger car toll) ▪ Speed limit on highways ▪ Reduction of fiscal benefits for (private) company car use ▪ Differentiation of fiscal benefits resulting from the commuting allowance
Strengthening rail and bus as a means of transport	▪ Reduction in the supply of domestic (short-distance) flights in Germany ▪ Re-expansion of the night train network (within Germany, cross-border) ▪ Expansion (but at least perpetuation) of flexibility in rail transport ▪ Facilitation of intermodal travel chains – bridging the 'first' and 'last mile'
Digitalization, virtualization	▪ Ubiquitous expansion of the technical communications infrastructure ▪ Facilitation and promotion of work from home and mobile work ▪ Creation of virtual worlds of experience
Influencing travel organization and travel flow	▪ Integration of business travel into corporate climate protection activities ▪ Modification of the Federal Travel Expenses Act (G. Bundesreisekostengesetz, BRKG) ▪ Flexibilization of work time regulations
Establishment of a sustainable mobility culture and communication strategy	▪ Flight shame instead of positive associations with air travel ▪ Support of decision-making: Comparison of time, CO2 emissions and costs ▪ Positive communication strategies: Incentives instead of prohibitions ▪ Promotion of soft tourism
Influencing long-distance commuting	▪ Adjustment and capping of the commuting allowance ▪ Reduction of commuting frequency ▪ Adjustment of the secondary residence taxation ▪ Influencing mode choice
Efficient handling of long-distance travel	▪ Expansion of long-distance services in the German/European rail network ▪ Closer integration of the German/European rail network into the periphery ▪ Abandonment of short domestic/intra-European (feeder) flights ▪ Keeping to timetables
Socialization of young people: Encouraging the use of environmentally friendly means of trans-port/choosing destina-tions closer to home	▪ Integration of sustainable travel into curricula ▪ School trips only with environmentally friendly modes of transportation ▪ BahnCard and Interrail to attract young people to rail travel ▪ Use of sustainable means of transport for school exchange trips and study stays ▪ Incentives for young families to travel by rail

Source: own compilation

6 Stakeholder

As diverse as the individual measures are, so are the stakeholders who, through their actions, have a decisive influence on the implementation and exploitation of the potential impact.

The **state** has very significant opportunities to exert influence in the context of **legislation**, which sets the framework conditions. In addition, as the **contracting authority**, it determines the scope, structure and financing of public transport services. Rather initiating and financially stimulating, the government can act in the area of **economic development** and **research funding** by supporting the development of transport services and technology. In the long term, however, private-sector activities must be self-sustaining. As **employer** it can set a good example, for instance through the sustainable management of business travel or the implementation of flexible work arrangements. Given the international dimension of long-distance mobility, first and foremost the federal government must exert its **political influence at the European level**, for example with regard to agreements on emissions trading or regulations for cross-border travel. Regardless of its legislative 'power', however, the state relies in the vast majority of cases on the **willingness of other stakeholders to cooperate**, especially when the state's measures have a supply character, such as in the areas of economic development and research funding.

The **transport industry** is responsible for the actual design of transport networks and fare schemes. Airlines in particular are being called upon to revise their offering of short-distance flights. The **tourism industry**, in turn, is asked to expand its portfolio, especially in the area of 'local' destinations, and to promote them effectively. In view of their still low level of awareness among the general public, the **providers of CO_2 compensation payments** are encouraged to proactively increase this awareness, ideally in direct cooperation with the transport and tourism industries. The **remaining private sector** is asked to develop environmentally compatible technologies and corresponding applications and services. In addition, in its role as **employer**, it can contribute in the area of sustainable management of business trips or in the introduction of flexible work arrangements such as work from home.

The **education sector** has the responsibility of familiarizing children and young people with environmentally friendly travel and thereby establishing sustained awareness. This includes appropriate curricula as well as the organization of travel in its own context according to sustainability criteria. Mode choice, for example, can be directly influenced by corresponding reimbursement rules.

Travelers themselves, however, are a key factor in all areas of action, as their individual decisions have a decisive influence on the further development of long-distance mobility. They must be able to recognize, evaluate and take advantage of respective offers, be they financial incentives provided by the government or services offered by the transport and tourism industry.

7 Conclusion and potential impact

The measures have been drafted irrespective of any legal reservations or political and societal enforceability at this point in time. All of them were qualitatively assessed and weighted with regard to their respective potential impact in the areas of **avoidance**, **modal shift** and **efficiency gains** (Table 5). **Avoidance** is understood as decision not to travel or as reduction in transport performance, **modal shift** refers to a change in mode choice towards environmentally friendly transport modes, and **efficiency gains** can be achieved through optimization within a transport mode.

Table 5: Overview of areas of action and the respective impact potential

Area of action	Impact potential*			
	Avoidance	Modal shift	Efficiency gains	Total
Monetary approaches (pricing, budgeting, compensation)	+++	++	+	+++
Influencing (= reducing) air travel	+++	++	+	+++
Strengthening vacation destinations 'nearby'	+++	++	+	+++
Influencing (= reducing) individual motorized transport	++	+	+	++
Strengthening rail and bus as a means of transport	+	+++		++
Digitalization, virtualization	+++			++
Influencing travel organization and travel flow	++	+	+	+
Establishment of a sustainable mobility culture and communication strategy	+	+	+	+
Influencing long-distance commuting	++			+
Efficient handling of long-distance travel		+	+	+
Socialization of young people: Encouraging the use of environmentally friendly means of transport/choosing destinations closer to home	+	+		+

* +++ = high potential, ++ = medium potential, + low potential

Source: own compilation

Monetary approaches, which can be designed in very different ways (such as CO_2 taxes, CO_2 budgets, CO_2 emissions trading systems), presumably have the greatest potential impact. Since voluntary initiatives such as CO_2 compensation payments have had too little effect so far, there is a need for distinct price signals. The focus is on making air travel more expensive in order to achieve avoidance or modal shift, whereby higher political resistance can be expected as costs rise. An important sub-segment in this context is business travel, where existing inappropriate incentives must be eliminated.

In addition to internalizing external costs, **air travel** can be influenced by regulating supply and infrastructure planning. Further expansion of airport capacities and access infrastructures must be assessed holistically in terms of costs and benefits.

The promotion of **vacation destinations nearby** has great potential, leading to reduced transport performance through a change in the choice of destination and also enabling a shift from air travel to other modes of transport. Initiatives by the tourism industry and the transport sector can be supported by the public sector through appropriate incentives.

Approaches related to **travel organization**, as well as to **sustainable mobility culture and communication strategy** are very much determined by the private sector. Compared to directly implementable campaigns, however, the integration of business travel into the climate protection management of both private companies and the public sector is likely to have a more significant impact.

Since **individual motorized transport** in the distance range up to about 1,000 km dominates not only day trips but also a large proportion of vacation and business trips, direct intervention in this area is associated with significant avoidance potential. In addition to financial measures such as passenger car and city tolls, speed limits should mainly increase efficiency as a result of improved traffic flow. Tax benefits for the private use of company cars should be reduced or phased out.

A reduction in the number of domestic flights would have a major indirect impact on **strengthening rail and bus services**, if they were expanded accordingly; this applies in particular to night train services. Apart from expanding services, ensuring reliability is at least as important. Improved information and booking systems are needed, especially in cross-border traffic. The current flexibility regarding the transport of baggage and bicycles should not be restricted. Long-distance bus services can be a beneficial complement to rail services for a price-sensitive, mostly younger clientele.

Digitalization and virtualization are expected to have less impact potential overall, as digitalization processes are already in progress and the telecommunications infrastructures are being expanded on an ongoing basis. There is a need for legal action with regard to virtual meetings, which are hampered, for example, by attendance requirements for votes or lacking legal certainty for digital votes and signatures. It is also very important to promote work from home, which would reduce the need for **long-distance commuting**. The creation of virtual worlds of experience currently has at best a theoretical potential impact, moreover for a rather small segment of users.

The socialization of **children and young people** offers theoretically great potential to increase the use of environmentally friendly modes of transport. The actual effects, however, depend on various societal and individual trends, values and attitudes, as well as on superordinate framework conditions, and therefore are relatively slow to change. Nevertheless, measures such as teaching units, study visits, sustainably organized school trips or similar can certainly have a signaling effect and can act as eye-openers.

8 Research needs

This research report is published in an extraordinary situation worldwide. Since the beginning of 2020, the COVID-19 pandemic has been shaping all aspects of life. Long-distance mobility in particular has declined considerably, especially in international transport. The research reflects behavior and assessments prior to the pandemic. There is some evidence for persistent behavioral changes, especially in commuting and business travel, due to increased work from home and videoconferencing. The extent to which this change will also affect private travel is more challenging to predict. There may initially be a great desire to catch up, and the supply side may also would like to win back its customers with (even) lower prices.
The entire report and also the recommendations for action should be read from the perspective of a situation not affected by the pandemic.

Research needs are identified in the following areas:

- Consolidation and regular updating of the information bases on long-distance mobility (comprehensive mobility survey covering long-distance travel)
- Future update of the 'fusion model' to track the dynamics of demand over time (time series analyses)
- Consolidation of the understanding of motives and impact potentials of specific measures

- Increasing the implementation chances of potentially effective measures that are, however, associated with major political and societal resistance
- Quantification of the impact potential of recommendations for action

Part B – Freight traffic

1 Motivation and objectives

The aim of the module on freight transport is to describe and explain the relationships between the individual modes of transport in detail in order to be able to assess how and with what success the competition can be intervened. Options for action are to be developed for the ecological design of long-distance freight transport and, in particular, for increasing the attractiveness of rail and combined transport.

In this context, the module focusing on freight transport pursues the following tasks.

- Determining the scope of long-distance freight transport in contrast to regional freight transport
- Assessing developments, trends and changed paradigms in production and logistics with regard to their effect on demand and the modal structure in long-distance freight transport
- Achieving a better understanding of the factors influencing the mode choice in freight transport and their context-dependent weighting
- Understanding the role of logistics and corporate culture on transport mode choices
- Developing measures and action plans to make long-distance freight transport more sustainable

In order to achieve these goals, a systematic literature research and synthesis is conducted first. Then an analysis of secondary data in this area is carried out. In addition, existing data and knowledge gaps are closed with our own primary data collection, survey of shippers and transporters. Finally, recommendations for action for transport policy are derived based on the findings from the previous theoretical and empirical analyses.

2 Systematic literature research and evaluation

First, **a systematic literature research and evaluation** was carried out, which aimed at collecting and preparing the current State of the Art, on the one hand to comprehensively describe the mode choice in freight transport and, on the other hand, to derive recommendations for a modal shift. If knowledge gaps are identified, corresponding concrete information are given for the planned survey of decision-makers about the choice of transport mode.

In the framework of the systematic literature research and analysis, the focus is on the following topics. Thereby, the essential findings are summarized in each case.

Hereby, research is considered in the State of the Art, which deals with the role and interdependencies of the various **decision-makers in the mode choice** in freight transport sector. Although decisions on the mode choice and related decisions in production planning and warehouse logistics are made by a large number of actors, it must be assumed that in the end a certain coordination will take place and long-term decisions will take place on an integrated system level – the level of the sender-recipient-relation. The latest evidence shows that the choice of mode and the choice of lot size represent interdependent decisions. In a model for choosing a mode, it is therefore necessary to explicitly take into account logistics variables such as the lot size and to model both appropriately. Information on the sender-recipient relationship (especially the annual demand, i.e. the annual flow of goods between sender and recipient) should be collected in surveys and taken into account when analyzing behaviour.

In the **segmentation** section, research work is analyzed that segment heterogeneous decision-makers in mode choice according to different market and behavioural groups. A segmentation of freight transport decision-makers for the purpose of strategic policy analysis must have one property above all: it must be operationalizable using measurable attributes. This means that all segmentations based on settings are omitted. The sole use of the NST / R classification is not useful in this case, since within each class there is great heterogeneity in terms of lot sizes, goods flows and packaging properties.

Furthermore, the **characteristics** are examined **with a focus on the transport service**. Although there are a large number of relevant service features, the features “price”, “reliability” (in various dimensions), “time” and “system accessibility” are of decisive importance. In addition, from the sender's point of view, the variable flow of goods plays an important role and interacts with the service features. The situation is diverse for other variables.

Another focus is on the **quality features of time (Value of Time) and reliability (Value of Reliability)**, which are processed in quantitative form using metrics. There is a great consensus in knowledge about the value of time. This is around 0.5-3 euros per ton transported and is surprisingly homogeneous compared to the otherwise ascertainable heterogeneity. The value of reliability fluctuates extremely. This is partly due to different dimensions and research designs. However, there is evidence that reducing the average delay produces benefits similar to reducing the average transit time. There are also some groups of goods that have almost zero tolerance for delays.

In the **elasticities** section, sensitivities in the mode choice of different influencing factors (elasticities for price, time, punctuality and delay) are shown based on the findings of the existing literature. Calculated price elasticities as well as elasticities for time, punctuality and delay based on a market segmentation for the transport modes road, rail and inland waterway are presented in an overview (BVU 2016). In addition, an overview is given of a large number of price elasticities that are dependent either on the ton-kilometers, the vehicle-kilometers or the fuel demand for the road (De Jong et al. 2010). The heterogeneity of the values results from the differences in the definitions of the markets, the countries, distance categories and goods groups.

In addition, research approaches are analyzed that deal with **other influencing factors on the mode choice**. In addition to the factors influencing the quality of the transport service (e.g. time, reliability), the focus of the analysis is expanded to include other influencing factors (e.g. properties of the modes, characteristics of the broadcast setting / perception of the decision-makers, etc.). Various influencing factors on the mode choice could be shown. Among other things, studies were identified that consider the influences of properties and convictions of the companies on decisions about logistics and transport modes. Thereby no studies could be identified that explicitly deal with the indirect influences of spatial planning aspects or multimodal network design on the mode choice. Although much of the work deals with the relevance of indirect (implicit) influences of transport services and their quality, explicit concepts for a service design to increase the attractiveness of rail freight transport have not yet been developed.

Based on the findings of the State of the Art, the **existing barriers** that prevent a shift to rail will be presented. These obstacles are primarily in the following areas: (i) service quality, (ii) resources (including unused own vehicle fleet), (iii) infrastructure, (iv) technology (including different security technology, restricted clearance profiles and different power supply in Europe), (v) handling (including overloading of handling terminals and ports, no suitable equipment, low availability of rolling stock) and (vi) lack of qualified workers. In addition, (vii) economic and operational barriers should be mentioned (including the goods structure effect, lack of opening of markets in other European countries, price and performance) and (viii) political barriers (including administrative effort).

Finally, research works are examined that gives concrete **recommendations for action and measures** to increase the attractiveness of rail freight transport and to promote the shift to rail. It can be observed that most measures in the literature are aimed at incremental improvements in infrastructure and transport offers. Only a few studies deal with drastic changes in framework conditions, prices and innovative transport offers.

3 Empirical analysis of rail transport

3.1 Data basis

In the preceding literature analysis transport costs and -times have been identified as essential decision-making parameters during transport mode choice. Based on data and information provided by the Federal Ministry of Transport and Digital Infrastructure for the year 2010 examinations were made regarding the existence of various transport mode affinities in the market by the type of goods and cargo, as well as delivery distances. It was examined whether or not these were connected to transport mode specific differences in transport cost per type of good and delivery distance. Further, infrastructural restrictions regarding the availability of the individual transport modes were investigated.

The database allows access to information pertaining the freight traffic data of the reporting year 2010. The data can be differentiated modally by transport carrier, relation-specifically by districts inside Germany and by NUTS-regions outside of it, as well as goods-specifically by 25 detailed NST 2007 goods classifications.

Unlike with passenger traffic, where the acting individuals can be differentiated relatively homogenously by their travelling purpose, the goods in freight transport are markedly more heterogeneous. Demand is only available in a derived form. Transport mode choices are based on preceding interactions between producers and consumers, the purchasing/ordering of goods. Due to them only amounting to a relatively low percentage of overall cost, transport costs have little influence on the choice of source and destination. A low price per ton of a good for example, can easily overcompensate higher transport costs when comparing offers. Regional operational decisions affect transport volumes stronger than changes in transport costs. However, the reasons for these decisions cannot be observed and sufficiently incorporated into transport mode choice models.

Goods can also be highly different from one another even within the same product classification due to their strongly aggregated nature. The NST 2007 classification 4 (food products, beverages and tobacco) for example includes fruit, vegetables, beverages and tobacco. However, it also includes goods with typically high delivery volumes, such as oil seeds and animal feed, which are more sensitive to transport pricing. A differentiated analysis would require a finer subdivision of goods classifications. However, this is not possible due to reasons of data protection and effort.

Nowadays, due to structural development towards smaller delivery sizes and higher flexibility it is almost exclusively the lorry that meets transport demands for most goods. On the other hand, there is no reason to shift the supply of an iron hut with ore or scrap metal towards lorries, due to the economies of scale of train and barge. Competition between lorries and other transport carriers exists only in justified cases, not as a rule.

3.2 Modal Split 2010

Lorries dominated the 2010 modal split. The combined market share of the sustainable transport carriers, rail and inland waterway, in 2010 was about 16%.

While there is a trend to utilize more rail and waterway for long distances of over 200 kilometers, road transport is still more prevalent than the two sustainable transport carriers. However, about 50% of train- and 40% of barge traffic does take place on relations with transport distances of over 300 km, while the respective share in lorry traffic only amounts to about 15%. Therefore, it can be inferred that train and lorry traffic are more long-distance types of traffic, even if the share of lorries in that sector dominates (compare Table 6).

Table 6: Traffic distribution by distance classes in 2010 (quantities in million t)

Distance class	Overall	Share in %	Thereof lorry	Thereof train	Thereof barge	Share train in %	Share barge in %
All traffic	3.704,6	100%	3.116,1	358,9	229,6	9,7%	6,2%
Up to 100 km	2.065,0	56%	1.931,8	107,6	26,2	5,2%	1,3%
101 - 200 km	516,5	14%	445,0	42,3	29,2	8,2%	5,7%
201 - 300 km	318,8	9%	197,6	35,7	85,4	11,2%	26,8%
301 - 400 km	177,3	5%	125,8	33,5	18,1	18,9%	10,2%
401 - 500 km	149,0	4%	91,2	30,5	27,3	20,5%	18,3%
501 - 600 km	118,6	3%	70,1	25,6	22,9	21,6%	19,3%
> 600 km	359,2	10%	254,8	83,8	20,6	23,3%	5,7%
Traffic distances exceeding 300 km	804,1	22%	542,0	173,4	88,7	21,6%	11,0%
Share of traffic exceeding 300 km	22%		17%	48%	39%		

Source: own contribution

This is also the case for types of goods that are dominated by bulk commodities. Local and regional supply is mostly handled by lorries, while train and barge are utilized frequently for long distance transport operations, if a high transport volume is present. Within the steel sector, transport distance appears not to play a large role. Here, there is no significant change in the road's modal split share across distance classes.

One of the prevailing reasons for the aforementioned dominance of the road is that not all relations are utilized intermodally. This means that for the largest part, a single transport carrier, usually the road, serves traffic relations. In 2010, this accounted for 2.9 billion tons or 73% of the overall traffic volume in Germany.

3.3 Intermodal competition

On transport relations for which intermodal competition is possible, rail and waterway attain market shares of 70% and 85% respectively for delivery distances of over 200 km. This means that when conditions for the use of rail and waterway are met, these carriers can realize high market shares (compare Table 7). This leads to a relatively small market potential for train and barge on intermodally utilized transport relations of over 200 km. In 2010, only about 44 m tons were transported by lorry on said relations. If this volume had been shifted a 100% towards train and barge for 2010, their combined share would have been only 1% above the actual realization that year.

Table 7: Traffic relations with intermodal transport carrier competition by distance classes in 2010

All relations with intermodal competition		**Thereof traffic relations of up to 100 km**	
Traffic volume overall in 1.000 t	742,1	Traffic volume overall in 1.000 t	466,1
Thereof train and barge in 1.000 t	319,3	Thereof train and barge in 1.000 t	111,0
Market share train and barge in %	43%	Market share train and barge in %	24%
+ straight lorry volume in 1.000 t	2.693,6	+ straight lorry volume in 1.000 t	1.576,7
Thereof traffic relations of 101 to 200 km		**Thereof traffic relations of 201 to 300 km**	
Traffic volume overall in 1.000 t	58,4	Traffic volume overall in 1.000 t	60,3
Thereof train and barge in 1.000 t	34,7	Thereof train and barge in 1.000 t	47,4
Market share train and barge in %	59%	Market share train and barge in %	79%
+ straight lorry volume in 1.000 t	421,3	+ straight lorry volume in 1.000 t	184,7
Thereof traffic relations of 301 to 400 km		**Thereof traffic relations of 401 to 500 km**	
Traffic volume overall in 1.000 t	27,8	Traffic volume overall in 1.000 t	33,7
Thereof train and barge in 1.000 t	19,8	Thereof train and barge in 1.000 t	27,6
Market share train and barge in %	71%	Market share train and barge in %	82%
+ straight lorry volume in 1.000 t	117,8	+ straight lorry volume in 1.000 t	85,1
Thereof traffic relations of 501 to 600 km		**Thereof traffic relations of above 600 km**	
Traffic volume overall in 1.000 t	27,2	Traffic volume overall in 1.000 t	68,5
Thereof train and barge in 1.000 t	22,7	Thereof train and barge in 1.000 t	56,0
Market share train and barge in %	84%	Market share train and barge in %	82%
+ straight lorry volume in 1.000 t	65,7	+ straight lorry volume in 1.000 t	242,4

Source: own contribution

There are certain, essential conditions for intermodal competition on traffic relations. Corresponding transport connections for rail and waterway must exist. Waterways are particularly restricted in this regard and bound to the locations of rivers and ports. The rail network covers almost all areas in Germany on a municipal or district basis and there is a high density of loading terminals. However, this does not mean that every company or industrial park has access to the network. Even if an industrial park is connected, only certain companies utilize the rail sidings while their neighbors do not.

In addition to this, high transport volumes are required for train or barge service. The economies of scale of the alternative transport carriers can only come into effect when sufficiently high transport and delivery volumes are existent. On principle, rail and waterway are cheaper than road transport for nearly all delivery distances as long as they can work to capacity (this applies for direct services and if differences in handling costs are assumed to be negligible). This requires block trains for rail and fully loaded barges for waterways. While a lorry can transport a maximum of 27 t, a block train can transport at least 1.250 t, while a motor vessel can transport between 2.800 and 3.500 t.

Even smaller barges can move cargo of around 1.000 t. In order for transport by rail and waterway to be comparatively cheaper than with a 27-t cargo lorry, a minimum transport volume of about 300 to 400 t per train and 600 to 1.000 t per barge respectively is required. These large transport volumes of shipments, in addition to the associated operational problems with such transport volumes, are usually the decisive obstacle to realizing higher market shares for rail and inland waterways.

For trains and barges to be chosen over lorries, these respective minimum volumes per tour and direction are necessary. Even the aforementioned figure of 300 t equals about 15 lorry tours per day in one direction. Such orders of magnitudes per day are not achievable on all traffic relations. Sadly, it is impossible to separate the number of daily traffics of more than 300 or 400 t out of the available dataset.

Where the aforementioned conditions are not met, i.e. high traffic volumes and delivery sizes per tour, the lorry dominates due to being able to transport smaller delivery sizes at lower cost.

However, the numerous evaluations of the transport statistic of 2010 imply that wherever (even for smaller traffic volumes) the use of train and barge is possible due to traffic connections, the transport cost structure and the delivery size, it is utilized to a high degree. On intermodal traffic relations, train and barge are already transporting 43% of traffic or 320 kt. If it would be possible to shift all currently existing traffic on these intermodal accessible transport relations towards train and barge, the market share of the two alternative carriers could increase from their current share of 18% to 27% (compare Table 8).

Table 8: Relations with intermodal competition in 2010

Total traffic volume in million t	**3.705**
Straight lorry relations in million (no intermodal competition)	**2.694**
Share of straight lorry relations in %	**72,7%**
Straight train and barge relations in million t	**269**
Share of straight train and barge relations in %	**7,3%**
Relations with intermodal competition in 1.000 t	**742,1**
Share of relations with intermodal competition in %	**20,0%**
Thereof share train and barge in %	**43%**
Highest possible share train and barge with 100% shift of all intermodal traffic in %	**27,3%**

Source: own contribution

Table 9 shows that on about 70% of transport relations with transport carrier competition, rail and waterway can achieve a market share of more than 30%. The average market share of the two sustainable carriers on these relations is about 92%. Part of these traffics are on relations with a volume of under 1.000 t. Even on these low volume relations, the market share of train and barge reaches 78%.

Table 9: Volume of traffic relations with a market share of train and barge of 30% or higher

Type of Good	Total traffic in 1.000 t	Traffic relations with a modal-split of train and barge of >=30%				
		Total volume of relations with MS >=30% in 1.000 t	Share of relations with MS (>30%) in %	Modal-Split of those relations in %	Relations of a volume of < 1.000 t	Modal-Split of relations with < 1.000 t in %
Agricultural & forestry goods	208.137	24.444	11,7%	94%	968	83%
Coal	66.391	63.045	95,0%	99%	48	91%
Lignite	14.112	10.574	74,9%	99%	15	98%
Crude oil & natural gas	2.524	1.320	52,3%	99%	45	96%
Ores	48.983	48.250	98,5%	100%	31	92%
Fertilizer	6.736	2.631	39,1%	99%	-76	99%
Stone and Earths	921.198	61.125	6,6%	88%	463	85%
Food products and tobacco	355.305	14.918	4,2%	85%	364	74%
Textiles and textile products	21.136	29	0,1%	90%	15	81%
Products of wood, paper, printed matter	179.901	12.736	7,1%	94%	355	75%
Coke	15.931	8.875	55,7%	99%	55	94%
Refined petroleum products	161.980	75.016	46,3%	93%	384	91%
Chemical products	218.787	54.791	25,0%	83%	856	72%
Other mineral products	337.828	15.944	4,7%	88%	258	68%
Basic metals and fabricated metal products	247.518	77.364	31,3%	90%	1.086	70%
Machinery and equipment etc.	77.544	971	1,3%	89%	155	71%
Vehicles	101.801	9.926	9,7%	87%	519	75%
Furniture, jewelry, musical instruments etc.	21.119	132	0,6%	57%	70	25%
Secondary raw materials, waste	282.469	29.780	10,5%	89%	646	83%
Mail, parcels	35.167	0	0,0%	0%	0	0%
Equipment and material utilized in the transport of goods	92.417	293	0,3%	85%	29	77%
Household removal goods, other non-market goods	39.159	53	0,1%	91%	32	89%
Grouped goods	116.581	2.049	1,8%	87%	21	66%

Type of Good	Total traffic in 1.000 t	Traffic relations with a modal-split of train and barge of >=30%				
		Total volume of relations with MS >=30% in 1.000 t	Share of relations with MS (>30%) in %	Modal-Split of those relations in %	Relations of a volume of < 1.000 t	Modal-Split of relations with < 1.000 t in %
Unidentifiable goods	131.924	4.193	3,2%	98%	141	80%
All goods	3.704.648	518.460	14,0%	92%	6.480	78%

Source: own contribution

3.4 Intermodal Traffic

In order to further increase the market shares of the sustainable transport carriers, it is necessary to shift traffic that is currently exclusively handled via lorries. One approach to strengthen the participation of rail and waterway is the concentration of traffic through multimodal transport, where pre- and on-carriage are handled by lorries while the main carriage is done via train or barge. To facilitate this, continuous services are required, which can only be operated when sufficient minimum amounts of traffic exist within a given catchment area. If daily services are not offered, a low degree of acceptance due to the low density of traffic is to be expected. However, regular service such as this does require certain minimum volumes of traffic on a given main relation.

Intermodal traffic plays a special role within multimodal traffic concepts. It entails the transport of goods in the same transport unit or vehicle involving two or more transport carriers, where the transport unit, but not the goods themselves, are handled during the tour. This is realized through transport in containers and swap bodies via train or barge during main carriage and via lorry during pre- and on-carriage, changing carrier in so-called CT (combined transport)-terminals.

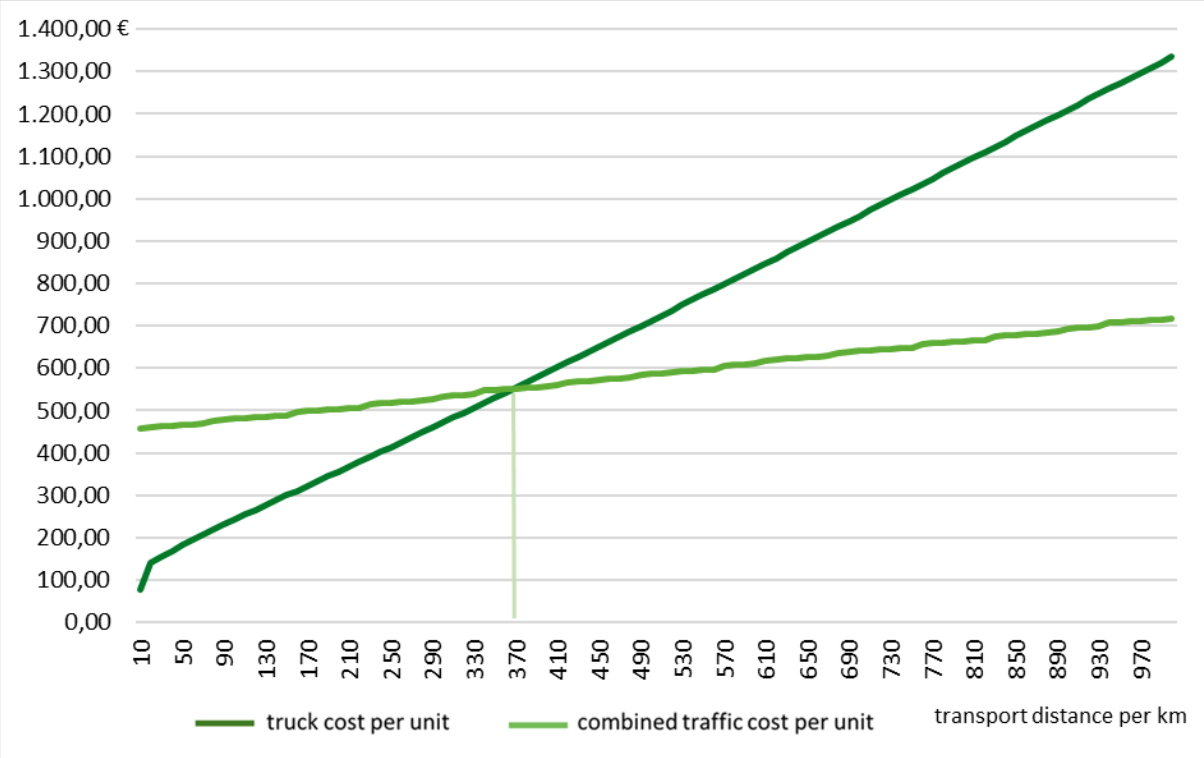
There already exists a high coverage of said terminals in Germany. Almost no region in Germany is not located within the 50 km catchment area of one or more German or foreign terminals. This high density of CT-terminals has already led to large shifts in traffic from road to rail and waterway over the past two decades.

The 2030 forecast of transport interconnectivity considers these alongside other shifts related to a stronger orientation towards foreign trade in this traffic segment. This also facilitates an overproportioned growth for combined transport of 73% between 2010 and 2030. Reports by the Federal Statistical Office indicate that the growth of combined transport since 2010 has aligned with this forecast.

In order to enable multimodal transport concepts in areas of conventional traffic, minimum transport ranges of 320 to 500 km and minimum transport volumes of about 60.000 t annually are required. The minimum transport distance for which combined transport is cheaper than direct transport per lorry is about 350 km, illustrated by Figure 3. Thus, in order for an intermodal service to be successfully implemented, a minimum volume of about 100.000 t or 6.700 LU annually is required[1].

[1] This assumes that the main carriage is handled via rail. The necessary minimum volumes are higher for main carriage by waterway.

Figure 3: Transport cost comparison for a swap body in direct lorry transport and in transport via train, including a pre- and on-carriage of up to 30 km (Cost in €/40-foot Loading Unit)



Source: own contribution

Transport volumes of this kind of size are only available on few relations for both conventional and combined transport. For conventional transport, this amounts to relations with a traffic volume of about 8 mi tons, for combined transport to relations with a volume of about 6 mi tons (state 2010).

If these traffic volumes could be shifted towards rail and waterway in their entirety, this would not significantly increase their modal-split share in light of an overall traffic volume of about 3,7 bn tons. However, an increase in frequenting rail and waterway for the already intermodal accessible transport relations could increase the market share of these carriers to up to 27% in total.

The relatively low volume of traffic that combined transport can siphon off is due to the fact, that it is already utilized often on relations of over 350 km with large individual quantities. We assume that 0,8 bn tons of lorry traffic has a sufficient affinity for CT. Of this, about 215 mi tons are transported on relations of over 350 km. Only relations on which – due to aforementioned minimum volumes – large annual volumes are transported and which are not already being serviced by CT can be considered as potential new CT-relations. Setting the minimum volume to about 40.000 t (equaling the volume of a weekly-touring service) and focusing only on relations not currently being serviced by CT or expecting such a service, then, even under the optimistic assumption that 50% of road traffic can be shifted towards rail, one can calculate a potentially shifted volume of about 6 mil tons.

4 Primary data collection

4.1 Research design

The aim of this work package was on the one hand to close the knowledge and research gaps identified in the previous work steps and on the other hand to confirm or to falsify the previously identified influencing variables and obstacles with regard to the change of transport mode by means of a primary data collection.

The primary data were collected in the form of computer-assisted face-to-face interviews (CAPI). The duration of the individual interviews was set at around 45 minutes. Initially, it was planned to conduct a total of n = 200 interviews with decision-makers regarding logistics details. The sample of companies was set up as a quota sample, in which primarily a stratification along different economic sectors (WZ 2008) was carried out. The focus was on branches of the economy in which experience has shown that a high proportion of long-distance freight transport is to be expected. A total of five corresponding economic sectors were defined and included in the sample: (i) manufacturing (n = 90), (ii) wholesale (n = 35), (iii) freight forwarding (n = 35), (iv) mining and quarrying of stones and earth (n = 25) and (v) retail (n = 15). In addition to the stratification according to company branches, the sample was also stratified according to the company size considering the number of employees. The company size was broken down into three classes: 5 to 99 employees (n = 35), 100 to 249 employees (n = 75) and companies with 250 or more employees (n = 90). In accordance with the stratification criteria described, a gross sample was drawn from an acquired address pool with company data from Kantar TNS. The sampling procedure was based on a random process. In addition, however, it was ensured that companies which, due to their cargo categories and other parameters, presumably have a high relevance for the research subject, are included in the gross sample. The gross sample was made available to the interviewers in the form of regional clusters so that they could contact them and conduct the interviews later. In a preliminary telephone interview, the interviewers determine the relevant decision-makers for logistics and transport processes. This target person is used to determine whether there are any transport processes in accordance with the criteria mentioned above. The actual CAPI interview was only carried out if the company carries out a significant volume of freight transport of approx. 100 km or more with lot sizes of 2 tons or more. As the main focus of the study is on the mode choice, a CAPI interview is only carried out if the company makes these decisions itself and a change of transport mode is possible in principle. If the company qualifies for the main interview, the willingness to participate is determined and, in the positive case, an appointment is made for the face-to-face interview. The questionnaire developed for the main interview is divided into a total of six sections: (1) general information on the company and infrastructure, (2) details on shipping and delivering the goods, (3) transport mode choice, (4) barriers and decision-making thresholds with regard to options for shifting to rail (including quality components of reliability), (5) evaluation of the ecological sustainability in the company as well as (6) assessing the previous transport offer of the rail and suggestions for improvement to increase the attractiveness of the rail.

4.2 Types of enquiry

In order to try to make the choice process of the transport mode transparent regarding decision parameters and to validate the results of the empirical analysis, companies with significant cargo volumes that utilize multiple transport carriers were surveyed. In this survey the companies in question were asked questions regarding the characteristics of their transports, the volume of their cargo, detailed information regarding transport relations, as well as

- whether or not the transport mode choice for specific customers/suppliers or types of goods/categories of cargo are made as fundamental decisions,
- which reasons exist for selecting the used carrier,
- which reasons exist against selecting unused carriers and
- which transport characteristics influence their transport mode choice.

Beyond that, the companies were also surveyed regarding their willingness to shift traffic from lorries to train and barge, as well as the improvements necessary for such a shift. Unfortunately, the planned amount of 200 interviews could not be realized. Only 140 questionnaires were ultimately available for analysis.

4.3 General data

- 60% of responding companies belong to the manufacturing industry, 18% to wholesale trade and 17% are transport companies. Mining and retail are, with 3% and 1% respectively in returns, underrepresented.
- 44% of surveyed companies stated that they facilitate transports for source and destination locations (reception and dispatch), 30% are engaged only in reception and 26% only in dispatch.
- 70% of responding companies employ more than 200 people and can thus be categorized as bigger companies. While a large number of big companies were interviewed, the actual number of employees at the operating sites where the interviews took place are significantly smaller. 80% of these sites employed up to 500 workers, two thirds between 50 and 500. There were no operating sites with more than 10.000 employees included in the survey.
- Most of the surveyed companies have access to a nearby motorway connection. 34% of the contacted companies are located a maximum of 3 km from the nearest connection, 57% a maximum of 5 km. Only a quarter of surveyed companies is located more than 10km from the nearest connection.
- Regarding connection to rail and waterway infrastructure, the situation is less favorable. While 23% of companies have their own connection to the rail network and 7% one to waterways, others fare much worse. 23% and 43% of companies are situated more than 30 km away from the nearest connection to rail and waterway, respectively. These values rise to 51% and 74% respectively with regards of being located more than 15 km from the nearest connection. The relatively high number of companies with a connection nearby was achieved by preferentially approaching companies with an affinity to rail and waterway transport.
- It is noticeable that about 30% of surveyed companies made no statements regarding connectivity with CT-terminals. Due to the high terminal density and coverage in Germany, this indicates that said companies have not considered this question due to their product or client structure. About 30% of interviewed companies stated to be situated within 30 km of the nearest CT-terminals. 10% note a distance of 30 to 50 km, while 26% are located further than 50 km from the nearest CT-terminal.

4.4 Primary data analysis results

The survey essentially confirmed the empirical results outlined in chapter 3.

Thus, the transport mode choice of the companies differs depending on the type of good/category of cargo, as well as the size of the delivery and the distance of the transport. Table 10 presents the choice of transport carrier by category of cargo in dispatch.

Table 10: Dispatch - Transport carrier by category of cargo

Category of cargo	Lorry	Train	Barge	Cont. CT	Marit. CT	Sum	n/a
Amount by transport carrier in tons							
Dry bulk comm.	638.420	199.499	400	6.260	122.600	967.179	0
Grabbable cargo	285.016	175.399	40.000	16.160	35.220	551.794	0
Liquid bulk comm.	314.140	43.089	46.800	30.000	42.200	476.229	224.999
Pallets	1.666.190	52.008	8.199	280.872	212.716	2.219.985	0
Bales, etc.	371.239	85.000	8.199	10.500	79.710	554.648	0
Coils	20.788	600	0	22.650	0	44.038	0
Piece goods	429.507	163	2.513	70.906	18.463	521.551	0
Sum	3.725.300	555.757	106.111	437.348	510.909	5.335.424	

Source: own contribution

With a share of 70%, lorries are the dominant carrier of choice in dispatch for the surveyed companies. 18% of recorded goods in dispatch are transported via CT and 10% via conventional rail freight transport. The share of goods transported via conventional barge transport is a low 2%. Barge and train transport mostly liquid and dry bulk commodities (about 82% for barge and 75% for train). The share in total transported traffic volume of bulk goods for lorry is significantly lower for lorries. However, in total 62% of all bulk commodities are transported by lorry.

Finding lorries dominating in bulk commodities is also in line with statistical analyses. The share of lorries is especially high for piece goods and pallets with 82% and 75% respectively. Reported coils are transported in almost equal measure via continental combined transport and by lorry. CT also transports more than 70% of piece goods. There is also a noteworthy amount of typical bulk commodities (such as seeds and building materials) being transported by CT, maritime CT in particular.

The transport volume in reception overall is about 40% or 3,2 mi tons lower than in dispatch. The large share of transported bulk commodities is partially responsible for lorry traffic only achieving a low share in 46% comparted to dispatch, where it amounted to 70%.

Train and barge are responsible for 41% of traffic, compared to 12% in dispatch. This in particular is rooted in the fact that liquid bulk commodities, which account for 30% of the overall volume, are three quarters being transported by train and barge, while train is transporting 60% of dry bulk commodities. Lorry traffic still dominates in regards to piece goods, especially pallets. The share of combined traffic of 14% is slightly below the share in dispatch (18%). Piece goods in particular are also handled via combined transport, which leads to a relatively lower share of 36% for lorry traffic for this category as well (compare Table 11).

Table 11: Reception - Transport carrier by category of cargo

Category of cargo	Lorry	Train	Barge	Cont. CT	Marit. CT	Sum	n/a
Amount in tons							
Dry bulk comm.	310.036	578.739	17.500	15.000	53.540	974.815	0
Grabbable cargo	148.598	4.240	9.660	50	150	162.698	0
Liquid bulk comm.	225.170	338.049	350.959	0	900	915.078	0
Pallets	598.467	0	1.800	109.052	3.890	713.209	0
Bales, etc.	27.869	0	0	0	0	27.869	0
Coils	11.151	0	0	100	0	11.251	0
Piece goods	148.540	10.133	0	27.788	230.000	416.460	15.000
Sum	1.469.831	931.161	379.919	151.990	288.480	3.221.380	

Source: own contribution

Lorries are the dominant carrier for both dispatch (70%) and reception (46%). Train and barge are used predominantly for transporting liquid and dry bulk commodities and for transport distances of over 300 km. Combined transport is mostly used for the transport of general cargo on journeys of over 500 km. Only about 30% of surveyed companies are situated less than 30 km from the nearest CT -terminal.

With regard to principal, fundamental decisions, it is apparent that about 42% of the surveyed companies make fundamental decisions regarding transport carriers in advance, while a further 32% make fundamental decisions for specific customers or types of goods. Usually, said fundamental decisions favor the lorry. Table 12 reflects the reasons given for the choices being made. Companies were also asked about their reasons against choosing specific transport carriers. This slight variation of the enquiry serves to give a more complete picture of decision-making criteria. The results of this enquiry are shown in Table 13.

Table 12: Reasons for choosing a transport carrier

	Lorry	Train	Barge	Cont. CT	Marit. CT	Sum
Shipment size	35	17	12	8	12	84
Distance	28	10	6	15	29	88
Transport cost	52	15	10	12	27	116
Transport duration	68	5	2	8	10	93
Reliability/punctuality	65	3	1	5	5	79
Bulkiness	6	1	3	2	1	13
Transport security	20	2	5	5	1	33
Fulfillment of ancillary services	3	0	0	1	1	5
Connection to rail/waterway for the shipper	1	7	2	2	2	14
Damage frequency	0	1	0	0	0	1
Fragility	1	0	0	1	0	2

	Lorry	Train	Barge	Cont. CT	Marit. CT	Sum
Oversize	2	0	0	0	0	2
Departure density	11	1	1	1	5	19
Storage area	0	0	0	0	0	0
Freight space suitability	6	4	1	0	5	16
Own vehicle fleet/storage space	24	0	0	0	0	24
Other reasons	14	5	2	6	3	30
N/A	0	1	0	2	1	4
Sum	336	72	45	68	102	623

Source: own contribution

It is apparent that transport costs are one of the elementary decision variables for transport mode choice. The primary reasons for choosing lorries for transport are their high reliability coupled with short transport times and a high punctuality of over 85%. Lorries are the most flexible carrier in their use, require the least amount of pre-planning and are the quickest to adapt to shifting market requirements regarding size, distance and cost of transport.

While trains and barges usually show lower transport cost and are suitable for long transport distances, as well as shipments of high volume and bulkiness, they also implicate long transport times. Low reliability and a punctuality of only 65% for rail are further, important shortcomings. The infrastructural requirement of having a rail or waterway connection are another hindrance for the use of train and barge, compared to the more flexibly applicable lorry. Furthermore, the surveyed companies do not use them due to transport distances being too short or volumes being too low (compare Table 13).

Table 13: Reasons against choosing a transport carrier

	Lorry	Train	Barge	Cont. CT	Marit. CT	Sum
Shipment size	1	14	19	14	9	57
Distance	1	16	27	15	17	76
Transport cost	2	21	15	20	13	71
Transport duration	1	48	43	34	28	154
Reliability/punctuality	2	45	13	27	15	102
Bulkiness	1	9	6	7	4	27
Transport security	0	4	1	4	3	12
Fulfillment of ancillary services	0	4	4	4	4	16
Connection to rail/waterway for the shipper	0	20	16	7	7	50
Damage frequency	0	0	1	4	2	7
Fragility	1	4	2	2	3	12
Oversize	0	2	1	1	0	4
Departure density	0	17	13	12	9	51

	Lorry	Train	Barge	Cont. CT	Marit. CT	Sum
Storage area	0	1	2	0	1	4
Freight space suitability	0	7	7	3	1	18
Own vehicle fleet/storage space	1	11	9	9	9	39
Other reasons	2	23	29	20	16	90
N/A	8	7	21	21	25	82
Sum	20	253	229	204	166	872

Source: own contribution

Turning attention towards combined transport, it is apparent that the surveyed companies already utilize it for large portions of their traffic. Only 10% of the so far not CT transported dispatch and 21% of the reception volume would potentially be suited for transport via combined means, due to its structure. Combined transport is primarily utilized for long-distance relations of over 500 km, maritime CT for dispatches towards oversees destinations.

In order to successfully shift traffic from lorry towards train and barge a satisfying supply of combined transport solutions is necessary. About 70% of companies deem more than one weekly tour necessary, 58% ask for at least bi-daily connections (compare Table 14).

Table 14: Necessary relation density for combined transport

Relation density per week	Sum
1 x per week	15
2 x per week	10
3 x per week	15
4 x per week	35
Daily	14
Irregular	6
N/A	45
Sum	140

Source: own contribution

Aside from concerns regarding the CT-affinity of goods, companies also listed other reasons against utilizing CT more strongly, for example short distances on the relations in question and additional cost compared to conventional transport. The costs caused by in part long distances to the nearest CT-terminals offering suitable relations in optimal departure frequency for pre- and on-carriage are being seen as too high. Other reasons mentioned are irregular or non-existing relations, transport times being too high and a lack of punctuality for CT (compare Table 15).

Table 15: Reasons against choosing combined transport per category of cargo

Factors	Dry bulk commodity	Grabbable goods	Liquid bulk commodity	Palettes	Bales	Coils	Piece goods	Sum
Distance too short	17	17	11	28	8	7	24	112
Transport cheaper by conventional transport	15	8	10	28	6	5	20	92
CT-terminal too far away from Target-/Source Location	10	9	4	18	7	2	14	64
No CT-relation for main carriage on offer	6	7	4	16	7	2	10	52
Irregular relations	6	5	4	16	6	5	15	57
CT Transport times too high	9	6	6	24	5	3	15	68
Punctuality in CT not assured	7	3	2	14	5	3	5	39
Transport security in CT not assured	4	2	1	5	2	1	5	20
CT-terminals do not offer sufficient storage area	3	4	4	2	1	0	1	15
Other reasons	2	6	2	8	0	1	3	22
N/A	6	2	4	9	4	2	9	36
Sum	85	69	52	168	51	31	121	577

Source: own contribution

Another important factor for transport handling is the flexibility of a carrier regarding its operational capacity. Shippers often have to adapt quickly to shifting market conditions. Hence, the time between procurement and pickup or implementation of transport is a deciding factor. Due to the long planning periods exhibited by alternative transport carriers – and thus, by extension, CT – they are once more at a disadvantage (compare Table 16).

Table 16: Time between procurement and pickup of a given transport

Transport carrier	Less than a day	More than one day	More than two days	Varying	N/A	Sum
Number of answers for each carrier						
Lorry	47	22	8	45	18	140
Train	2	7	9	6	116	140
Barge	1	3	7	4	125	140
Cont. CT	3	6	5	11	115	140
Maritime CT	1	5	17	19	98	140
Time between procurement and pickup in h						
Lorry	11	37	204	0	0	38
Train	4	40	229	0	0	117
Barge	20	35	154	0	0	95
Cont. CT	15	31	187	0	0	57

Transport carrier	Less than a day	More than one day	More than two days	Varying	N/A	Sum
Maritime CT	20	36	357	0	0	257

Source: own contribution

The survey shows that lorries have the advantage over other carriers in numerous comparisons, such as flexibility in operational capacity, adaptability to changing market demands (delivery sizes, transport distances, cost), punctuality, reliability and transport duration. Due to these advantages, a shift towards trains and barges is not an option for 46% of the surveyed, even with constant transport costs. A further 13% of companies did not comment on this. As such, it can be assumed that a shift is not an option for a total of 59% of the surveyed. There is a willingness to shift for 19% of the surveyed if both transport costs and transport times remain constant. Only 13% of the surveyed would be willing to shift their transport to sustainable carriers if the costs will not change, disregarding all other disadvantages, due to positive sustainability and environmental effects. The willingness of companies to shift falls in relation to a rising demand for shorter transport times, despite equal costs (compare Table 17).

Table 17: Willingness to shift a transport from lorry towards train or barge at same costs

Willingness to shift	Number	Share in %
Yes, in any case	18	13%
Only if train and barge need exactly as long as lorries	26	19%
Only if the additional demand in time does not surpass 10%	7	5%
Only if the additional demand in time does not surpass 20%	5	4%
Only if the additional demand in time does not surpass 30%	1	1%
Only if the additional demand in time does not surpass 40%	0	0%
Only if the additional demand in time does not surpass 50%	0	0%
No	65	46%
N/A	18	13%
Sum	140	100%

Source: own contribution

Table 18 and Table 19 show that further willingness to shift is only given for companies if transport costs of train and barge are further decreased. On average, they would need the alternative carriers to be 26% cheaper than lorries. For 39% of these companies, transport times would have to be equal in addition to lower cost. A further 28% would be willing to shift regardless of transport time.

Table 18: Willingness to shift a transport from lorry towards train or barge at lower costs

Willingness to shift at lower costs	Number	Share in %
Yes, in any case	5	28%
Only if train and barge need exactly as long as lorries	7	39%
Only if the additional demand in time does not surpass 10%	1	6%

Willingness to shift at lower costs	Number	Share in %
Only if the additional demand in time does not surpass 20%	2	11%
Only if the additional demand in time does not surpass 30%	0	0%
Only if the additional demand in time does not surpass 40%	0	0%
Only if the additional demand in time does not surpass 50%	1	6%
N/A	2	12%
Sum	18	100%

Source: own contribution

Table 19: Shift of transports from lorry towards train or barge at lower costs

Willingness to shift at lower costs	Number of replies
by x %	18
No	39
N/A	8
Sum	65
Average required cost advantage of alternative carriers in %	26%

Source: own contribution

The survey clearly shows that shifting freight traffic is not easy to implement and is subject to multiple hindrances. Despite this, only few companies (14%) note a general impossibility of realizing a shift away from road traffic. The remaining majority of companies is convinced that it is possible to shift traffic towards alternative carriers if the essential obstacles are removed. Said companies indicated in which areas key activities should be implemented in order to facility a shift from the road towards rail and waterway (compare Table 20).

The surveyed suggest the following five key improvements in order to improve the share of railways:

- improving the offered services: expansion of existing infrastructure, improved railway connections to companies or expanding CT-terminals (more terminals, more developed areas in proximity to existing terminals)
- lowering transport costs for alternative carriers compared to lorries (22%)
- improving the reliability for rail freight transport (13%), also in relation to the removal of capacitive bottlenecks
- higher departure frequency for CT (5%)
- shorter transport times (4%)

Ecological aspects were mentioned only once as a reason for shifting and are therefore irrelevant as drivers of shifting traffic. Also, of interest: only 38% of companies take ecological aspects into account when choosing suppliers and only 33% reward sustainable solutions in traffic handling.

Table 20: How to achieve a shift from lorry towards train

Improvements to increase willingness to shift	Number of mentions	Share in %
Not at all	20	14%
Improved infrastructure and connectivity (rail sidings, CT-terminals)	43	30%
Lower transport costs	31	22%
Improved reliability	18	13%
Higher frequency of CT relations	7	5%
Shorter transport times	6	4%
Higher flexibility	5	3%
Higher volumes	3	2%
Changing client preferences	3	2%
Improved container design for CT	1	1%
Changing the framework	2	1%
Quicker provision of goods	1	1%
Larger delivery sizes	2	1%
Environmental aspects	1	1%
Sum	143	100%

Source: own contribution

Importance of ecological sustainability for companies In this context, the question is pursued whether companies are already integrating concepts for ecological sustainability into their work processes or how these are implemented in their operations. In the general environmental impact assessment of transport modes, the railway is perceived as the most environmentally friendly, whereas the truck is assessed as the least environmentally friendly. 70% of the respondents stated that ecological sustainability is an issue in their company on a strategic level or in the direct work environment. Around a third of the respondents each work in a company that has a corporate social responsibility program or applies ISO 26000. In addition to an unspecific general "pay attention to ecological sustainability", tours are primarily optimized so that empty trips are avoided and vehicles are used to the full as possible. In addition, emphasis is placed on modern, environmentally friendly vehicle technology that complies with current emissions standards. Furthermore, some respondents state that they consider ecological sustainability with regard to choosing a transport mode, energy supply and packaging. They are also bound by certain requirements through certificates or an environmental management system. When asked how ecological sustainability is defined or lived in the company, the following aspects were most often mentioned: Part of the corporate culture or addressed at management level, environmental certificates and environmental / energy management.

37% of the companies stated that their company has a sustainability certification. According to open answers, the largest part of it is available as an ISO standard (ISO 14000, ISO 5001, or similar). 9% of the respondents take part in competitions related to ecological sustainability. The types of competition mentioned here included, among others, Ökoprofit, the German Sustainability Award and the Federal Government's CSR Award. 26% of the companies carry out sustainability reporting. Information on the form of reporting includes certificates and annual / sustainability reports. The information on the addressees of the sustainability reporting includes management / board of directors, the public, internal / employees, funding agencies / Federal Office of Economics and Export Control. The implementation of resource-saving solutions is rewarded in 23% of companies. This is mainly done through prizes or idea management. 26% of the companies stated that suppliers or transport service providers are selected and checked according to ecological sustainability criteria. 19% of the respondents also determine a carbon footprint.

In summary, the size of the company, measured by the number of employees, seems to be the significant factor for the sustainability of a company, with freight forwarders implementing fewer measures regarding environmental sustainability and social responsibility regardless of size.

Quality demands and requirements of both customers and non-rail users. In this context, the companies surveyed provided information about the necessary transport offers or transport services that induce them to use rail and / or multimodal offers. The information needs of customers about offers also play an important role, which are shown in the following. Respondents who already use the rail services indicate that the criteria punctuality, better connections as well as reliability and flexibility would lead to increased or continued use of the rail network. Respondents who do not use the rail services also gave the suggestions for improvement better connections, flexibility, lower costs, punctuality and better infrastructure, which would lead to the use of rail being considered. The test subjects were also able to contribute ideas for designing a transport service of an attractive rail offer from their point of view. They have given specific information on this (including better connections, reliability, shorter delivery times, flexibility, higher frequency, tracking & tracing, punctuality, network expansion, low costs). According to the companies that do not use the rail, the following information is necessary to allow rail use (in descending order of frequency): price, transit times, frequency of departures or timetable, connection, special transport requirements and contact persons / providers. However, around a quarter of those companies stated that they did not need any further information because their company would not be able to use the railways.

5 Policy advice

Based on the survey results regarding identified hindrances and the suggestions given by the surveyed companies regarding potential improvements, recommendations for the implementation of measures were designed, which may help reduce hindrances and increase the sustainable modal share. The following prioritized recommendations, differentiated by four categories, were derived within the study:

5.1 Regulatory and overarching measures to improve offerings of alternative transport modes

These overarching measures or policy suggestions are mostly directed towards the federal government and state institutions. They have a more fundamental nature and include e.g.:

- infrastructure of sustainable transport carriers is to be improved urgently

  This improves the accessibility of the system and allows for reliable service. In order to ensure a demand-oriented expansion, the federal government should not only review the measures included in the FTIP regarding the validity of their extension approvals, but also consider the inclusion of other infrastructure projects into the requirements plan, if these can be derived from traffic demand development.

- ► measures defined as urgent in the FTIP are to be accelerated in their implementation

A transport cost increase of 1% due to bottlenecks in the rail infrastructure leads to, on average over all traffic, volume shifts from rail to road of 0,4%. In the more competitive CT system, this even leads to a volume shift of 0,8%.

Rapid implementation or already defined measures to resolve bottlenecks, especially through a simplification and acceleration of planning and administrative processes, can prevent this development.

- ► measures for the pro-allocative reduction in conflicts between the interested public and developers of infrastructure projects are to be improved

Societal consent to infrastructure measures has an essential influence on both their cost and duration. Civil protest and administrative court proceedings can delay projects and increase their costs. Hence, reducing these conflicts can contribute to a timely realization of projects and expand public participation. The following improvements in this area are still possible:

- Clear definition and delimitation of discussion contents for public participation, with legal and administrative requirements taken into account
- Better and more structured drafting of project needs
- Increasing the transparency of project flows
- Increasing the cost transparency of infrastructure projects
- Public sensitization regarding the costs connected to individual processes

- ► combined transport is to be further strengthened
  - through the provision of sufficient transshipment areas (especially areas for empty containers and storage) and superstructure
  - through expanding CT-installations

These measures allow realization of the disproportionate growth of combined transport of 73% between 2010 and 2030 projected by the FTIP. Due to the high density of CT-terminals, almost no new installations are necessary. However, the future operational capacity of existing terminals has to be ensured.

- ► Logistics- and commercial areas (regional and urban planning) are to be sufficiently provided in order to attract companies and concentrate traffic near intermodal transshipment areas. Near central traffic points (traffic intensive), areas suitable to the promotion and concentration of combined transport are to be supplied, in order to prevent long pre- and on-carriage distances, as well as unnecessary traffic. This is to be assisted by a federal support program.

For a pre- and on-carriage of 30 km, lorry costs make up 60% of total costs. If this distance for pre- and on-carriage is increased from 30 km to 50 km, this share increases to 70%. Concentration of logistics and commercial areas near intermodal handling locations can reduce the necessary distances for pre- and on-carriage. This reduces their transport costs and, consequently, improves the competitive situation of the alternative transport carriers.

- subsidies for building rail sidings are to be continued and enhanced

  These subsidies aided in bringing about 10,5 million t (or about 3,1 billion tkm) additional goods onto rails between 2004 and 2010. This equates to about 30% of all growth for rain freight traffic in tons and about 20% of additional transport performance during that period. Each accepted application was able to shift about 120 kt (or about 35,7 million tkm) towards rail. Despite being few in number (about 15 applications per year), these results indicate how important this promotional tool is.

- interoperability in European rail freight transport and the harmonization of entry conditions (e.g. ETCS-Expansion) for rail freight transport are to be promoted and expanded upon.

  These measures avoid time-intensive locomotive- and personnel changes in border stations necessary due to diverging technical standards and insufficient language skills or route knowledge. Should the conversion of the ETCS come with an adjustment of block sections, the performance of affected routes could be improved by up to 10%, which can save expansion investments.

5.2 Measures for cost reduction

The survey has shown that there is, in principle, a strong interest in utilizing rail and waterway, as long their services are not more expensive than straight road transports. Thus, increasing price-competitiveness of train and barge compared to lorries is an important lever for changing the modal split, if not simply a necessary prerequisite. This means that many an infrastructural measure, especial for railways and combined transport, would be futile as long as price-competitiveness is not ensured.

The policy suggestions outlined in the following do not directly originate in the survey. Instead, they were derived from the empirical analysis, as well as the practical experience of the evaluators involved, which indicate that these measures in particular can achieve absolute and relative cost reductions for the alternative transport carriers.

- the external costs of road transport are to be fully included in the lorry toll

  Charging lorry traffic with its full external costs through tolls, regardless of emission class, would equate an additional burden between 8% and 16% of lorry cost, if external costs of alternative transport carriers are considered.

  For combined transport in particular, train and barge would receive significant competitive improvements compared to lorries if the latter had to take their full external costs into account. In an assessment for the state Baden-Württemberg, TRIMODE calculated that an increase of lorry cost of about 37%, would lead to an increase in freight train traffic of about 15% and an increase of waterway traffic of about 5%. An increase of costs of up to 30% for lorry traffic, in order to account fully for the external costs it causes would hence influence traffic volumes for the alternative transport carriers positively.

- the costs of accessing rail infrastructure (train track prices) are to be lowered – the train track price subsidy is to be continued

The federal government aims to indirectly relieve shippers with its promotion. It is assumed that rail transport companies will relay the gains from reduced costs of rail transport to them. However, the promotion does not ensure this happening.

Calculations by TRIMODE in other studies showed that halving train track prices in Germany could achieve a traffic shift of up to 3% of the projected overall freight train traffic. The expected competitive improvements for rail would be taken to about 90% from lorries, which indicates that the desired traffic shifts can be achieved with this measure.

- operating subsidies are to be granted in order to strengthen intermodal transport

  Empirical analysis shows that intermodal traffic can only be efficiently realized for transport distances of over 500 km for conventionally transported goods and 350km for combined transport, due to the incurred costs for pre- and on-carriage transport.

  In order for intermodal transport to compete with direct lorry transport for lower shipment sizes and on ranges below those mentioned, the costs for pre- and on-carriage must be subsidized by the state. This subsidy would at least have to apply to relations with a distance of up to 500 km for conventionally transported goods and to relations of below 300 to 350 km for combined transport. The subsidies themselves would have to be about 25€/t for conventional transport and 450 € per transport unit for combined transport.

- the electrification offensive for the most important train freight routes is also to be continued

  Diesel locomotives exhibit 25% higher contingency costs and 150% higher operational costs compared to electric locomotives. This causes transport cost disadvantages that can amount to 20% to 30%, relation specific. In order to avoid these disadvantages, diesel locomotives are only utilized for as long and far as necessary in long-distance transport. Usually, traction is shifted at the nearest possible marshalling yard.

  Fully electrifying the infrastructure network would limit the use of expensive diesel locomotives exclusively to marshalling yards. In addition, other routes can be used more flexibly as a replacement without requiring a change of traction in the case of a disruption. This leads to an increase in transport reliability and thus rail competitiveness.

- last-mile and dual-mode locomotives are to be included in funding programs

  These types of locomotives are supposed to replace straight diesel locomotives in electrification gaps. At time of writing, they are not included in the planned funding program, yet are more efficient for freight train traffic than the included hybrids etc.

- operational measures for transshipment-automation for rail and waterway are to be implemented and supported

  Experts estimate that stronger automation and digitization of process can save up to 50% of handling costs. This could amount to a reduction of overall transport costs of 12% to 15% for rail and 11% to 20% for waterway in conventional transport. For combined transports, the potential savings of 5% to 8% of overall transport costs are lower.

- in freight train (classification-) yards capacities and tracks suitable for 740 m long trains are to be expanded

For combined transport, a train of about 735 m length is about 5%-7% cheaper than one of about 670 m. The FTIP expects about 2,6 million tons of traffic to shift from road to rail due to increasing train lengths alone. In order to actually realize these shifts, train formation depots need to supply sufficient capacities and 740 m long tracks.

- other drivers of cost and interference within the rail network are to be removed (e.g. pushing processes, routes with insufficient axle load)

  Pushing processes lead to costs of hundreds of € per tour and can be mitigated through building tunnels, straightening routes and installing alternative routes.

  Newly registered locomotives usually have an axle load of more than 21 t. Three out of four newly registered locomotives are unable to frequent 25% of the future German rail network. This mostly involves one-track sections that are seldom utilized by freight traffic. However, these sections in particular are then unavailable as diversions in the case of disruptions on main routes. Hence, the increased use of locomotives with higher axle loads lowers the reliability and resilience of rail network infrastructure significantly. As such, a more intensive expansion with attention to axle load is required.

- standardization and normalization of transport containers in rail freight transport are to be continued

  These measures reduce vacant space caused by containers that do not fit the carriage. The use of 30-foot-containers in particular is to be reduced.

- shippers have to optimize their packaging with regard to the logistical aspects of transport mode shifting.

  Packaging optimized for transport allows more products to be included in each delivery. Experience shows that doing so can reduce transports and by extension transport costs by up to 25%.

5.3 Measures for the reduction of transport times and improvement of reliability

These suggestions aim to mitigate rail disadvantages on the temporal axis of transports. Since the time component is always a cost component as well, this naturally also affects the cost side. Furthermore, a certain reliability of infrastructure is a basic requirement to build an attractive hub-and-spoke network, where carriages or large load carriers switch trains in marshalling yards or gateways/terminals within the rail network.

- the implementation of automation and digitization of operational measures (especially promoting wagonload traffic) is to be accelerated and strengthened

  This includes e.g. automated coupling - automated carriage and train composition – automated inspections (e.g. weighing, checking circuits and contacts, etc.) – automated transshipping– and loading procedures.

  Surveys show that a 1% improvement in transport times for rail in combined transport can lead to a shift in traffic of 0,2% to 0,4%, with less impact in conventional rail transport. Even though the direct time effects may be low, analyses by TRIMODE in unpublished projects show that halving carriage and train composition times – which is certainly achievable through the measures outlined above – would decrease costs in rail freight transport by 4%

to 5%. Combined with the related time effects, this would lead to an additional increase in volume of up to 4% of the rail traffic volume projected for 2030.

- the automation of transport carrier inspection and shipment tracking are also to be implemented more strongly

  This allows freight traffic clients to see through the transport technical black box, track deliveries, as well as notice and adjust to delays early on.

- operators are to optimize the time efficiency of carriage and train composition

  This can be achieved through e.g. more efficient planning for personnel and schedules, as well as increasing capacities and buffers.

- processing- and loading times (24/7) are to be expanded

  Equalizing possible departures and arrivals allows shippers to be more flexible, to improve distribute peak loads of storage and depot capacities, to provide better service offerings and thus higher demands, and to reduce operational inefficiencies, in particular those caused by bundled deliveries at the gateways.

  Changing the assumed average operating time of CT-terminals from about 260 operational days to 275 in the FTIP-Forecast for the year 2030, leads to a synonymous increase in network performance of between 10% and 15%.

- sufficient routes for express freight trains are to be supplied

  On freight transport routes in particular, sufficient lines for express freight trains need to be ensured and, if necessary, be prioritized over passenger transport. Then faster trains can realize their advantages (meeting critical transport deadlines, overnight connections, better utilization of bound capital and personnel, as well as a better fit for good classifications with increased value of time).

- a system of indicators is to be constructed in order to better consider buffer times and to avoid delays during the operation of trains

  This system should include the daily publication of indicators in relation to traffic load, weather conditions and route specific special actions.

- prioritizing freight traffic in route reservations and a stronger separation of passenger and freight transport are to be more intensely observed.

  This should be done e.g. by building new high-speed lines to segregate older lines and equalizing or at least partially prioritizing freight train traffic to passenger traffic on routes especially relevant for freight traffic.

5.4 Measures for the increase and expansion of departure frequencies for combined transport and wagonload transport for rail

The increase in departure frequencies that companies demanded in the survey, in particular for combined traffic, is primarily a task for the private sector. Here an increase in frequency is a direct result of an increase in transport volumes, which also positively impacts average costs.

An increase in departure density is only possible through increasing the volumes handled by CT-terminals. Since it cannot be expected that companies shipping high volumes always settle near CT-terminals, the following measures should be pursued:

- CT-terminals are to be concentrated regarding area and service, as well as developed into storage- and distribution-centers, as noted in chapter 5.1.
- The 45-foot container network that is developing in maritime transport between European harbors should be promoted for continental CT as well and offered additionally by CT-operators in the hinterland. These can be transported and stacked more cost-effectively, leading to overall cost advantages.
- The federal government should assume an intermediary role in influencing a full shift towards exclusively producing trailers suitable for crane handling, which can be utilized in unattended CT. There are two possible courses of action for this. Firstly, the acquisition of said trailers could be subsidized. A possible range for these subsidies would be about 30% to 50% of the difference in purchase cost of 1.500€ to 3000€ between trailers suitable for crane handling and those unsuitable for it. The alternative would be to prohibit the purchase or production of unsuitable trailers on transport policy grounds.

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