International Transport Forum

# Mode Choice in Freight Transport

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**Research Report**
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# The International Transport Forum

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# Executive summary

## What we did

This report examines why freight carriers and shippers choose one transport mode over others. It analyses the main determinants for using road, rail, inland waterways, coastal shipping or pipelines to move goods and assesses government policies to influence it. Airfreight is not considered. The study also reviews how shifting freight to more sustainable modes could reduce the contribution of goods transport to climate change and provides recommendations for more effective policies. The role of mode choice in alleviating congestion and making goods transport safer is also addressed. Three case studies from China, Canada and the Netherlands highlight modal-shift policies.

## What we found

Road transport currently represents approximately 40% of the tonne-kilometres transported in 37 out of the 51 countries examined. This share is significantly larger than that of rail freight (24%), coastal shipping (16%), inland waterways (13%) and pipelines (7%). Road freight's share of goods transport has increased steadily, rising from 25% in 1980 to 40% in 2017. In China, around one-third of freight uses roads, a quarter inland waterways, another quarter coastal shipping and about 14% rail. Generally, non-road transport modes are more often used for bulk goods such as coal, petroleum products and minerals. Containers are transported by lorry as well as by other modes.

Shifting freight to different transport modes is a policy goal in its own right in several countries. Such modal shift can achieve high-level policy objectives such as environmental sustainability, better connectivity and increased safety. Over the past forty years, only three of the countries examined for this report have succeeded in shifting the modal split from road freight to other forms of transport. Slovenia and Austria have increased the share of rail and Italy that of coastal shipping, at least in part related to policy interventions. In all other countries that saw changes in freight's modal split, the movement has been from non-road modes to different non-road modes. It shifted from rail to coastal shipping in Turkey, from rail to inland water transport in Romania and China, and from coastal shipping to rail in the United States and Australia. In 44 out of the 51 countries examined, the modal share of road freight transport has increased over the past four decades.

Shippers prefer road transport because it often perfectly fits their requirements in terms of reliability, flexibility, accessibility and shipment size. Although rail freight is cheaper per transported tonne-kilometre, it usually adds costs to shippers' logistics systems. In most circumstances, rail's ability to substitute road transport is limited. For example, demand for rail transport is mostly for bulk commodities over long distances, while trucking demand is for short distances. That said, non-road modes offer economies of scale while the external costs generated by road transport are generally higher than for other modes. $CO_2$ emissions from road transport are usually higher per tonne-kilometre than for pipeline, rail, inland waterways or coastal shipping.

The overall external costs of road transport (per tonne-kilometre) such as air pollution, climate change, noise, congestion, habitat damage and crashes are, on average, at least twice those of rail or inland waterway transport. For this reason, governments have sought to influence mode choice in freight transport via targeted policies. Yet, while governments can create conditions for a change in modal split, private actors within the logistics chains have freedom of mode choice. Various countries have formulated explicit modal-split targets and supported rail transport, inland water transport and coastal shipping. Governments also adopt policies that do not directly aim at mode shifts but impact mode choice. Such policies can take the form of subsidies, tax benefits, regulation, infrastructure provision and other measures. However, policies are often not aligned. Despite measures aimed to stimulate non-road modes, most governments simultaneously continue to support road freight transport, for example via fuel tax exemptions.

Pinpointing those policies that demonstrably alter the modal split in freight transport is difficult. Not many of the evaluated policy measures allow the effects of reduced emissions and mitigation of other external costs to be quantified. Overall, policies can result in a modal shift, but these cases are relatively rare. The crucial factor blocking interventions from effecting real change appears to be an inelastic demand for road transport. Other factors can include missing infrastructure links, high transaction costs of shifting to another mode, and lack of competition or regulation in freight-rail markets in certain countries. The reach, speed, flexibility and reliability road transport offers is generally superior, so price changes do not fundamentally alter the mode-choice decisions of shippers.

In some cases, government intervention has been insufficient or poorly targeted. Subsidy programmes for non-road freight operations are sometimes too short-lived and thus do not create the long-term confidence that will make shippers switch to other transport modes. Additionally, subsidies for modal-shift projects may have little effect if they apply to existing non-road transport operations.

The big transport trends will also impact modal shift: digitalisation, automation, zero-carbon technologies and multimodal logistics chains. These developments will have mixed effects on the attractiveness of different freight-transport modes. Self-driving trucks could ultimately help relieve driver shortages and improve road transport's safety record; electrification could improve the road sector's environmental performance. At the same time, the growth of road freight transport will not help alleviate congestion.

Within the rail sector, electrification is well advanced. Further electrification will help sustain its position as a low-emission, energy-efficient freight transport provider. In the meantime, governments could support more business innovation in rail-freight transport to increase its attractiveness.

Incentives to use more waterborne transport could help to decongest road and rail infrastructure. At the same time, this might negatively affect the environmental performance of inland and coastal shipping unless the decarbonisation of this mode is accelerated. Shifting liquid bulk transport to pipelines could require additional infrastructure costs but would also reduce safety risks. Digitalisation can help build multimodal logistics chains – if rail and waterborne freight modes can develop services and products that meet customer requirements better than they do today. The outlook for each freight mode is context-dependent, making specific rather than generic mode-shift policies all the more relevant. In light of ongoing change, the value of shifting freight from road to other modes will need regular review.

The Covid-19 pandemic has had significant impacts on freight transport. Whether and which of these effects will be long-lasting is not yet clear. Cost explosions (notably for container shipping), deterioration of schedule reliability, equipment bottle-necks and labour shortages challenge the resilience of the freight transport system.

## What we recommend

### Apply integrated policy approaches to create coherent interventions across freight-transport modes

Achieving modal shift is challenging. All elements of the multimodal chain must align to achieve the targeted change, which requires coordination and cooperation. Effective programmes focus on specific corridors and networks to offer shippers multimodal options with complementarities and interoperability between different modes. Effective interventions also align the strategies and instruments of different tiers of government, including non-transport measures such as spatial planning. Effective interventions are also coherent across modes in terms of infrastructure investment, tax subsidies, regulation, support for innovation, standards for data and information exchange to stimulate more informed modal choices. Modal shift requires multimodal options but also better information about them. Only then can users make the appropriate choices. Here, digital technology is critically important – and therefore government standards for data and information exchange. Integrated policy is necessary to avoid conflicting incentives, contradictory policy measures or isolated measures that risk being ineffective by nature.

### Focus on mitigating external costs associated with each freight mode, rather than on modal shift as such

Instead of making modal shift as such the policy objective, on the assumption that such shifts will reduce freight emissions, alleviate congestion and reduce safety risks, governments should formulate more immediate policy goals. For example, they could quantify the desired emissions reduction for a freight transport mode and develop measures to achieve this. Such a specific and differentiated approach would make policy more effective because it addresses clearly identified objectives with specific instruments within a determined area and period, rather than deploying generic instruments without considering local specificities.

### Improve the evaluation of policy interventions' effectiveness to better inform measures that influence the choice of freight transport modes

Clear objectives for policy intervention require relevant performance indicators. Performance evaluation must go beyond establishing whether modal shift has occurred and also measure the benefits this shift has generated. Such performance evaluations should be publicly available. Full transparency will enable policy makers to assess which measures have worked in other countries and learn from the experience of others. Regular monitoring of interventions' success, rather than occasional reviews, would allow continuous adaptation of policy. A reduced need for significant adjustments would help provide the continuity and stability that shippers and carriers value.

### Create fair competition between freight transport modes

Governments should maintain a framework for fair competition between freight transport modes and work to reduce market and government failures. Climate impacts, air pollution and safety risks require fiscal or regulatory intervention to contain them. Fossil-fuel subsidies, in particular, need to be phased out. Many modal-shift policies attempt to address cost distortions caused by fossil fuel subsidies and tax exemptions for specific transport modes. For instance, subsidies for rail freight operations co-exist with fuel tax exemptions for road freight. Such contradictions must be addressed. A coherent framework for intermodal competition would create momentum towards a multimodal transport system in which all modes play their role based on where they are more efficient, more sustainable and safer than others.

# Mode choice: Concepts and the rationale

Countries throughout the world have deployed mode shift policies to achieve a variety of objectives, in particular environmental and economic objectives. What could we learn from these policies? Can they be effective? Under what conditions and compared to which alternative policies? This report assesses the factors driving mode choice in freight transport. Better informed choices between modes can support broad government objectives related to accessibility, sustainability, climate change, safety, resilience and economic development. Mode-choice policies are of particular importance to policy makers in light of growing attention to greenhouse-gas emission reductions required to achieve climate goals.

This chapter sets out the methodology for the analysis throughout the report. It introduces the terminology, concepts and considerations that will be further developed in the report. In doing so, it analyses government policies and their effectiveness including those of transnational organisations like the European Union.

## Concepts, conceptual approaches and methodology

This report covers six freight transport modes: road, rail, inland waterways, short sea shipping, short-haul air transport and pipeline. These modes are considered within the context of end-to-end freight transport chains, with a focus on longer distance connections – national and intra-continental – whilst avoiding extensive coverage of urban logistics, which would require a separate report.

*Modal shift* refers to changing the transport mode used to transport a certain good; for example a modal shift from road to rail means that a good that was previously transported by road will now be transported by rail. Modal shift over time means that that non-road modes increase their market share – and road transport decreases its market share. Theoretically, it is possible to shift between all six of these transport modes. In practice, this obviously is not the case: some modes can be excluded depending on geography – for example by lack of navigable rivers or coastlines – or lack of technical or commercial feasibility. Policy makers have focused efforts mainly on shifting freight from road to rail and water transport, for a variety of reasons, including assumed positive impacts on environment, safety and congestion. This report will use the concept of modal shift in line with this policy practice, as developed over the last decades. The shift from rail and waterborne transport back to road transport will here be considered as "*reverse modal shift*" or "*modal back shift*". The term "*mode choice*" refers to the choice shippers or other transport stakeholders make with regards the modes of transport for transporting their goods. Mode-choice changes often go hand-in-hand with changes of logistics chains. This means that an analysis of mode choice should also include logistics. *Modal split* or *modal share* refers to the share of goods transported via a certain mode (e.g. a rail modal share) and usually measured in tonne-kilometres. Most freight transport is offered in multimodal or intermodal transport chains. Intermodal transport requires standardised load units, e.g. containers.

There is a huge literature on mode choice in freight transport with a variety of methodological approaches to how research has been conducted. These approaches try to describe, explain and predict mode choice, mostly by aggregated freight flows or by individual companies. There are different ways to categorise these studies. A common distinction is between macro and micro-level. A *macro-approach* analyses aggregated freight flows on regional, national or international levels, using freight flow matrices and characteristics of the transport network. A *micro-approach* analyses transport chains at the firm level, using information on the behaviour of individual companies, and the key determinants for their choices on logistic solutions and transport modes, such as cost, reliability and transport time. Such models could be qualitative or quantitative and can differ with respect to the transport modes that are covered. Road and rail transport being the most extensively studied modes. Despite various methods of available analysis two models are most common for analysing mode choice in freight transport: case studies at the firm level and freight transport network models in which behaviour is econometrically estimated.

Case studies survey the preferences of individual firms. These preferences can be used to estimate modal elasticities and cross-elasticities that indicate the extent to which the utilisation of one transport mode (e.g. road transport) changes due to changes in the price of another transport mode (say rail). Modal elasticities are the sensitivity of the utilisation of a transport mode to changes in its price and can be used to predict modal shift. The range of cross-elasticities found in the literature is wide and values are location-specific.

Freight transport network models usually start with modelling economic processes, such as production, consumption and trade. Based on these economic estimations, these models then use four steps related to flows of freight:

- trip generation: the flow to be generated
- trip distribution: distribution of goods
- mode choice: the transport mode used
- route assignment: the transport networks used.

This four-step model often needs additional steps to transform trade flows in monetary units to physical flows of goods in tonnes and then further into vehicle flows with specific vehicle utilisation factors. In past decades, the modelling of freight transport demand has evolved significantly, from the use of aggregate models based on global data of shippers and shipments, to the use of more sophisticated disaggregated models taking into account individual firm-level data. Recently, freight transport models have integrated logistics-behavioural modelling in order to increase policy sensitivity and realism (De Jong et al., 2013).

Several challenges to mode choice remain despite considerable efforts to improve analytical approaches. These challenges – not unique to freight transport modelling – are related to the fact that neither the decision makers of mode choice, nor the transport modellers, have comprehensive information on prices and performance of transport providers in different modes. Even if available, many freight logistics decision makers would not dispose of the analytical tools to utilise such comprehensive information were it available. There is systemic inertia and path dependency that sustains certain past choices, which makes changing more challenging. Additionally, switching from one mode to another – or even switching carriers within the same mode – can be costly if contracts need to be broken, or new information-sharing arrangements need to be put in place.

## Who influences the choice of freight transport modes?

Many actors have an impact on mode choice in freight transport. The private parties that constitute the demand and supply on freight transport markets are the main influencers:

- *Shippers* generate demand for freight transportation as they are the senders or recipients of the goods. They plan shipments to satisfy their customers and define how their freight should be moved. Thus, they formulate their logistics strategy, which may include intermodal transport. They can organise their freight transport themselves, or outsource this to logistics service providers.
- *Logistics service providers* (including freight transport forwarders) undertake various logistics tasks within an intermodal transportation system. They provide a range of value-added logistics services, such as warehousing, distribution, shipping, inventory management, co-packing, labelling, repacking, weighing, and quality control. They can also act as intermediaries for shippers with respect to both domestic and international intermodal transportation activities, also referred to as integrators. Shippers often outsource logistics activities in order to focus on their core businesses and benefit from the expertise of logistics providers.
- *Carriers* are the transport operators or transport companies that perform the transport for the shippers or logistics service providers. Some carriers operate dedicated services, in which a vehicle or container serves a single customer. Others operate on the basis of consolidation, in which each vehicle or container may contain different customers' freight with different origins or eventual destinations.

In addition, there are the actors that influence the conditions for private firms:

- *Infrastructure managers* may be public entities, private entities or hybrid entities. They deal with the management of the physical network and infrastructure, including roads and highways, the rail infrastructure, intermodal port terminals, and so on. Thus, they play a central role by providing efficient physical networks and the necessary technology to control and optimise the use of infrastructure and facilities.
- *Policy makers*, that is governments and public administrations who tax, give incentives, set up policies, and regulate transport activities. Policy makers also address externalities related to transport. That is, the effects on others than the direct transport users that are not taken into account in the price of transport. Policy makers frequently aim to guide the transport and logistics system towards being more beneficial to society and resilient ways of operation. For example, , the usage of specific corridors or vehicle and motorisation types, mode changes from road-based to water- and rail-based transportation, the reduction of externalities, the consideration of environmental impacts, etc.. National governments as well as transnational institutions such as the European Commission are included in this class of actors.

It is the interaction between these actors that determines the mode choice in freight transport but the literature generally considers that shippers, and logistics service providers play a dominant role in this choice. There are, however, several reservations to be made here.

First, the choice of the preferred transport mode is often part of a larger decision-making process that includes other factors, such as supply chain strategies. The choice of transport modes is often derived from these other issues.

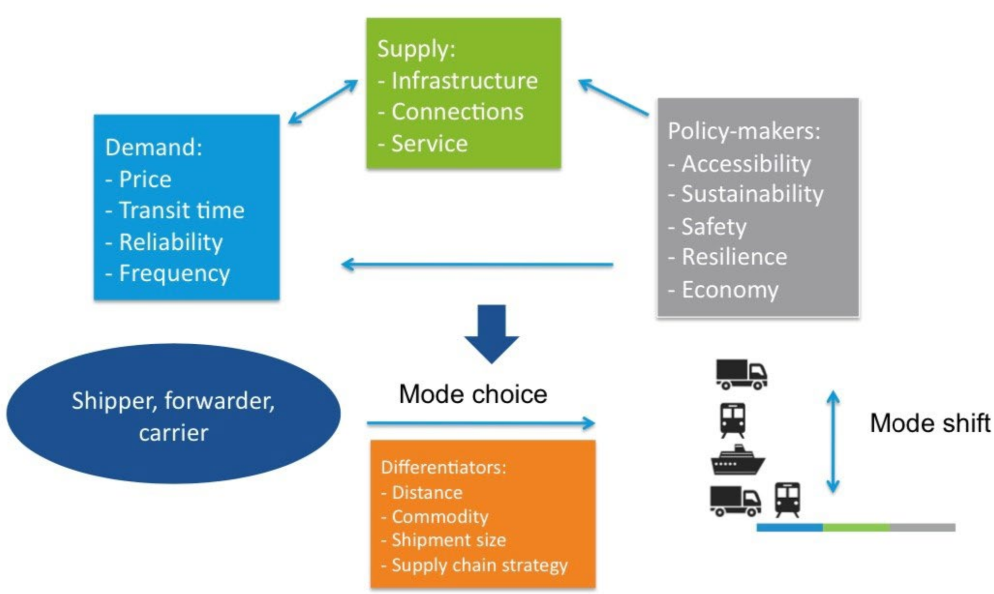
Second, although the subject of this report is mode choice, the actual choice for shippers and logistics providers is often between different logistics solutions that comprise several modes. Sometimes, one leg is served by several modes in parallel (synchro-modality). In this situation, modal combinations and operational schedules could be changed after the shipment is on the way, in response to new information. Transport chains are frequently constituted by several modes, which is then defined as multimodality, inter-modality and combined transport. Containerisation of freight transport has increased the possibilities of intermodal transport as it has reduced the time and costs of transferring cargo from one transport mode to another.

Third, in some freight-transport sectors the power of decision might be shifting from shippers to carriers, due to increased market power and vertical integration. Vertically integrated carriers will give priority to infrastructure or modes that they operate themselves. For example, container-shipping companies are also active in port-terminal handling and trucking: they will prefer to use their own port terminals that might not have rail connections and give priority to their own trucking services. Market power in container-shipping could give them the possibility to impose a certain bundle of transport modes that would not necessarily be in line with the preferred combination of the shipper.

## What are crucial determinants for freight transport mode choice

Freight transport could be considered an interlinked set of markets – the interplay of demand and supply – embedded in regulatory frameworks and other policy instruments (e.g. infrastructure fees and taxes). These instruments constrain to a more or lesser extent the market; they take certain public objectives into account that can make modal shift possible. The following three elements – the demand of shippers, the supply of transport infrastructure and the regulatory framework – constitute the main determinants for freight transport mode choice (Figure 1). The section below describes these three determinants.

Figure 1. The main determinants for freight transport mode choice




### Demand of shippers

A huge number of studies deal with the criteria that shippers or their intermediaries – like freight forwarders – take into account when choosing their transport mode. Independently of who has conducted the studies, costs, transit time, and reliability have been found to play the most important role in transport mode choice.

### Supply

While shippers have a set of criteria for the transport services they prefer, the extent to which these could be realised depends on geography, which is fixed in the long term, and the infrastructure supply which cannot be changed in the short term but that could be influenced by government policies.

### Policy instruments

Modal shift in freight transport is a policy goal to achieve high-level policy objectives, such as environmental sustainability, connectivity and safety. Modal goals often are expressed in a target for the desired modal split or modal shift. In this report policy interventions are classified according to the main determinants that are important for shippers when deciding on mode choice: costs, transit time, reliability and frequency. A central question in that analysis will be the extent to which the policy instruments manage to influence these determinants. It is important for policy makers to assess the extent to which policy instruments manage to promote connectivity, environmental sustainability, safety and economic development in a cost-effective way. The different institutional contexts that these policies are implemented in – for example the responsibilities of different levels of government – must be considered, as they could explain why certain policies work in some countries but not in others. It could help to determine under which conditions policy interventions should be considered.

## Different characteristics

Whereas the previous sections have set out determinants for mode choice generically, the final choice made is highly dependent on the specific characteristics of the cargo and cargo flow; the main differentiators.

The main characteristics that need to be differentiated here are:

- the distance between origin and destination
- the commodity type
- shipment size and
- the profile of the decision-makers on mode choice.

## Possible game-changers for freight transport

The merits of the various transport modes for both transport users, and society as a whole, are not static, but in continuous flux due to new developments that make some modes more and others less attractive. Policy instruments, can stimulate such developments, for example via support for innovation, creating new markets and transitions towards uptake of alternative fuels. Such measures that policy makers can take form the focus of this report, but new developments can obviously also take place without government intervention, instead driven by market forces, research and other societal forces. In the final chapter, this report explores a few of these possible future developments that might act as game changers with regards to mode choice in freight transport.

# Modal split and its determinants

This chapter gives an overview of official statistics on the freight modal split and data sources on its performance. Existing modal-share data show that in most ITF countries road transport is the pre-dominant freight transport mode, and that this share has considerably grown over the last four decades. The chapter provides findings of the different transport modes with regards to costs, transport time, reliability and service frequency, as well as performance of transport modes on environmental sustainability, alleviation of congestion, safety and reduction of other external costs.

## Modal split in freight transport

Modal split figures are usually expressed in tonne-kilometres. Other, but less frequently used indicators are based on tonnes of goods or value of goods. These are less frequently used because they do not express the extent of transport activity in a certain mode: there clearly is a difference between transporting a tonne of crude oil over 10 kilometres or 200 kilometres. This analysis expresses freight flows in tonne-kilometres, but will also contrast with the modal split when focusing on tonnes. The domestic transport flows being considered are inland transport modes – via road, rail and inland waterways – and also coastal shipping and pipelines. As such, it is different from many overviews of modal splits in freight transport that are traditionally focused on inland transport, e.g. the modal-split statistics of the European Commission. Our data source are ITF data, as collected from national transport authorities.

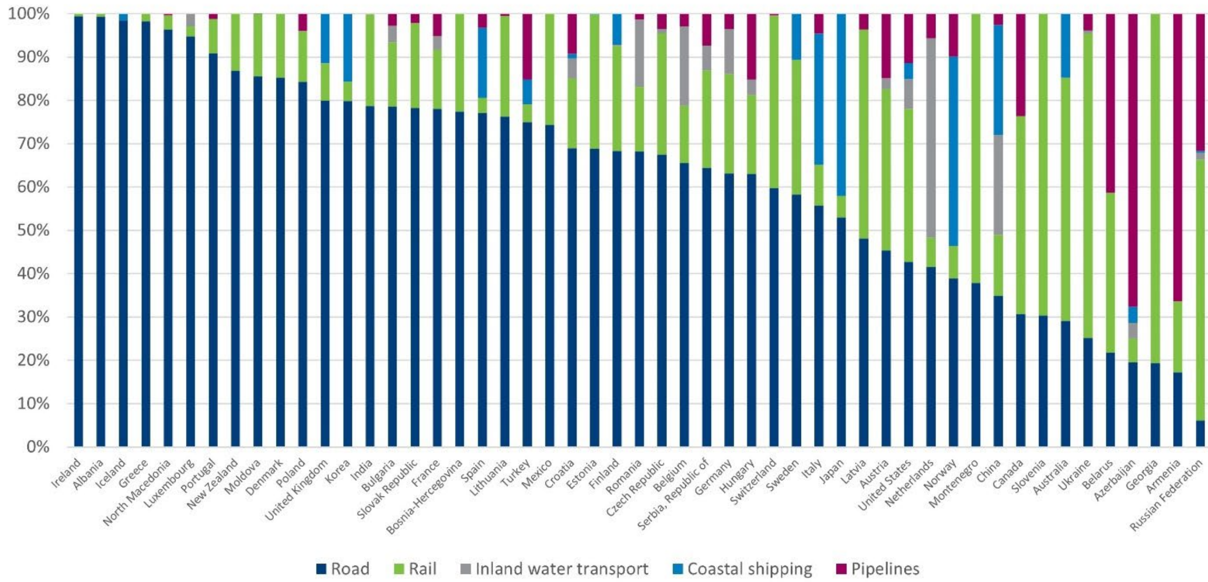
Road transport has the highest share of freight mode in most ITF countries. The ITF statistics database consists of 51 ITF countries which have recent and complete data on freight transport modes. Road transport currently represents approximately 40% of the tonne-kilometres transported in these 51 ITF countries, a significantly larger modal share than freight transport via rail (24%), coastal shipping (16%), inland waterways (13%) and pipelines (7%).

In 37 out of these 51 countries, road transport is the predominant mode; in 35 of these countries road transport represents more than 50% in the modal split (Figure 2). In only 14 out of 51 ITF countries is a non-road transport mode the dominant transport mode. Rail transport is the next most widely used, predominantly in a few Eastern European countries, the Russian Federation, Australia and Canada (Table 1). These last three countries all have vast land surfaces; these large distances are generally more favourable to rail transport. Eastern European countries generally have a legacy of freight rail transport, dating back to Soviet times when these countries where highly interconnected to and acting as gateways to the Soviet economy. Inland waterways represent the highest modal share in the Netherlands, coastal shipping in Norway and Japan and pipelines in Azerbaijan, Armenia and Belarus, but these are relatively rare cases.

The dominance of road freight transport is expressed even more clearly when calculations of modal shares are based on tonnes transported (and not on tonne-kilometres). This comparison cannot be made for all the countries that were covered in Figure 2 as the relevant data were not publicly available, but for the countries where this could be done (Figure 3), the road share is almost always higher when calculations are based on tonnes and not tonne-kilometres. This reflects that distances travelled via road are almost always shorter than those by rail, inland waterways and coastal shipping. In Austria, Slovenia, Sweden and Finland the average distance per tonne transported via rail is considerably higher than via road. In Norway and Italy the average distance transported via short sea shipping (SSS) is considerably higher than road.

Figure 2. Modal split shares in freight transport in 51 ITF countries

*in tonne-kilometres*

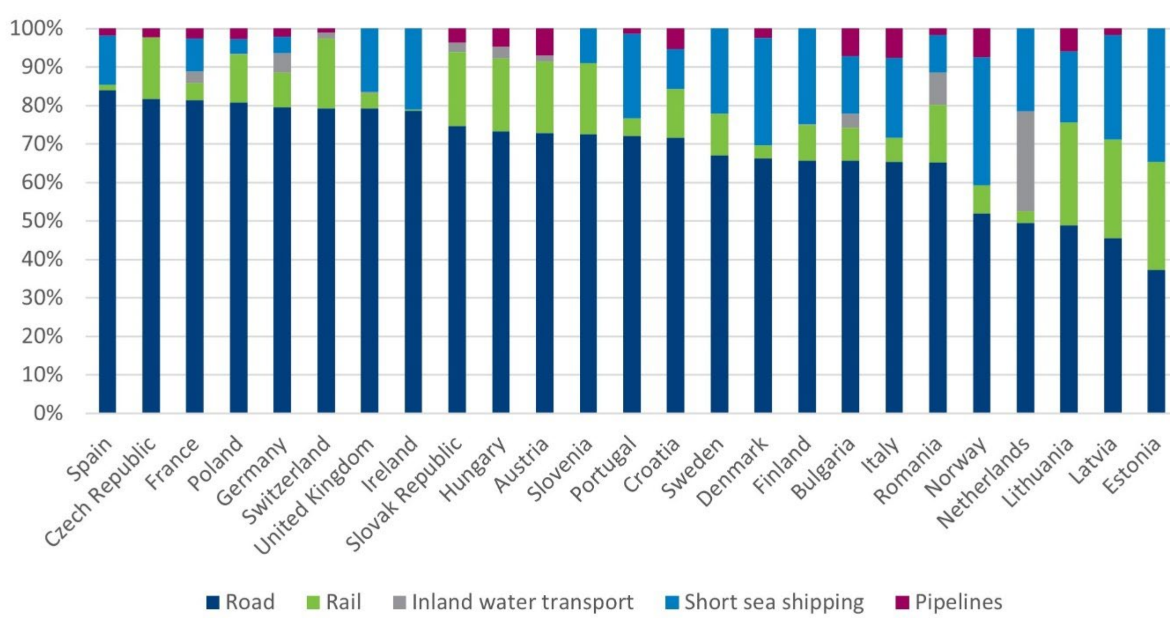



Note: data are presented for the most recent year for which data are available. For most countries this is 2019, with the exception of China, Denmark, Iceland, Korea, Spain, Switzerland, United Kingdom, United States (all 2018), Armenia, India, Montenegro (2017), Australia, (2016), Canada (2015), Albania (2013) and Belgium (2011).

Source: ITF statistical database and Eurostat (PIPE_GO).

Figure 3. Modal split shares in freight transport in 51 ITF countries in 2019

*in tonnes*

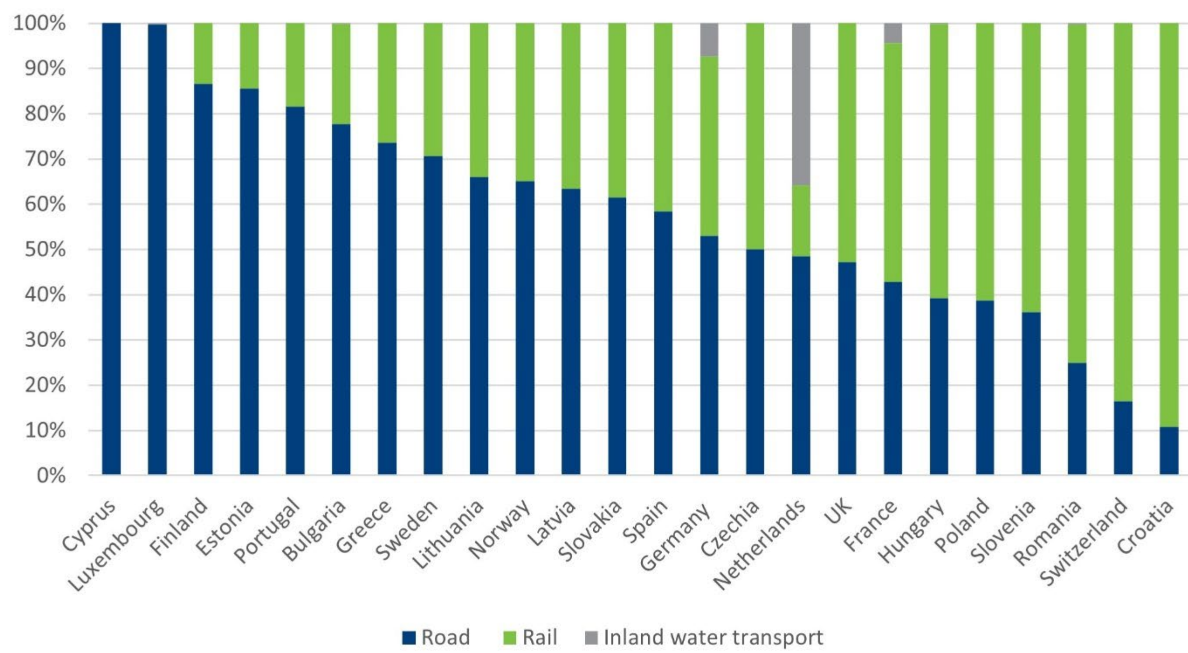



Note: data are presented for the most recent year for which data are available.

Source: ITF statistical database and Eurostat database (MAR_SG_AM_CW, PIPE_GO_TON, IWW_GO_ATYGO).

Rail modal shares hold a relatively higher level in containerised transport (Figure 4). In most of the European countries examined, the ratio of road compared to rail and inland waterway transport is lower for containerised transport than for non-containerised transport. Thus, rail and inland water transport are modes that are attractive for transporting containers in most European countries. The main exceptions to this are Sweden, Finland, Estonia and Latvia where freight trains are predominantly used for transporting bulk goods. Some of the countries in Figure 4, such as Sweden, also have a relatively large share of containerised coastal shipping.

Figure 4. Modal split in containerised freight transport in European countries in 2019
*in tonne-kilometres*



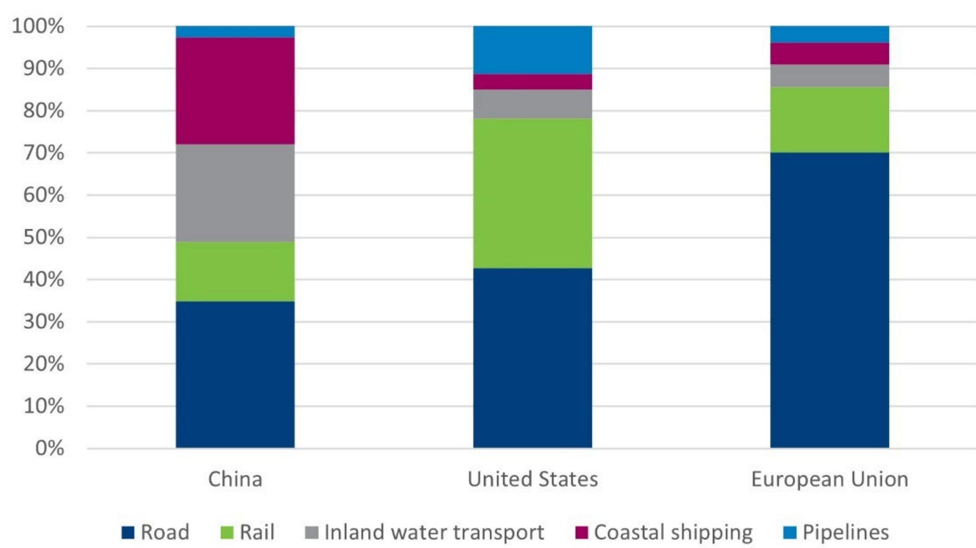

In the People's Republic of China, around one-third of the freight transport is done by road, a quarter by inland waterways, another quarter by coastal shipping and around 14% by rail (Figure 5). In comparison, freight transport in the United States is dominated by two modes – road and rail – that together represent 78% of the tonne-kilometres of freight transport. Freight transport within EU countries, another big market for freight, is dominated by road transport, representing 70% of the freight transport modal split.

Table 1. Countries with predominantly non-road freight transport modes

| Freight transport mode | Countries | Modal share |
|---|---|---|
| Rail | Georgia | 81% |
| | Ukraine | 70% |
| | Slovenia | 70% |
| | Montenegro | 62% |
| | Russian Federation | 60% |
| | Australia | 56% |
| | Latvia | 48% |
| | Canada | 46% |
| Pipelines | Azerbaijan | 68% |
| | Armenia | 68% |
| | Belarus | 41% |
| Coastal shipping | Norway | 44% |
| | Japan | 42% |
| Inland waterways | Netherlands | 46% |

Note: data are presented for the most recent year for which data are available. For most countries this is 2019, with the exception of Armenia, Montenegro (2017), Australia, (2016) and Canada (2015).

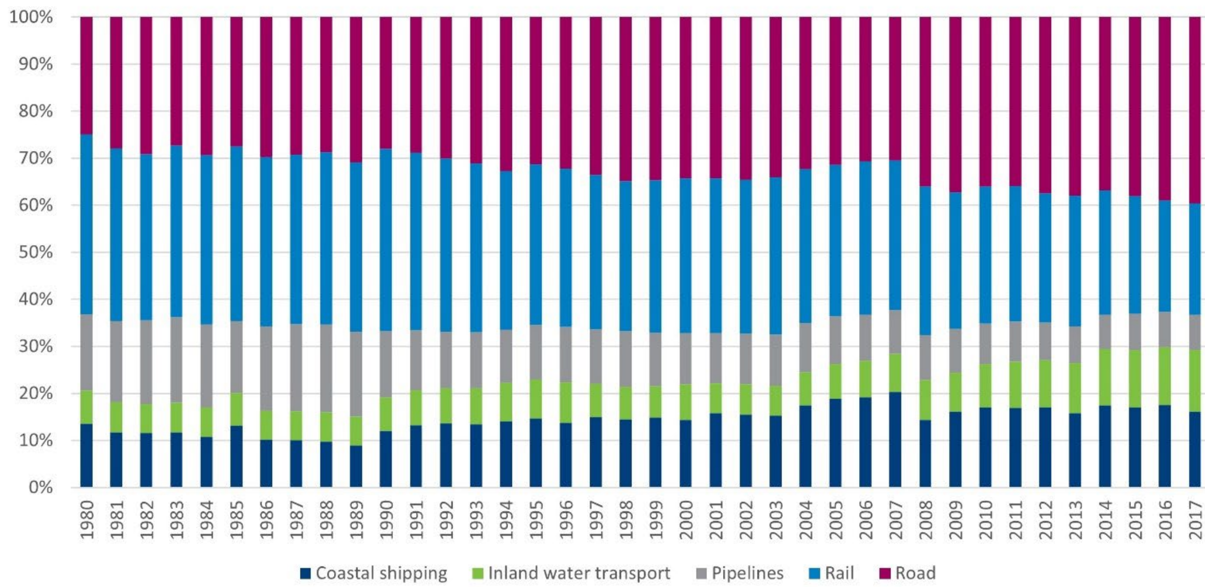
Figure 5. Modal split shares in freight transport in China, United States and the European Union in 2018




The modal share of road freight transport has increased steadily from 25% in 1980 to 40% in 2017 (Figure 6). Looking at individual countries, there is a clear trend of an increasing road freight share in 44 out of 51 countries. In three countries, this trend has remained stable since 1980: Belarus, Denmark and Portugal. Only two countries show a declining modal share of road transport over 1980-2019: Slovenia and Italy, and then Montenegro since 2001.

Figure 6. Modal split shares in freight transport in 51 ITF countries over 1980-2017

*in tonne-kilometres*

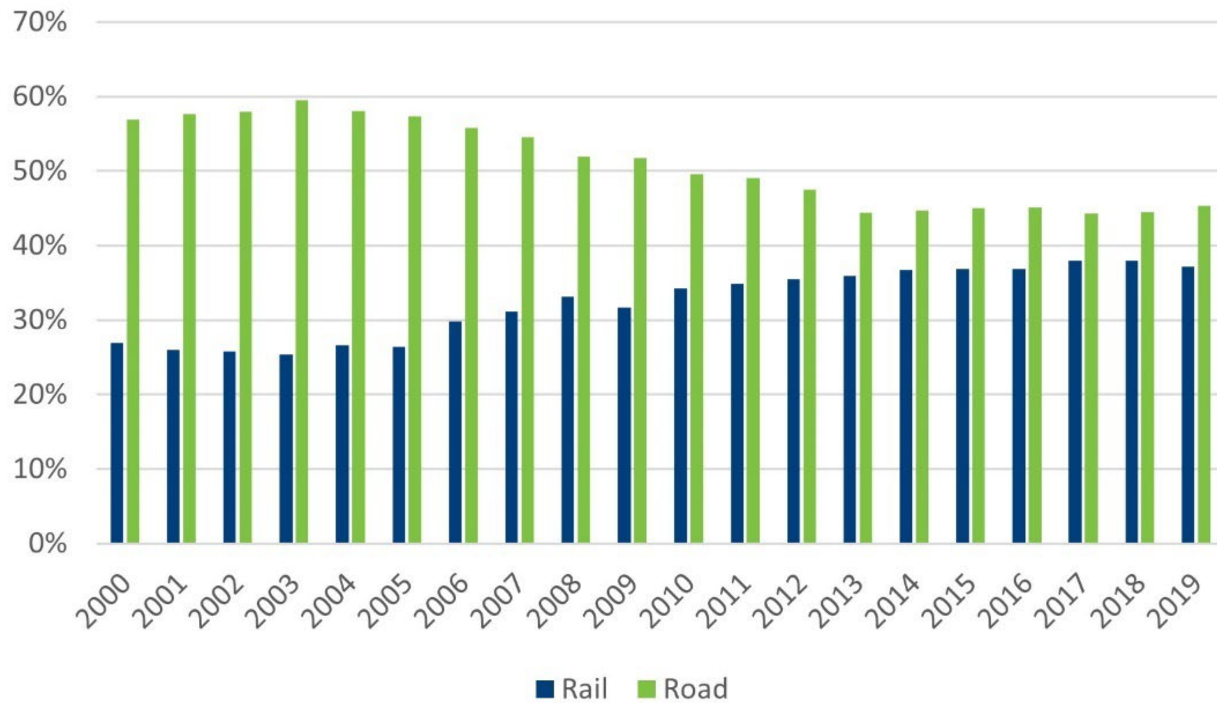



Modal shifts to non-road modes are rare. Between 1980-2019, Slovenia shifted from road to rail and Italy from road to coastal shipping (Table 2). Over that same period, there were five countries that witnessed a shift from one non-road mode to another non-road mode, namely rail to inland water transport (Romania and China), coastal shipping to rail (United States and Australia) and rail to coastal shipping (Turkey). More changes in modal splits are taking place when reviewing shorter time periods. For example, between 2003-19 Austria managed a change in modal split from road to rail, returning its rail usage to its share from 1980 even if rail did not become the dominant mode (Figure 7). Montenegro has managed a change in modal split from road to rail since 2001. Policy interventions in these countries are at least partly responsible for these changes in modal split, which will be described in the next chapter.

Table 2. Modal shifts in 51 ITF countries, 1980-2019

| Which modal shift? | Countries | Modal shift development over 1980-2019 |
|---|---|---|
| Road to rail | Slovenia | Rail (from 50% to 70%); road (from 50% to 30%) |
| Road to coastal shipping | Italy | Coastal shipping (from 17% to 30%); road (from 66% to 56%) |
| Rail to inland water transport | Romania<br>China | Inland water transport (from 2% to 16%), rail (from 68% to 15%)<br>Inland water transport (from 13% to 23%), rail (from 49% to 14%) |
| Coastal shipping to rail | United States<br>Australia | Rail (from 25% to 35%); coastal shipping (from 17% to 4%)<br>Rail (from 29% to 56%); coastal shipping (from 48% to 15%) |
| Rail to coastal shipping | Turkey | Coastal shipping (from 0% to 6%); rail (from 9% to 4%) |

Figure 7. Modal shift in Austria, 2000-19




## Determinants of mode choice

### Freight transport costs

Cost models exist for each individual freight transport mode. These models give insight to the costs of a typical transport vehicle in various typical situations. For example, the maritime consultancy Drewry releases an annual publication on operational costs in maritime transport that make it possible to assess the costs for a selection of ship types, sizes and ages under different circumstances. Such publications show that the annual operating costs of a container ship likely to be used in coastal shipping is USD 1.6 million, per year. Similar publications exist for other transport modes. Another approach of estimating transport costs is to assess the prices of transport services. Transport costs (for the transport provider) and transport prices (for the transport users) differ but correlate, and prices are often used as a proxy for costs. Transport prices are expressed in freight rates for typical corridors that can be public, although many contractual rates between transporters and their clients are not publicly available. Some organisations have the ambition to provide comprehensive and detailed overviews of freight transport costs per corridor, commodity and transport mode, but do not yet exist, as far as known. A recent example of such an ambition is the Global Transport Costs dataset for International Trade, developed by UNCTAD and the World Bank.

A variety of case studies exist that give insight to the costs of different transport modes. It is prudent not to generalise, however, it is possible to note that road freight transport is often the least expensive transport mode over short distances. The economic business models for rail freight transport and inland waterways only works with large volumes and massification of cargo. When such a large and stable volume for both fronthauls and backhauls does not exist, it is difficult for transport operators to make a non-road service viable (Woroniuk et al., 2013; Zunder et al., 2012).

Road freight transport is a competitive market with fairly limited concentration. This is different in rail freight transport where market competition is imperfect and characterised by oligopolies, in many cases also monopolies, despite decades of policy efforts aimed at liberalisation (Crozet, 2017). In coastal shipping, many countries protect their national operators via cabotage restrictions. This limited competition could also explain, in part, the higher costs of certain non-road modes in certain countries, especially in countries where economic regulation of the freight transport sector is insufficient (Schmidt, 2001; Betarelli et al., 2020).

Instead of focusing on freight transport costs per mode, various researchers have focused on total logistics costs. The central idea here is that the freight mode choice process is characterised by a trade-off between transportation costs and inventory costs (Baumol and Vinod, 1970). Faster and more reliable transport modes might be more expensive, but they could also reduce the inventory costs of the shipper. This approach considers more mode choice determinants than simply transport costs. For example, transit time is acknowledged when calculating the costs of inventory in-transit and costs of safety stocks, and reliability of a transport mode is also expressed via the costs of the safety stock (Blauwens et al., 2006). These approaches have been used to provide comparisons of different mode choices on freight transport corridors.

The relevance of transport costs and prices can be determined by assessing elasticities. Such elasticities express the changes in demand for a transport mode (e.g. road transport) if the price of that mode changes. Cross-elasticities indicate the changes in demand for a transport mode (e.g. road transport) if the price of another transport mode (e.g. rail transport) changes. Negative price elasticities lower than minus one (an absolute value larger than one) means that a price increase leads to a decrease in demand. Positive cross-elasticity higher than one means that the price increase in one mode (e.g. road) results in more demand for another mode (e.g. rail), so a positive cross-elasticity generally also indicates that these modes compete with each other.

Many studies focus on multimodal freight transport price elasticities, in particular for road and rail freight transport. Methodological choices and data can influence estimates of transport demand elasticities that might be sources of biases. For example, Oum (1989) finds that trucking price elasticities range from -0.69 to -1.34 depending on the methodological specifications. Moreover, elasticities differ per country, commodity, market structure and transport volumes, so they cannot always easily be compared or generalised (Beuthe, Jourquin and Urbain, 2014). Table 3 provides an overview of the price elasticities as found in the literature. A summary of these findings is provided in Table 4.

Table 3. Studies on price-demand elasticities for freight transport modes

| Study | Road | Rail | Waterways |
|---|---|---|---|
| Oum (1979a) | -0.16 | -0.29 | -0.74 |
| Lewis and Widup (1982) | -0.52 to -0.67 | -0.92 to -1.02 | |
| Beuthe and Nouillet (1992) | -0.26 | -0.11 | -0.51 |
| Lenormand (2002) | -0.26 to -0.48 | -0.41 to -0.93 | |
| Levin (1978) | | -0.25 to -0.35 | |
| Oum (1979b) | -0.33 to -1.07 | -0.39 to -1.20 | |
| Friedlaender and Spady (1980) | -0.14 to -1.72 | -1.45 to -4.01 | |

| Study | Road | Rail | Waterways |
|---|---|---|---|
| Friedlaender and Spady (1981) | -0.83 to -1.81 | -0.37 to -1.16 | |
| Kim (1987) | -0.10 to -1.24 | -0.12 to -1.73 | |
| Oum (1989) | -0.65 to – 0.69 | -0.54 to -0.60 | |
| De Jong (2003) | -0.40 to -1.01 | -1.40 to -3.87 | |
| Rich et al. (2011) | -0.01 to -0.28 | -0.10 to -0.40 | |
| Beuthe et al. (2001) | 0.00 to -4.50 | 0.06 to -4.42 | -0.04 to -11.7 |
| Winston (1981) | -0.04 to -2.97 | -0.08 to -2.68 | |
| MacFadden et al. (1985) | -0.75 | -1.16 | |
| Inaba and Walace (1989) | -0.25 to -0.92 | -0.04 to -0.99 | |
| Abdelwahab (1998) | -0.75 to -2.19 | -0.91 to -2.49 | |
| Marzano and Papola (2004) | -0.01 to -0.02 | -0.78 to -1.35 | |
| Garcia-Menendez et al. (2004) | -0.32 to -0.49 | | |
| De Jong and Johnson (2009) | -0.03 | -0.13 | -0.073 (short sea shipping) |
| Windisch (2009) | 0 to -1.43 | -0.68 to -3.18 | -0.84 to -2.78 (Short sea) |
| Stratec (2010) | | | -0.56 to -4.74 |
| Arencibia et al. (2015) | -1.53 to -1.79 | | |

Source: Beuthe, Jourquin and Urbain (2014).

Table 4. Overview of price-demand cross-elasticities for freight transport modes

| Cost | Demand | | | |
|---|---|---|---|---|
| | Road | Rail | Inland waterways | Short sea shipping |
| Road | 0 to -1.2 | 0.4 to 1.7 | 0.3 to 0.9 | 0.2 to 1.1 |
| Rail | 0.1 to 0.5 | 0 to -1.6 | 0.2 to 0.8 | 0 to 0.3 |
| Inland waterways | 0.1 | 0.2 to 0.9 | -0.4 to -1.3 | |
| Short sea shipping | 0.1 to 0.3 | | | 0 to -1.8 |

Source: Vierth et al., (2017); Merkel et al., (2021).

The picture that emerges from the analysis of price elasticities of freight transport modes is mixed and depends on the aggregation level. The more aggregated the data, the more inelastic values are found. On the other hand, individual data models tend to exhibit a wider range of estimates and frequent cases of elastic demands (Beuthe et al., 2014). Most aggregated time series analyses from countries find inelastic demand, whereas there is a larger range of elasticity values and higher elasticities in studies based on disaggregated individual shipment data.

There is a tendency for rail elasticities to be higher than for road freight transport, for which many cases of inelastic demand are found. There are only a few estimated elasticities for inland waterways and short sea shipping (SSS); so the values in the Table 4 are probably specific to local market circumstances and difficult to generalise. Road transport demand is more price sensitive on longer distances, whereas rail and waterborne transport are more price sensitive on shorter distances. Road transport demand is also more price sensitive for heavy bulks, for which alternative modes compete more intensely. Rail and inland water transport are more price sensitive for time-sensitive goods, such as agricultural products and food (Vierth et al., 2017)

Cross-price elasticities have lower absolute values than own-price elasticities. This means that the demand for a transport mode tends to respond more to a percentage change in its own price than to the same percentage change in the price of a competing mode. However, there are differences between transport modes. The demand for rail, inland waterway transport and coastal shipping are relatively responsive to changes in the price associated with road transport. This is not the case the other way around: the demand for road transport is insensitive to the cost of the alternative freight transport modes. One explanation for this could be that trucks are considered to have a comparative advantage in service quality that is sufficiently high to off-set any price cuts of competing modes (Vierth et al., 2017).

### Transit times, reliability, service frequency

Rapid transit times are of importance for shippers of time-sensitive goods. These include perishable goods (such as fresh food), goods that rapidly lose market value over time (such as fashion and computer components) and goods where urgent delivery is required, such as Covid-masks and replacement parts. These goods are often transported by the more rapid transport modes, such as aviation and road transport. Rail transport and sea transport are generally slower transport modes, used for goods that are less time-sensitive. However, much depends on local circumstances. High-speed freight trains have been established in China that compete with short-haul aviation, the Asia-Europe rail connection is more expensive but faster than maritime transport, for goods where faster transit times are advantageous. In shipping, the average speed is lower than what could be offered to clients, but high-speed ocean transport services with price premium have generally not found enough interest in the market. For the shorter distances, intermodal transport is often not competitive due to considerably longer transit times in comparison to road transport. Investments in infrastructure and intermodal capacity can help in reducing that gap in attractiveness.

Reliability of transport services is of great importance for shippers that deploy just-in-time supply chain strategies. Transport delays will translate quickly into disruptions in the production or sales process. Recurrent problems in reliability will mean that shippers must increase their buffer inventory capacity, which will increase their inventory costs. Reliability is all the more important in case of limited-service frequency, as this means that the costs of unreliable transport are larger. For this reason, service frequency is often considered one of the most important mode-choice criteria for shippers, as it provides them with the possibility to limit or catch up with transport delays. In addition to reliability and service frequency, shippers also value certain transport modes – such as road transport – that provide the flexibility to circumvent delays or congestion, e.g. by using alternative routes.

Other criteria that shippers consider important, depending on commodity types, regions and markets are: service quality, flexibility, security, sustainability and marketing value. Service quality could refer to many attributes of the transport service, e.g. transparent communication, possibilities for tracking and tracing cargo, service help-desks, and guaranteed stable conditions for certain types of cargo, such as refrigerated cargo. The transport of high-value goods and dangerous goods requires more security – e.g. less accidents, lower lost cargo rates – that cannot always be guaranteed by all transport modes. In terms of sustainability, there is increasing pressure on firms, especially producers and sellers of consumer goods, to reduce the environmental and carbon footprint of their logistics supply chains. Carriers are also confronted with increased scrutiny of their environmental impacts, for example with regards to pollution, land use and climate change. Virtuous behaviour in this respect could boost the brand value of the firm.

As for transport costs, it is possible to express these service attributes into elasticities. The elasticities are interpreted as the effect on mode substitution holding total transport demand constant. They reflect the changes in demand for that transport mode if one of its own attributes (e.g. transport time) changes. Table 5 provides elasticities for transport time, service frequency, reliability (delay time) and damage risk, based on an overview study by Vierth et al. (2017). The values in the table represent the full range of estimates found in the literature. As there is only a limited number of studies expressing these service attributes into elasticities the results should be interpreted with caution.

Table 5. Demand elasticities for freight transport modes

| | Road | Rail | Coastal shipping |
|---|---|---|---|
| Transport time | 0 to -0.9 | -0.3 to -1.3 | 0 to -0.8 |
| Service frequency | 0.1 to 0.2 | 0.1 to 0.2 | 0.1 to 0.2 |
| Delay time | -0.2 to -0.5 | -0.1 to -0.4 | -0.1 to -0.4 |
| Damage risk | -0.2 | | -1.9 to -3.4 |

Source: Vierth et al. 2017, based on Garcia-Menendez et al. 2004; Arencibia et al. 2015; Bergantino et al. 2013; Román et al. 2016; de Jong, 2003; Rich et al. 2009; Johnson and de Jong, 2011; Johnson and de Jong 2011; Bühler and Jochem 2008; Vierth et al. 2014; Feo et al. 2011

Across all transport modes, elasticities for transport time, delay time and damage risk are negative, which means that the demand for these modes decreases when their transport time, delay time or risk of damage increases. In contrast, the sign of the impact of service frequency is positive. This means that each transport mode is more likely to be chosen when it offers more departures per time unit.

There are also some differences between transport modes. Demand for road transports seems to be less time sensitive compared to the other modes. Although the average values in Table 5 overlap, demand for road is consistently less elastic than demand for the other modes when estimates from the same study are compared (Vierth et al., 2017). The responsiveness to the other variables is similar across the transport modes, although demand for coastal shipping stands out as being more sensitive to the damage risk.

Road transport is in many cases well aligned to demands of shippers in terms of reliability, flexibility, accessibility and shipment size. Rail freight is often cheaper per transported tonne, but it can also create additional costs in logistics systems of shippers. Substituting road transport by rail transport is often challenging: for example, rail transport is attractive mostly for bulk commodities over long distances providing economies of scale, while the trucking demand is for short distances.

## Infrastructure and superstructure

Transport infrastructure can be categorised into nodal infrastructure and modal infrastructure. –. Nodal infrastructure brings transport flows together and includes terminals, ports, airports and dry ports. Modal infrastructure is needed for transport modes to function, connects transport nodes, and includes roads, railroads, inland waterways and fairways.

The quality of infrastructure networks is determined by how modal and nodal infrastructures are linked together. The possibilities of mode shift are often dependent on how well nodes are connected to modal infrastructure. For example, ports without on-dock railway connections or barge terminals will have considerably more difficulties shifting port hinterland cargo from truck to train or barge than ports that have such connections. More links between nodal and modal infrastructure increase the possibilities of intermodality. The costs to use the modal and nodal infrastructure are reflected in the price of transport.

Infrastructure managers can apply different strategies to make sure that infrastructure costs are covered by transport users.

The services connected to transport infrastructure are a crucial element in effective transport networks. This means, the flows of transport vehicles utilising the infrastructure. The more services connected to an infrastructure, the more attractive it can become, as connectivity is a major attractor of more services, especially in the case of hub-and-spoke transport networks. This is also the case for value added services in nodal infrastructures, such as storage space, refuelling, recharging points, repair facilities and transport service providers. Transport services benefit from proximity and institutional arrangements that facilitate co-ordination and reduction of transaction costs.

The availability of infrastructure is not sufficient for mode shift. The extent to which infrastructure is aligned to the characteristics of the different transport modes is crucial. For example, whether road and rail infrastructures are designed in such a way that road and rail transport could substitute for one another, if needed. In some cases, the lack of appropriate infrastructure is not prohibitive, but will lead to longer handling times, and therefore higher transport costs. Terminal structure and costs for loading and unloading inside the terminals are also crucial for the possibilities of multi- and intermodality.

The possibilities of mode choice are delimited by geography. Island states will be more dependent on shipping, countries without navigable rivers cannot realistically aspire to develop inland waterway transport. Mountains could constrain the possibilities of road or rail transport, but various countries (e.g. Switzerland) have found ways to work around these constraints. Differing geographical characteristics often inhibit best practices in modal-shift policies from being applied universally across countries. The economic structure of a country is also, to a significant extent, determined by geography and drives the need for easily available and high quality infrastructure and transport services. Shippers can decide to relocate due to high-transport costs if policy does not mitigate geographical constraints.

## Environmental sustainability

There are many environmental factors to consider when electing mode choice to create sustainable supply chains. This report focuses on greenhouse gas-emissions, local air pollution and noise pollution. The emissions –of different freight transport modes, such as $CO_2$ and local air emissions, can be assessed by expressing them in grammes of emissions per tonne-kilometre. This can be done conceptually and via real cases. A conceptual assessment usually calculates emissions of different vehicle types, considering the energy efficiency of engines and the emission factors of the fuel used and relates these to the average tonne-kilometres transported by these vehicles. It is conceptual in the sense that it defines typical transport vehicles in each mode and makes certain assumptions about load factors of fronthauls and backhauls. Case studies usually calculate the actual emissions on certain corridors, considering actual emissions and loads. The difference between conceptual modelling and case studies is not trivial, as fuel consumption of vehicles – and hence emissions – is very sensitive to vehicle-load factors. Industry representatives promoting the green credentials of their mode sometimes base the calculations for their mode on high levels of utilisation, while using average-load data for competing modes (McKinnon, 2014).

*Greenhouse gas emissions* can be assessed for transport operations, but also for upstream emissions. Emissions from transport operations, or gas emissions, are also called *tank-to-wheel* (TTW) emissions. Upstream emissions are those associated with fuel extraction, production and transport and electricity production and transmission, also called *well-to-tank* (WTT) emissions. Adding tank-to-wheel and well-to-tank emissions creates *well-to-wheel* (WTW) emissions, which gives the most comprehensive overview of transport emissions. This report focuses on $CO_2$ emissions for the assessment of greenhouse emissions.

Table 6 presents a selection of studies on the $CO_2$ emissions per tonne-kilometre for the different transport modes. A graphic representation of these findings (Figure 8) shows that the transport mode with the highest $CO_2$ emissions per tonne-kilometre is road transport and that rail and inland waterway transport are emitting less $CO_2$. There is a large range of values for SSS, indicating that its emissions per tonne-kilometre are highly sensitive to assumptions on load factors. Various authors concluded that cleaner fuels in road haulage and improving the truck emissions-efficiency via innovative technologies might be better strategies to minimise $CO_2$ emissions in freight transport than deploying SSS (Hjelle, 2010; Hjelle, 2014; Nealer et al., 2012; Rodrigues et al., 2015; Raza, Svanberg and Wiegmans, 2020).

Variations in local circumstances often explain the differences between the outcomes of the studies. For example, the relatively low $CO_2$ emissions found for trucks in Johansson, Vierth, and Holmgren (2021) can be explained by the high share of relatively $CO_2$-efficient 60-tonne truck in that study; and the very low values for trains in the same study are due to the high level of electrification of railways in Sweden and its use of “green” electricity.

The energy production from and the production of vehicles and infrastructure all have negative environmental impacts. The most significant effect are the greenhouse gas emissions due to energy production for the transport sector: the well-to-tank emissions. Those well-to tank emissions are more or less similar for the different modes: 0.20 euro-cents per tonne-kilometre for heavy goods vehicles, between 0.14 and 0.16 for freight trains and 0.13 for inland waterway vessels (CE Delft, 2020). In terms of the costs of emissions from production of vehicles and infrastructure, a study on Germany showed that in 2016 these costs were forty to one hundred times higher per vehicle-km for a freight train than for a truck (UBA, 2019).

**Table 6. $CO_2$ emissions for different transport modes**

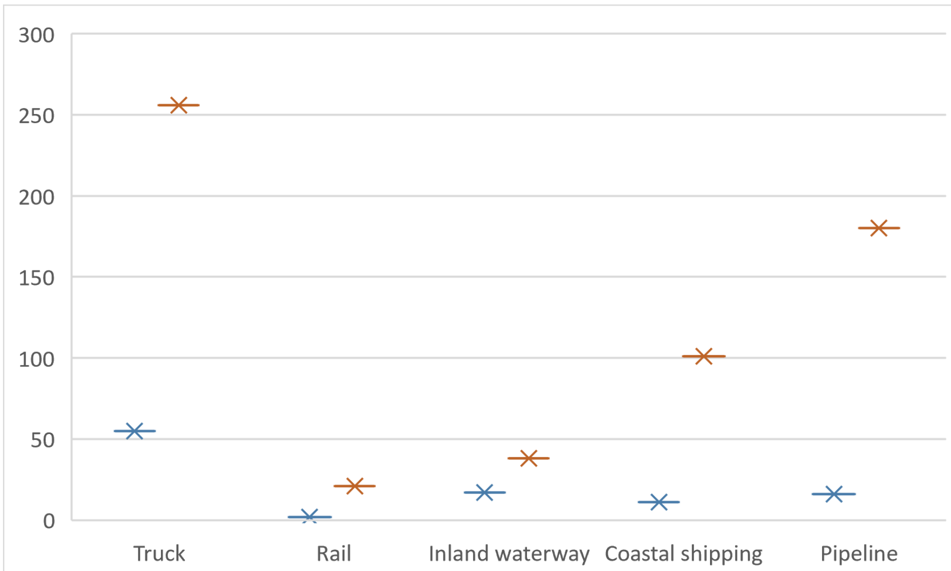
*in grammes per tonne-kilometre*

| Truck | Rail | IWT | SSS | Pipeline | Period | Place | Calculation | Source |
|---|---|---|---|---|---|---|---|---|
| 88-256 | 12 | 24-38 | 22 | | 2020 | Netherlands | WTW | CE Delft (2021) |
| 60-190 | 18-21 | 17-34 | | 180 (gas), 16 (oil) | 2002 | United States | WTW | Nealer et al. (2014) |
| 65 | 2 | | 29 | | 2017 | Sweden | TTW | Johansson, Vierth, and Holmgren (2021) |
| | 14 | | | | 2018 | World | | IEA-UIC (2017) |
| 55-124 | | | 80 | | | | | Hjelle 2014 |
| | | | 101 | | | | | Leonardi and Browne (2010) |
| | | | 11 | | | | | IMO (2009) |

The *air pollution costs* of the different freight transport modes have been relatively well studied. The emission of air pollutants can lead to: negative health effects, damages to buildings and material damages and loss of crops and biodiversity. The inhalation of air pollutants leads to a higher risk of respiratory and cardiovascular diseases, such as bronchitis, asthma and lung cancer. These negative health effects lead to medical treatment costs, production loss at work due to illness and, in some cases, to death. Air pollutants can lead to pollution of building surfaces through particles and dust, and to damage of building facades and materials due to corrosion processes, caused by acidic substances. An increased concentration of ozone and other substances can lead to lower crop yields. Air pollutants can directly damage ecosystems, including the acidification of soil, precipitation and water and the eutrophication of ecosystems. Damages to ecosystems can lead to a decrease in biodiversity.

Figure 8. Range of values on CO2 emissions for different transport modes

*in grammes per tonne-kilometre*




Note: the blue symbol indicates the lowest value found in the literature; the orange symbol the highest value found in the literature. Source: own elaborations based on CE Delft 2021; Nealer, Matthews, Henrickson 2014; Johansson, Vierth, and Holmgren 2021; Hjelle 2014; Leonardi & Browne 2010 ; IMO 2009

Air pollution costs in road freight transport are much higher than in other freight transport modes. The total external costs related to air pollution for the EU-28 is EUR 29.4 billion for road freight transport, EUR 1.9 billion for inland waterway vessels and EUR 0.7 billion for freight trains. In relative terms, things are more nuanced. Road freight transport with heavy goods vehicles generates air pollution costs of EUR 0.76 per tonne-kilometre on average in EU-28-countries, which is slightly higher than the score for diesel freight trains (EUR 0.68) and considerably higher than the score for electric freight trains (EUR 0.004). However, inland waterway vessels generate more air pollution costs than heavy-duty vehicles, namely EUR 1.29 per tonne-kilometre (CE Delft, 2020).

*Traffic noise*, in particular prolonged exposure to traffic on busy roads, can create significant costs. Such costs are mostly health care costs, as prolonged exposure to traffic noise has been linked with increased chance of heart disease, strokes, dementia and hypertension. The external costs related to traffic noise range from EUR 0.4 to EUR 1.2 per tonne-kilometre for heavy goods vehicles on average in EU-28-countries, and EUR 0.4 to EUR 0.6 for freight trains (CE Delft, 2020). Noise costs for inland waterway transport and maritime transport, however, are negligible as they usually take place in sparsely populated areas and the noise emission factors for those transport modes are relatively low.

Figures like these should be treated with caution. They cannot really be used for intermodal comparison. Modes can only be properly compared in specific cases, with due allowance being made for the distances travelled by the respective modes and the up- and downstream transport involved in getting from origin to destination. This is why many studies compare different multimodal options for the same transport corridor. Many studies indicate that SSS does not perform better than road transport on emissions per tonne-kilometre: due to factors such as high-fuel consumption and lower load factor, intermodal SSS generates more emissions, at least in the scenarios analysed, per tonne-kilometre than road haulage (Hjelle, 2010; Hjelle, 2011; Corbett et al., 2007; Hjelle, 2014).

### Congestion

Congestion refers to a condition where vehicles are delayed when travelling. The costs of congestion are determined by the travel time lost in comparison to a situation of flee flowing traffic. For scheduled modes, like rail, the cost of congestion depends on two factors: the extent to which one scheduled service delays another and the extent to which the presence of a scheduled service prevents another scheduled service from operating. The estimated costs of road congestion for heavy goods vehicles in EU countries are EUR 23.8 billion per year. This represents EUR 1.30 per tonne-kilometre. The estimated costs of rail congestion for EU countries is considerably lower, namely on average EUR 0.043 per tonne-kilometre (Christidis and Brons, 2016). In the United States, the estimated scores range from zero to EUR 0.014 per tonne-kilometre (Austin, 2015). Christidis and Brons (2016) indicate that congestion costs of freight transport for both inland waterways and SSS can be assumed negligible for EU countries.

### Where does safety stand?

Traffic accidents incur various costs: damages to vehicles, production loss, medical costs, administrative costs and human costs, such as shorter lifetime, suffering, pain and sorrow. Market prices can be used to calculate material costs, but not for human costs, that are valued based on the Value of Statistical Life (VSL). There are various ways to classify victims of traffic accidents. A typical classification consists of fatalities, serious injuries and slight injuries. A fatality takes place when a person is killed immediately or dies within 30 days as a result of an injury sustained as a result of an accident. A serious injury is when a person has sustained an injury as a result of the accident and was hospitalised for a period of more than 24 hours. Slight injuries involve a person who sustained an injury as a result of the accident but does not fall under the definition of serious injury (UNECE, 2011). Another classification system is the Abbreviated Injury Scale (AIS) commonly used by medical professionals, which has formed the basis for data collection in EU countries since 2014.

Data on traffic accidents are widely collected for road and rail transport, but more difficult to find for inland waterways. For example, in Europe, road and rail accident statistics can be extracted from the EU's Community Road Accident Database (CARE) and databases from the European Union Agency for Railways (ERA). CE Delft constructed an accident rate based on data from the Dutch Department for Waterways and Public Works that could be considered a proxy for the risk of inland waterway transport, rather than data on actual accidents that occurred in the period considered (CE Delft 2020).

Traffic accidents are much more frequent in road freight transport than in any other freight transport mode. As a result, the costs related to traffic accidents are much higher for road transport. According to CE Delft, the total external costs related to accidents for the EU-28 is EUR 42.8 billion for road freight transport, EUR 0.3 billion for freight trains and EUR 0.1 for inland waterway vessels. Road freight transport also has higher external accident costs: these were EUR 6.0 per tonne-kilometre for light commercial vehicles and EUR 1.3 per tonne-kilometre for heavy goods vehicles, compared to EUR 0.1 per tonne-kilometre for both freight trains and inland waterway vessels on average for EU-countries (CE Delft, 2020).

Freight transport vehicles can also be involved in accidents with major impacts on the environment. These impacts can be particularly severe when the accident affects densely populated areas or areas with unique biodiversity. Non-road mode accidents tend to cause the most drastic effects considering their shipment size and cargo characteristics: high quantities of bulky cargo, sometimes highly inflammable.

### External costs

Rail and waterborne freight transport tend to generate less external costs. These modes have lower GHG-emissions than truck transport and result in a reduced number of accidents and congestion on roads. According to recent estimations, external costs in 2016 for heavy trucks, rail, and inland waterway transport were EUR 4.2, EUR 1.3 and EUR 1.9 per tonne-kilometre, respectively, on average for EU-countries (CE Delft, 2020). In this study of CE Delft, external costs include costs related to accidents, air pollution, climate, noise, congestion, well-to-tank and habitat damage. However, the external costs of the different transport modes vary, depending on several factors such as load factor, where the transport takes place, and which energy sources are used to power the transport modes.

Even though the external costs are generally lower for rail freight and inland waterways than for road, this is not always the case for intermodal transportation (Kaack et al., 2018). For example, Santos et al. (2015) finds that, internalising external costs can even disadvantage intermodal transport operations, depending on the length of the road haul. External costs for waterborne transports are not automatically lower than for road.

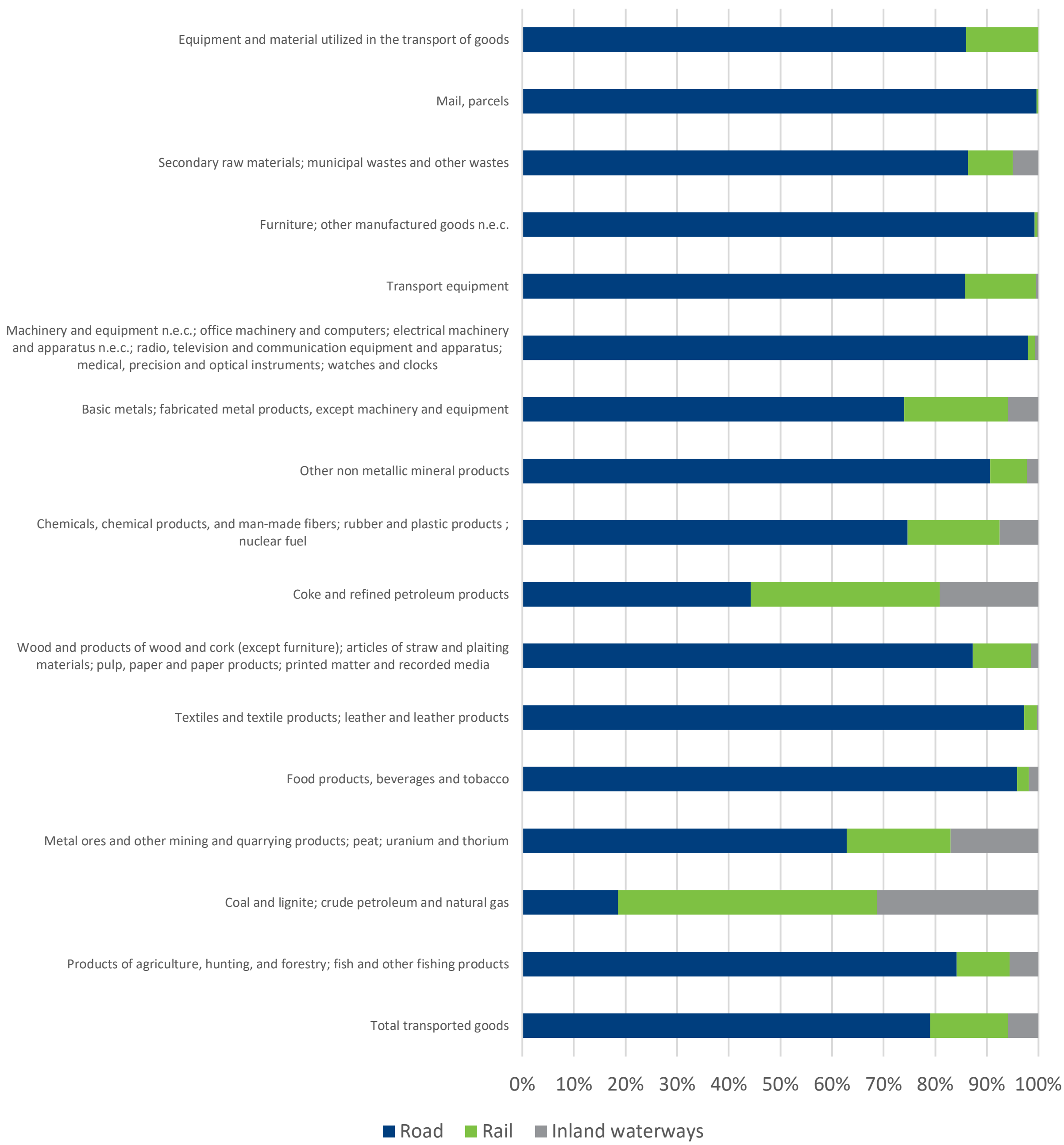
Many of the external costs, described above, are not considered in the price of freight transport. Government policies often attempt to internalise external costs – for example via infrastructure user charges, truck tolls, taxation and regulation – or create fairer competition between the modes via subsidies for positive external effects via modal shifts from road to non-road modes. These policies will be covered in the next chapter of this report.

## Main differentiators

Distance is one of the main differentiators in mode choice between regions. Certain transport modes are more appropriate for longer distances, and others for shorter distances. Longer distances facilitate economies of scale, bundling of flows and generate fewer intermodal handling costs (changing from one mode to another) relative to the total voyage cost. For example, sea and rail transport between Asia and Europe allows for economies of scale and bundling of flows whereas trucks do not. Rail transport within Europe taking place over longer distances means that intermodal handling costs are smaller in proportion to total voyage costs. Large cargo volumes make it possible to realise economies of scale in capital-intensive vehicles that would not be appropriate for small volumes. In other words, multi- and intermodal transport is feasible for short and medium distances if the volume is big and if the drayage distances at origin and destination are low. Cargo volume is more important than distance for efficient intermodal transportation (Bouchery and Franssoo, 2015).

Heavy bulky goods, such as coal, grain and gravel, are often transported by rail or water. In the EU-28 the share of rail and waterways within inland transport is slightly over 20% for all transported goods, but more than 80% for the transport of coal, crude oil and gas (Figure 9). Oil products and metal ores are other commodities often transported by non-road modes. However, low-weight goods are frequently shipped by road: in the EU-28 nearly all the furniture, machinery, textiles and food products are transported by truck. Most high-value goods are relatively low-weight. Shipment mode choice is influenced by the standards that policy makers and infrastructure holders in a country/corridor impose on truck and rail car weights. Some commodity groups, such as live animals, fresh food or chemicals, require specialised equipment. Shelf life, temperature and humidity requirements, sensitivity to acceleration forces and the risk of accidents can limit the modal choice (Brogan et al., 2013). Commodity type often correlates with shipment sizes and time-sensitivity. Both heavy bulky and the very light high-value goods can be considered "captive" cargos that can, in practice, hardly be contested with by other transport modes.

Figure 9. Modal split in freight transport per commodity group in the EU-28, 2019




Note: n.e.c. means not elsewhere classified.

For time-sensitive goods, shippers usually consider road transport to be the most reliable mode. This is due to its flexibility and ability to avoid congestion by taking alternative routes. Moreover, rail and inland waterway transport often cannot reach the final destination of the cargo, so is dependent on road transport for the last-mile delivery. For just-in-time operations, high-value or high-demand goods, the shipment frequency is also important, as it affects inventory costs.

These specific requirements for different commodity types translate into divergent price elasticities. For trucking, elasticities are the highest for shipments of heavy bulk cargoes – such as solid fuel, petroleum, iron ore, and scraps – whereas they are very small for food, chemicals, and diverse goods. The reverse is true for water transport that has the lowest elasticities for heavy bulks for which it has some competitive advantage. Rail elasticities are more dispersed but show a strong competitive position for metallurgical products (Beuthe et al., 2014).

# Modal shift requires specific government interventions

Government policies have a significant impact on mode choice in freight transport. Various governments have or are developing explicit modal-shift policies. Other governments do not have explicit targets or policies but it is clear that their policies have – intended or unintended – effects on the mode choice in their countries. This chapter examines both explicit and implicit modal-shift policies. It aims to identify the most common government policies that influence mode choice in freight transport and assess what existing evaluation studies reveal about their effectiveness.

## Modal shift policies and their motivations

Modal shift policies are used to reduce external costs of transport, mitigating GHG emissions, connectivity, environmental sustainability (such as air pollution and noise), safety and resilience. These different government policy goals can be complementary but also partly contradictory. Modal shift policies can sometimes also be considered the expression of a trade-off between high-level government policy goals, for example that of between accessibility and environmental sustainability.

Various countries, including the United States, Japan, and France have formulated modal-shift policies for freight transport. China formulated a Road to Rail Modal Shift policy in 2016, elaborated in 2018 by the State Council in its Three-Year Action Plan for Advancing Modal Shift (2018-20). Modal shift is one of the objectives of Sweden's National Freight Transport Strategy, adopted in 2018. Modal shift in freight transport has been also a recurrent objective of freight transport policies of the European Union, most recently in the EU Sustainable and Smart Mobility Strategy, released in 2020.

Modal shift ambitions are sometimes expressed in targets for the desired modal split or modal shift. Such targets often take the form of a desired share of non-road transport in the modal split. The modes most regularly preferred to road transport are rail, inland waterways and short sea shipping (SSS). An often-cited modal shift target comes from the EU Mobility Strategy, released in 2011 that aims at a 30% modal shift away from road transport by 2030 and of 50% by 2050. These could be considered aspirational targets. The Netherlands has formulated a more specific target to shift 5 million tonnes and 0.7 million standard containers (TEUs) from road to rail and waterways within the East and Southeast freight corridors in the Netherlands (IenW, 2019). Frequently, countries have modal shift ambitions included in their freight transport policies without specifying an explicit target.

The main motivation for governments to formulate modal shift policies appears to be the reduction of external costs of freight transport. Some countries have translated their modal shift target into expected GHG reductions. Rail and inland waterway transport are generally considered to be safer transport modes and preferred for dangerous goods. There might also be regional policy motivations for modal shift, for example to guarantee minimum service of rail transport in certain regions with low demand.

Even if countries do not have explicit modal shift targets, it is evident that government policies have an impact on the mode choice. For example, the way in which different transport modes are supported, taxed and regulated will directly affect their attractiveness to shippers. Choices about public infrastructure provision will determine the extent to which the different transport modes are competitive options.

Implicit mode choice polices could have similar – sometimes even larger – effects as explicit modal shift policies.

## Classifying policy instruments

Government interventions on freight transport modes can be classified in different ways. Researchers have come up with taxonomies of mode choice policies, such as push-and-pull instruments; and infrastructure and incentives. In this analysis of government interventions, policy interventions are classified according to the main determinants that are important for shippers when deciding on mode choice: costs, transit time, and reliability (Table 7).

Table 7. Government policy goals and instruments

| Mode choice determinant | Policy goal | Policy instruments |
|---|---|---|
| Costs | Bridge cost differences between modes<br>Internalising externalities | Subsidies, taxation, charges, pricing and regulating externalities, reducing market barriers |
| Transit time | Reduce time loss | Infrastructure, dedicated corridors |
| Reliability | Better coordination between modes | Digitalisation, information exchange |
| Flexibility | Interoperability, inter-connectivity | Innovation policy (platforms, management) |

Government policies are often motivated by reducing the cost differences between road transport and alternative transport modes. Also to compensate for the fact that external costs are not considered equally between different transport modes. Policy instruments to realise this objective include subsidies, taxation, charges, pricing and regulating externalities.

The policy goal on transit time is to reduce time loss, such as waiting times and congestion. The associated policy instruments are infrastructure development and dedicated freight corridors.

Better reliability could be achieved by better co-ordination between modes. The relevant policy instrument here is information exchange and digitalisation.

More flexibility could be achieved by better interoperability and inter-connectivity between transport modes. This could be stimulated by innovation policy, e.g. innovation subsidies, terminal innovations, innovations in digital multimodal platforms, multimodal supply chain management.

## Subsidies

A subsidy is a monetary transfer from a government to a private or public company active on the market, with or without conditions for services to render. Subsidies can be justified if they generate positive external effects or reduce negative external costs, for example because they contribute to lower air pollution. A firms' internal costs and external costs due to freight transport should be distinguished, even if these categories are often interlinked in practice. For example, many subsidies for freight transport aim to reduce the differences in costs for road transport and the alternative transport modes because the higher costs (firms' internal costs) for these alternatives are often considered to be the main barriers for their uptake. The reason for the relatively low costs of road transport is the relatively low rate of internalisation of the negative external costs of road transport, such as air pollution, greenhouse gas emissions and accidents. The negative externalities are lower for rail, inland waterway transport and SSS, or internalised more significantly. Subsidising these modes is considered a way to level the playing field between transport modes.

Some subsidy schemes explicitly target a modal shift from road freight to other modes. Examples of modal shift subsidies for SSS are Italy's and Sweden's Eco-bonus programme; Norway has a similar scheme. Long-standing modal shift subsidies to stimulate rail freight can be found in Belgium and Italy (the Ferro-bonus programme). Such programmes are motivated by the positive externalities of the modal shift, that are made explicit and that form the basis for the subsidy. In many cases, the difference in marginal external costs of freight transport by road and the alternative, forms the basis of the aid. For example, in the Norwegian scheme the subsidy sum per service is reached by multiplying tonne-kilometres (shifted from road to water) with the difference in external costs between road and sea transport. However, the boundary between modal shift subsidies and modal subsidies is not always clear-cut, as many of the subsidies for rail freight and SSS are justified by the lower negative externalities compared to road transport, even if they lack a specific target for modal shift.

Rail seems to be the most frequently subsidised freight transport mode. In Europe alone, subsidies for rail freight transport – in a variety of different forms – exist in Austria, Denmark, Germany, Italy the Netherlands and Sweden. Outside Europe, China, Japan and South Korea also subsidise rail freight transport. Subsidies for inland water transport are granted in the Netherlands, Belgium, Austria, Sweden and Czech Republic. Countries that have subsidies for SSS are Italy, Sweden, Norway and the United States. The European Union has subsidy programmes for rail transport, for SSS (Marco Polo, Motorways of the Sea) and for inland water transport (NAIADES.

Rail freight subsidies exist for intermodal (containerised) transport and for bulk transport (Single Wagon Load). Subsidy-bases in the rail freight schemes are often similar and based on an amount per train-kilometre or wagon-kilometre. Some of these subsidies, e.g. Belgium's, compensate for the additional costs of combining freight volumes in intermodal terminals and the additional handling costs related to intermodal transport. In several countries, national schemes are complemented with regional or local subsidy schemes for rail freight transport. For example, in Italy sub-national rail freight subsidy schemes exist for the provinces of Trento and Bolzano; the regions of Emilia Romagna, Friuli Venezia Giulia; and the city of Genoa.

The beneficiaries in almost all subsidies are either the transport operators or the contractors of transport services. For example, the Swedish Eco-bonus scheme is a subsidy for ship-owners offering new short sea services, whereas the beneficiary of the Italian Eco-bonus scheme are road haulage companies that make use of existing or new maritime routes instead of road transport. Most of these subsidies are provided on a temporary basis, assuming that after the subsidy period the new services should be commercially viable. In most cases, the subsidies are granted to the firms that will operate new services.

Subsidies to road transport are rarer, but exist, and are often linked to environmental performance. In 2020, Sweden put a subsidy scheme in place that provides a premium to companies, municipalities and regions that buy heavy-duty vehicles that run on electricity, gas or bio-ethanol. In 2019 Italy implemented an investment incentive for third-party road haulage companies, aiming at renewal and technological upgrading of the vehicle fleet, collaborative projects and equipment for collaborative projects. Germany provides an investment subsidy scheme of EUR 8 000 for the acquisition of each truck running on compressed natural gas (CNG) and EUR 16 000 for each truck running on liquefied natural gas (LNG) (ITF, 2021).

Transport subsidies in European countries are regulated via supra-national EU state aid guidelines. Many of the generic state aid principles apply to the transport sector, but there are also sector-specific state aid guidelines for the railway sector and maritime transport: the 2008 State aid guidelines on railway undertakings and the 2004 Maritime state aid guidelines that also covers aid to SSS. Despite the sector-specific differences, there are also various commonalities, such as the requirements that aid must not exceed 30% of total operational costs and be granted based on transparent criteria applied in a non-discriminatory way. Short sea shipping aid must not exceed three years in duration and the service that is covered by the project must be commercially viable after the subsidy (EC, 2004; EC, 2008).

## Taxes and charges

This section focuses on taxes and charges and how they impact freight transport mode choice. Whereas subsidies refer to monetary transfers in the form of expenditures from the public sector to private sectors, such transfers could also take the form of exemptions from taxation or charges, so tax revenues foregone. The following examines fuel taxes, carbon taxes, corporate income taxes and infrastructure charges.

### Fuel taxes

Some freight transport modes are taxed less than others, in particular the global transport modes – aviation and maritime transport – that have more mobile assets. This is apparent with regards to the taxation of energy use of transport. Long-haul aviation and maritime transport are generally excluded from taxation on fuels. The Chicago Convention (the Convention on International Civil Aviation) determines that for international flights fuel is exempt from national or local duties and charges. Fuel tax exemptions extend to regional or domestic transport as well. Only a few OECD countries have a fuel tax for domestic shipping and aviation. The EU Energy Directive actually discourages fuel taxation of domestic shipping and aviation, but the European Commission presented a proposal in 2021 for the revision of its Energy Taxation Directive, currently under discussion, which could imply that the fuel tax exemption for intra-EU shipping will be abolished.

The fuel for inland waterway transport is tax-exempt in many countries. This is, for instance, the case in Belgium, Switzerland, Germany, France and the Netherlands. The tax exemption in these countries is based on the Mannheim Convention, an agreement between the Rhine-States, in which it is stipulated that Member States must refrain from imposing any toll, tax, duty or charge on inland navigation. Other countries with inland navigation also exempt inland navigation from fuel taxes, including Austria, Romania, Hungary and Slovakia.

Railway transport is taxed more frequently than aviation and shipping, but many countries provide exemptions. Twelve European countries do not charge an electricity tax on rail transport or have an exemption regime. Belgium, Hungary, Norway and Sweden do not charge fuel taxes on diesel used for rail transport.

In contrast, energy use in road transport is generally taxed, but there is a large variation in the extent to which it is taxed. Fuel for road transport is taxed considerably less in the United States and Canada than in Europe and Japan. In most EU countries, diesel – that most trucks use – is less-heavily taxed than petrol. Some EU countries – including Belgium, France, Hungary, Ireland, Italy, Romania, Slovenia and Spain – exempt part of the excise duty for diesel that is used for commercial purposes, such as heavy-duty vehicles. In Chile, truckers benefit from a tax credit on the tax on diesel, and cargo transport companies owning or renting a truck weighing more than 3 860 kg may recoup a percentage of the tax on diesel under a tax credit on the VAT. This tax credit is generally about 25% but it exceptionally went up to 80% between 2008 and 2009 following a strike (ITF, 2016).

## Carbon taxes and emission trading

Carbon pricing aims at reducing greenhouse gas emissions by putting a price on carbon emitted. This strategy generally takes the form of a carbon tax or an emission trading scheme. Various countries have introduced carbon pricing schemes. As of 2018, a total of 51 carbon pricing schemes were implemented or scheduled for implementation: 25 in the form of emissions trading schemes, predominantly introduced at the subnational level, and 26 in the form of carbon taxes, mostly implemented at a national level (Klenert et al., 2018).

Transport is included in carbon tax schemes in Finland, Denmark, Sweden, Iceland and Ireland. The Swedish carbon tax mainly affects the transport sector, with around 90% of the revenues from the carbon tax coming from the consumption of gasoline and motor diesel (Andersson, 2019). Road transport is currently excluded from the EU Emissions Trading System (EU-ETS) but is part of carbon pricing schemes in many EU countries. The European Commission has proposed to include emissions from fuels used in road transport in a new, separate emissions trading system, designed to start in 2026. Around 95% of carbon emissions from road transport are priced, most of this via taxes alone (not only carbon taxes): around 91% of road emissions are priced by taxes alone at an average rate of EUR 96 per tonne of $CO_2$. About 4% of road emissions are subject to taxes and an ETS at an overall average effective carbon rate of EUR 72 per tonne $CO_2$ (OECD, 2021).

Coastal shipping is included in some carbon pricing schemes. Notable examples are Norway and Shanghai. In Norway, the carbon tax rates for inland transport depend on the energy source, with highest rates for petrol and lowest rates for heavy mineral oils, such as ship fuels. In 2006, the average carbon tax for inland transport and domestic shipping was NOK 190 (EUR 17.6) per tonne of $CO_2$, compared to NOK 208 (EUR 19.3) per tonne of $CO_2$ for taxi operations and domestic air transport (Bruvoll and Dalen, 2009). Since 2018, Norway has applied the standard carbon tax rate also to LNG and liquefied petroleum gas (LPG) for domestic shipping. Shanghai has a regional emission trading scheme in which both ports and domestic shipping are included. International shipping is for the moment excluded from carbon-pricing schemes, but the “Initial IMO Strategy on the reduction of GHG emissions from ships” mentions market-based measures (carbon pricing) as one of the candidate measures, and various countries have submitted proposals to the IMO in 2021 for carbon pricing mechanisms.

The European Commission also has formulated in 2019 the ambition to include shipping into the EU-ETS. Since 2021, the European Parliament has discussed a proposal to include $CO_2$ emissions from the maritime sector in the EU Emissions Trading System (ETS) using revenues to support investment in innovative technologies and infrastructure, such as alternative fuel and green ports, to decarbonise the maritime transport sector.

## Corporate income taxes

Maritime transport companies are clearly less taxed than other transport modes when it comes to taxation of corporate income. Shipping companies frequently register their ships in open ship registries (flags of convenience), which minimises their tax burden. In addition, many maritime countries have developed very favourable tax regimes for shipping companies, often in the form of tonnage taxes; a fixed tax dependent on the cargo volumes of ships that replaces regular corporate income taxes. More than 20 EU countries have tonnage tax regimes, as do the United States, South Korea and India. Short sea shipping, although not subject to international tax competition, benefits from similar tax advantages in most of these schemes. Maritime companies are in various countries exempted from the obligation to pay social security charges.

### Infrastructure charges and internalising external costs

The cost coverage for the infrastructure of freight transport is generally very low. A study on EU countries found cost coverage rates of 25% for diesel freight trains, 17% for electric freight trains, 13% for heavy-duty vehicles and 12% for inland waterway transport. The cost coverage ratios found for seaports was 4% (CE Delft, 2019). Cost coverage of external costs is higher than for infrastructure cost: 56% for freight diesel trains, 36% for heavy-duty vehicles, 32% for electric trains and 12% for inland waterway vessels. There are considerable differences between countries when it comes to cost recovery. For example, in Sweden, where a national system of fairway dues is applied to cover infrastructure costs and external costs, the degree of internalisation ranges from 53% to 90%, or 23% to 28% when the effects of a recent re-appraisal of $CO_2$ in the Swedish official guidelines for cost benefit analysis are taken into account (Vierth and Merkel, 2020). Cost coverage for passenger transport appears to be higher than for freight transport, both for road and rail transport.

Some countries have made deliberate efforts to increase the cost coverage of infrastructure. Canada's National Marine Policy, introduced in 1995, noted that much of Canada's maritime infrastructure was overly dependent on government subsidies, which represented an unfair treatment towards other transport modes. In order to solve this, the financial burden for marine infrastructure was shifted from the Canadian taxpayer to users, by transforming port authorities and the Pilotage Authority – in charge of the provision of pilotage services in seaports – into self-sufficient entities. A similar requirement of self-sufficiency is in place for the services that Transport Canada provides for the vessels using facilities in the public ports that it owns.

In rail freight transport, operators must often pay a user charge to an infrastructure manager. EU Regulation 2020/1429 allows and encourages governments to reduce, waive or defer charges for accessing rail infrastructure below direct costs. The objective of this measure is to support modal shift from road to rail. Several countries have used this possibility. For example, Germany reduced the rail-user charge by 98% in 2021 compared to the original charge and reserved EUR 410 million in its federal budget to make up for the revenue foregone from the lower user charges. Similar reductions or cancellations of rail-user charges have been implemented in Belgium and Austria. Deductions of rail-user charges can also stimulate reduction of negative externalities from freight rail transport. For example, in Hamburg (Germany) the operation of hybrid shunting locomotives is facilitated by a 50% exemption of rail infrastructure charges on the port railway network for hybrid and electric shunting locomotives (ITF, 2021).

As for heavy goods vehicles, there is a wide variety of countries with road charges. In Europe, the main framework in this respect is the Eurovignette Directive, in place since 1999. It defines how EU member states can charge heavy goods vehicles for the use of certain roads. EU member states are not required to levy road infrastructure charges, but if they introduce charges, member states have to respect the provisions of the Directive, in order to avoid distortion of competition between transport operators. A revised version of the Eurovignette Directive is currently under discussion. It aims to align the Directive with the European Green Deal by basing user charges for heavy goods vehicles on $CO_2$ emission standards. Current vignettes are planned to be phased out of the core TEN-T network as part of that revision.

As of 2016, seventeen EU countries applied distance-based road charges. Eight use physical barriers and nine apply an electronic network-wide scheme. In 2017, Slovenia switched to an electronic network-wide scheme as well. Additionally, Denmark, Luxembourg, the Netherlands and Sweden apply the Eurovignette for heavy goods vehicles above 12 tonnes, while Bulgaria, Latvia, Lithuania, Romania and the United Kingdom apply alternative vignettes for heavy goods vehicles (HGVs). In the European Union, only Finland applies neither road charging for trucks, nor a vignette. In most countries, charge levels are different between truck type and emission standard of the truck, reflecting the fact that these charges are often differentiated to vehicle weight and emission standard (Schroten et al., 2019). Various countries have urban congestion pricing schemes, but these are not specific for freight.

Several countries use exemptions from road tolls and charges as a policy instrument to reduce emissions from trucks. For example, trucks running on compressed natural gas (CNG) and liquefied natural gas (LNG) are exempted from the German toll system for trucks (known as LKW-Maut), the logic being to internalise the external costs of truck transport. This toll exemption was put in place in 2019 and was recently extended to 2023 (ITF, 2021).

## Reducing barriers to competition

Competition can help to improve service level and bring down costs. Various countries have attempted to increase competition by liberalising freight rail transport operations. The European Union has gradually opened the rail transport markets up to competition. An initial liberalisation package was adopted in 2001. Important elements in that package were the licensing of railway undertakings, the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification. That package was followed by a second one in 2004 that aimed to open up the rail freight market in the European Union. Its main instruments were the establishment of a European Railway Agency and directives on the interoperability of the trans-European high-speed and conventional rail system. A third package was adopted in 2007 focusing on the certification of train drivers operating locomotives and trains on the railway system in the community. A fourth railway package was adopted in 2016, designed to complete the single market for rail services (Single European Railway Area). As a result of these different packages, the rail freight market was opened to competition on 15 March 2003 on the trans-European rail freight network, then on 1 January 2006 for international freight and finally for rail cabotage from 1 January 2007.

There are also cabotage regulations in trucking. In the European Union. Provisions on cabotage are reflected in Regulation 1072/2009/EU, also called Mobility Package 1, that restricts the number of cabotage operations that each haulier is entitled to perform to three operations within a period of seven days, starting the day after the unloading of the international cargo. This restriction (three operations in seven days) was maintained in EU Regulation 2020/1055 that amended the 2009 regulation, but the 2020 regulation also introduced a cooling-off period of four days before more cabotage operations could be carried out within the same country with the same vehicle.

There are also other market restrictions related to road freight. In some countries, such as Austria, there are driving restrictions for trucks on weekends and public holidays, general bans on night driving for heavy goods vehicles, as well as specific local traffic bans for trucks. There are also restrictions on certain cargo categories transiting the country that cannot be transported by road but need to be transported by railways.

Short sea shipping is often subject to restrictive cabotage laws. Such laws prohibit coastal shipping by foreign-flagged ships, vessels with foreign staff, vessels that were not constructed in the country, or a combination of these restrictions. Such laws have had a very discouraging impact on SSS. Generally, the range of maritime cabotage regimes is wide, ranging from very restrictive in the United States and Japan to very liberal in New Zealand (Merk and Notteboom, 2015). The regime in the United States, regulated by the Jones Act, requires not only US-flagged vessels and US crews, but also that the vessel is built in the United States. Many countries are less restrictive and do not include the "built in" requirement. Although cabotage legislation is sensitive and difficult to reform, various countries liberalised their legislation. One of the more recent liberalisations was conducted in China in 2013, with the implementation of the Shanghai Pilot Free Trade Zone. Thanks to this measure, foreign-flagged vessels are now allowed to operate in cabotage between Shanghai and other domestic ports – provided that the owner of the vessel is Chinese (ITF, 2016).

In practice, many countries have exemptions to cabotage rules. For example, coastal shipping in Mexican waters is, as a general rule, reserved to Mexican shipowners with Mexican vessels, but if there are no Mexican-flagged vessels available, foreign flagged vessels may engage in cabotage trade under temporary cabotage permits granted by the Ministry of Communications and Transportation. These cabotage permits are granted for three-month periods and can be renewed seven times, with a maximum total of two years (OECD, 2017). Many countries have such exemptions, sometimes to the extent that the cabotage rules practically no longer apply. The European Union has cabotage regulation that applies to the entire intra-EU market (Box 1).

**Box 1. Maritime cabotage regulation in the European Union**

In 1993, the European Union liberalised coastal shipping for member states. The regulation allows providing maritime transport services within a Member State for Community ship-owners operating ships registered in an EU State and flying the flag of one of these States. Vessels must comply with all cabotage conditions in the host country, especially with the manning requirement for island cabotage. This reform was part of the regional integration process, aiming at completing the common market, and establishing a common maritime policy. It had to deal with different backgrounds on coastal shipping; Southern European countries like France, Italy, Spain and Greece were more protectionists, while Northern Europe and mainly the United Kingdom had a more open vision of cabotage. This is linked to countries having different needs for costal shipping, with the south being more dependent on cabotage for mainland/island passenger transport than the north.

Consequently, reluctance to a liberalisation of short sea shipping mainly came from Mediterranean seafarers. However, the European Union was able to overcome it, thanks to a gradual and consensual process. First, a legislative package opened the way to a common maritime policy in 1986. In 1992, the council regulation tackled the issue of cabotage and set a gradual phasing of the timetable for coastal shipping liberalisation, acknowledging the differences between the north and the south of Europe. Southern countries had until 1999 to open up their regular coastal passenger services, and Greece had until 2004. In addition, the process was flexible enough to adapt to certain demands of opponents; for example, one issue was that Mediterranean seafarers feared that the change from host-State to flag-State manning conditions on ships engaged in coastal shipping would distort the market. This was linked with the possible entrance of northern ship-owners, hiring low-paid foreign crew, hence jeopardising European seafarers' employment. The Commission heard this concern and a compromise was found; in the case of regular passenger services (island cabotage), all matters related to manning are the responsibility of the State in which the vessel is performing transport services.

Source: ITF (2016).

## Infrastructure

The possibilities for mode choice in freight transport are conditional on the availability of infrastructure. At the same time, government and private investors must weigh such investments in infrastructure against alternative uses of funds, space and political capital. Infrastructure policy frequently reflects such tradeoffs: it often consists of optimising existing infrastructure, identifying the missing links that limit the interconnection between different modal and nodal infrastructures. Investments in transport infrastructure could focus on resolving these missing links but could also be much more substantial in case of huge transport demand, obsolescence of existing infrastructure or in order to accelerate decarbonisation of transport. For example, large investments in charging stations or electric roads (Box 2) would be needed electrify road freight and coastal shipping, as well as alignment of private investments in vehicles and public or private investments in charging stations, which would also necessitate harmonised and common standards.

Infrastructure or superstructures are also frequently financed, designed and developed by private actors. Governments or public bodies can engage in public-private finance arrangements, such as leases and concessions. An essential part of such arrangements is the distribution of risks. If risks and benefits are not balanced among different stakeholders, projects might be challenging to realise, as illustrated by the case study on SSS in Canada.

### Box 2. Electric road systems

Electric road systems (ERS) enable a transfer of electricity between vehicles in-motion and the road transport infrastructure. They are wireless or conductive systems. The latter include roadside, inroad and overhead catenary arrangements. A number of demonstrative projects for wireless systems have been developed in France, Korea, Italy, Germany, Spain, Sweden and the United States.

Sweden has been the country that developed the most consistent set of demonstration projects on conductive systems, along with Germany and Japan (Bateman et al., 2018). These efforts drew positive conclusions on the capacity of these technologies to operate effectively. Overhead catenary technologies have been the most frequently considered and extensively tested ERS projects at highway speed or on high-capacity roads and developed in partnership with major truck manufacturers. Large-scale shuttle pilots for the overhead contact line solution were opened in Germany at a first test track in 2019 (BMU, 2019).

One of the core challenges for the development of technical standards to-date include the need to ensure interoperability. This would enable ERS to be developed by more than a single manufacturer. In addition, metering systems will be important to enable payments that account for the electricity consumed. ERS will also need adequate safety specifications.

ERS faces challenges regarding billing users but may take advantage of existing regulations for road tolling. It could use road tolling components, processes and structures (billing and metering on a kilometre basis would fit in the existing road tolling system) to enhance an energy premium once a metering system is developed.

Additional important areas for research are whether ERS should be assimilated to a power grid, a road infrastructure, or both. This has implications for the need to meet existing regulatory standards or require standards to be adapted to allow for the implementation of these novel technologies (Bateman et al., 2018).

Source: ITF (2020b).

### Modal infrastructures

Rail infrastructure is often a bottleneck to modal shift. The same rail infrastructure is often used for passenger and freight transport that obviously do not have the same requirements: passenger trains usually connect city-centres, not the most natural destinations for freight trains. Hence, freight train networks might require by-passes to avoid travelling through city-centres. Freight rail capacity is also dependent on how long freight trains are allowed to be. The longest freight trains can generally be found in North America. Longer trains could increase the operational efficiency of freight trains but would require adaptations of infrastructure on certain parts of the rail system. The European Union has developed criteria regarding the speed, length and weight of trains that operate on the TEN-T network. China has developed high-speed freight train services, which can be competitive on the market for mail and parcels. Rail infrastructure investments can also include traffic management systems, electrification of rail tracks and adaptations to facilitate larger and heavier trains.

Road freight transport is confronted with similar issues. Most road infrastructure is used for passenger and freight transport, and there are limited dedicated road-freight connections. One of the few connections are direct access roads to seaports – circumventing city centres – that are often more or less dedicated to truck traffic. Longer trucks could also help to optimise efficiency of the road network but might raise concerns on traffic safety that would need to be considered. Finland and Sweden have a long tradition in using 25.25 m and 60-tonne articulated vehicles, commonly referred to as long and heavy vehicles (LHVs), while other countries in Europe and North America mostly use 18.75 m and 44-tonne vehicles, commonly referred to as heavy goods vehicles (HGVs). Since 2013, Finland allows trucks of up to 76 tonnes on Finnish roads. On bridges and smaller roads, usage of such high capacity vehicles (HCVs) can be restricted with traffic signs, but otherwise HCVs can operate freely. After successful trials, in January 2019 the longest permitted truck length was extended to 34.50 m from the previous 25.25 m on all roads in Finland (Liimatainen et al., 2020).

The use of inland waterway transport is dependent on the navigability of the waterways. Frequent bottlenecks include insufficient depth, currents and sudden differences in water level. Navigability of waterways often requires canalisation, dredging and a system of locks to deal with water level differences. Regular investments to upgrade infrastructure include increasing locks and deepening of fairways.

Pipelines could also provide alternatives to freight transport. An extensive network of pipelines connects the petrochemical areas around the ports of Rotterdam and Antwerp. The Netherlands has set up a working group to assess the cost-efficient use of pipelines as part of further development of the national freight system.

### Nodal infrastructures

Seaports require regular upgrades to receive calls from ever-larger ships or new sorts of ships, e.g. those powered by alternative fuels or electricity. This could mean investments in stronger quay walls, larger turning basins, shore power, electric charging or alternative fuel bunkering facilities. The possibilities of modal shift in ports are radically increased if all possible transport modes are connected to the port. This could mean dedicated short sea terminals, barge terminals and on-dock rail. All three measures minimise additional handling costs, facilitate cargo consolidation and smoothen the intermodal process (Merk and Notteboom, 2015; Gonzalez-Aregal, Cullinane and Vierth, 2021).

Several countries have invested in intermodal facilities to transfer containers from road to rail transport. Belgium has invested in an intermodal facility in Genk as France has in Le Havre. In most cases, these investments cover infrastructure, but some schemes – e.g. in Poland – also subsidise purchase or modernisation of rolling stock. There are generally three main models for intermodal terminal development, depending on who develops and finances: the port authority, terminal operator or ocean carrier. In the first case, the seaport authority regularly invests in inland ports or terminals. In the case of development by terminal operator or carrier, the infrastructure will likely be privately owned; in case the government subsidises part of the facilities, it will generally require equal access provisions for all potential users. In some countries, there are enough intermodal facilities available, but the awareness of the opportunities offered by these facilities is limited. For that reason, Sweden has mapped the existing infrastructure to make the offer visible (Trafikverket, 2019).

Various countries invest in greening nodal infrastructures for freight transport. The Netherlands decided in 2020 to equip all public berths for inland waterway transport with shore power facilities. These facilities will make it possible for barges to switch off their engines at berth, which reduces emissions and noise.

## Integrated freight corridors

A special transport infrastructure that needs mention here is the dedicated freight corridor: a piece of infrastructure that will exclusively be used for freight transport. This can help to decrease transit times, as rail infrastructure is often shared between passenger and freight rail, but passenger transport often gets priority. A distinction can be made between short-range and long-range corridors. A well-known short-range corridor is the Alameda-corridor that connects the ports of Los Angeles and Long Beach to the inter-state railway network, providing for right of way and no interruptions of the freight train traffic within the metropolitan region of Los Angeles. A longer-range corridor is the Betuwe-line, dedicated to rail freight that connects the port of Rotterdam to the German hinterlands.

In Canada, a set of freight transport corridor projects are funded by the National Trade Corridors Fund (NTCF) as part of the Trade and Transportation Corridors Initiative, launched in 2017. This builds on an earlier National Policy Framework for Strategic Gateways and Trade Corridors that aimed at fostering development and optimisation of transportation infrastructure, operations, technology, regulation and policies for all modes (marine, road, rail, and air) that support freight and passenger flows of national significance. In order to strengthen and keep building a strong national transportation network the Canadian Government identified three Gateways and Trade Corridors based on the most strategic routes within the country. The creation of inland logistics platforms have taken place based on the National Policy Framework and the establishment of the three large infrastructure corridor investments.

One of the most ambitious freight rail corridor projects is the one formed by the Chinese Belt and Road Initiative (BRI) that includes a variety of dedicated Eurasian freight rail corridors. The European TEN-T corridor network also means to improve the connectivity of freight rail transport. The EU Regulation No 913/2010 initiated the establishment of a European rail network for competitive freight. It sets out rules for the selection, organisation and management of the freight corridors. The Regulation also required EU Member States to establish international market-oriented rail freight corridors in order to strengthen co-operation between infrastructure managers, finding the right balance between freight and passenger traffic and promoting intermodality between rail and other transport modes. An important role in the co-ordination of these rail freight corridors is played by RailNetEurope (RNE), a non-profit association whose members are rail infrastructure managers or allocation bodies. RNE facilitates co-ordination of timetables and rail freight corridors.

## Digitalisation

Intermodality requires the smooth interconnection between modes. In order to minimise time loss during this interconnection, information exchange between the different modal stakeholders is essential. This can avoid waiting times, congestion and missed connections. Some countries, e.g. the Netherlands, have a digital transport strategy to integrate various transport modes. Port community systems are arrangements for information exchange involving many stakeholders in the freight transport chain. Many ports, mostly in Europe, have initiated such port community systems, sometimes developed by port authorities themselves, sometimes outsourced to private service providers. In addition, shipping companies have developed similar initiatives aimed at improving digital information exchange along the freight transport chain, e.g. Tradelens. Other transport modes also benefit from information exchange platforms; e.g. the Swedish Transport Administration hosts a rail sector platform “Together for on-time trains” that aims at improving punctuality in the rail sector via digital collaboration.

As part of the emerging focus on information exchange, a growing number of port authorities are investing in performance dashboards that regularly update metrics on handling and waiting times for different transport modes (ships, trucks, trains) in the port. A notable example includes the performance monitoring in the port of Los Angeles. In Canada, the Vancouver Fraser Port Authority (VFPA), Transport Canada, the Prince Rupert Port Authority and other stakeholders collaborate in the “West Coast Supply Chain Visibility Program”, which aims at increasing the visibility of the supply chain via operational planning and optimisation tools. An example is the supply chain visibility dashboard tool, which leverages rail and port terminal activity information and produces key performance metrics for industry participants. This Supply Chain Visibility Program builds on a successful pilot project launched in 2018 that developed a near real-time dashboard for grain, coal and fertiliser shipments handled through rail and bulk terminals.

## Innovation policies

Policies to stimulate innovation in transport can help to accelerate modal shift or the objectives underlying modal shifts, such as better environmental sustainability. Besides generic support for research institutes and R&D incentives for companies, many countries support applied transport research bodies and innovation programmes focused on transport. Co-operation between industry, research and government could set the agenda for the innovations to support and implement, e.g. in rail freight transport where more business innovation could help to increase its attractiveness to customers. Government interventions are often also needed to create markets or support transitions to new market equilibriums, within the perspective of decarbonisation, for example.

An example of an area where government interventions have supported transitions is electrification of coastal shipping in Norway, where a subsidy programme of the government agency Enova has managed to stimulate electrification of 75 coastal vessels and the installation of electric charging systems in 60 seaports, within the period of five years, described in more detail in Box 3. Sweden has developed various pilot projects to assess the viability of electric road systems, i.e. roads that can charge trucks whilst they drive, as a possible alternative for electrification of trucks. Another example is the German scheme to support uptake of light and heavy commercial vehicles with alternative, climate-friendly propulsion systems. This grant scheme with a total budget of EUR 507.5 million offers aid to companies that want to acquire electrical, plug-in hybrid or hydrogen/cell-fuelled vehicles, charging facilities for electric vehicles, and the environmental studies carried out related to these acquisitions (EC, 2021).

**Box 3. Roll-out of electric charging systems for electric ships in Norway**

In Norway, battery installation on ships and shore power projects in ports are all funded with the goal of greening maritime transport. The agency Enova, allocated NOK 2.7 billion (EUR 270.0 million) for the transport sector between 2017-19. By the end of 2019, Enova had allocated more than NOK 500 million (EUR 49.6 million) for battery installation and other energy efficiency measures in about 75 vessels, along with a small number of fully electric vessels. In terms of funding commitments, Enova has awarded more than NOK 900 million (EUR 89.2 million) for the electrification of 39 ferry connections with 52 associated ferries. Between 2015 and 2019, it supported 89 onshore power projects in more than 60 Norwegian ports with more than NOK 600 million (EUR 59.5 million).

Source: ITF (2020).

Interventions to stimulate alternative transport modes could also focus on information provision and brokerage activities. Information provision on rail and inland waterways can be promoted via subsidies. Brokerage activities are used in the Netherlands where logistics brokers advise companies on the use of alternative transport modes; they actively look for companies that could consolidate cargo flows, in order to facilitate transport by rail and inland waterways. Many EU countries also have Short Sea Promotion Centres that aim to contribute to a modal shift by providing information about SSS. The Short Sea Promotion Centres in Europe are connected in the European Shortsea Network, which acts as a platform for exchanging ideas and as a main information source on SSS. Various countries, such as Mexico and Chile, have also recently invested in the development of logistics observatories (ITF, 2016).

## Which policies have been effective?

Meaningful evaluation of modal choice policies in freight transport is lacking. Governments deploy many policies, most of which have never been evaluated: a recent study identified ninety-three relevant policy measures, but only twenty evaluations (Takman and Gonzalez-Aregall, 2021).

Most of the existing evaluations do not contain quantifications of effects therefore it is difficult to assess if policy measures have been effective. Evaluations lack quantification because many policy instruments have broad, general and unclear targets, which make it difficult to measure to what extent objectives have been reached. Several evaluations focus only on the modal shift achieved, and do not evaluate the effect on negative externalities. Notably, some large EU programmes lack specific targets and key performance indicators – and thus meaningful evaluations. The evaluation of the Connecting Europe Facility (CEF) does not quantify any effects on modal shift or externalities, due to a lack of clearly defined key performance indicators and targets (Takman and Gonzalez-Aregall, 2021). The EU Regulation No 913/2010 concerning a European rail network for competitive freight aims to improve the efficiency of rail freight transport relative to other modes of transport, but its evaluation does not specifically evaluate the policy in terms of modal shift. The EU Motorways of the Sea policy has unclear overall goals and objectives, which makes it difficult to evaluate the policy quantitatively (ICF, TRT and ISL, 2017).

Various national programmes have been evaluated positively. This can be illustrated by a positive ratio between benefits and costs of the programme. The benefits are the savings on external costs, e.g. less costs related to air pollution, GHG emissions, congestion or accidents. These cost savings (or benefits) can be related to the cost of the programme. Several national measures – as well as the EU Marco Polo II programme – managed to generate positive benefit/cost-ratios (Table 8). Several subsidy schemes for modal shift to freight rail have been effective in achieving modal shifts, according to their evaluations, e.g. in the United Kingdom and Austria. The Italian Ecobonus scheme, which aims to promote a modal shift to SSS, has been evaluated as effective also because of the simplicity of the programme and the user-friendly approach.

Table 8. Benefit/cost-ratio of modal shift instruments

<table>
<tr><th>Programme</th><th>Favoured mode</th><th>Subsidy amount (EUR million)</th><th>Benefit ratio for every unit of subsidy spent</th><th>Evaluation study</th></tr>
<tr><td>Marco Polo II (European Union)</td><td>Short sea shipping</td><td>435</td><td>2.9-3.1</td><td>INEA (2020)</td></tr>
<tr><td>Mode Shift Revenue Support (United Kingdom)</td><td>Rail or inland water transport</td><td rowspan="2">GBP 89</td><td>4.27 (inland water transport)</td><td>DfT (2014)</td></tr>
<tr><td>Waterborne Freight Grant (United Kingdom)</td><td>Short sea shipping</td><td>4.66</td><td>DfT (2014)</td></tr>
<tr><td>Rail subsidy Emilia Romagna (Italy)</td><td>Rail</td><td>1.9</td><td>8</td><td>EC (2019)</td></tr>
<tr><td>Ecobonus (Italy)</td><td>Short sea shipping</td><td>240</td><td>5.81</td><td>Ram S.p.a (2019)</td></tr>
<tr><td>Rail subsidy Austria</td><td>Rail</td><td>1 118</td><td>3.39-3.41</td><td>EC (2017)</td></tr>
</table>

Several evaluations of EU-policy instruments describe a poor or a mixed performance. The Marco Polo I programme was qualified as ineffective by Europe Economics (2011) and the European Court of Auditors (ECA, 2013), pointing out that only 46% of the expected modal shift was achieved and that several of the funded projects would have taken place without support from the scheme. However, the European Commission considers that the modal shift under the Marco Polo Programmes is substantial and that the perception of underachievement is caused by the fact that the objectives were very ambitious. In another report the European Court of Auditors is critical of the NAIADES programme, observing that the policy objective of shifting freight transport from roads to inland waterway transport has not been achieved and overall navigability conditions have not improved (ECA, 2015).

Many subsidy schemes of freight transport operations only have temporary effects. According to the evaluation report of the UK Mode Shift Revenue Support scheme, the most likely outcome of withdrawing the grant would be that cargo flows, transported by rail or inland waterways, would shift back to road or simply not take place (DfT, 2020). The evaluation of the Italian Ecobonus programme highlighted the risk that subsidies and grants to the users of transport services may be followed by price increases in tariffs. The end of the Italian Ferrobonus aid scheme coincided with a decrease in rail freight operations but had recovered by the time of a new provision of the incentive during 2015 (Marzano et al., 2018).

Some measures have been problematic because they were not aligned with demand. Many services developed in a Swedish measure under the EU Motorways of the Sea-programme were not based on an assessment of user need. The implication was that many of the services could not be commercialised (Dahlman, 2019 as quoted in Björk and Vierth 2021). The 2013 evaluation of the Marco Polo programmes I and II by the European Court of Auditors pointed out that there was no *ex-ante* market analysis on the reasons for the lack of multimodal transport, which meant that the programme's effectiveness in removing barriers for a modal shift was limited (ECA, 2013).

Schemes have sometimes also been observed to support operations that have taken place (or would likely have taken place) without the subsidies. The Swedish Miljökompensation scheme to transfer goods from road to rail is paid retroactively and has been criticised for the fact that approximately 22% of the total funds in 2018 and 2019 went to the LKAB mining company for ore transports, where rail already is the dominating transport mode and where limited competition from road transport exists (Takman and Gonzalez-Aregall, 2021).

There is, however, some evidence for the effectiveness of pricing mechanisms. Part of the modal shift from road to rail in Germany and Austria could be related to the road pricing system in both countries. However, the evaluation study indicates that it is difficult to prove the causality between the modal shift and the introduction of the tolls and to isolate the effects from other policy instruments and effects on the transport sector. According to the evaluation, distance-based toll systems are more efficient than time-based vignettes as they can internalise the external costs in a more efficient way, via the user pays principle. It is also noted that the wide range of charging systems in the member states and the wide range of technologies applied within the systems impose unnecessarily high administrative costs to haulers (EC, 2013).

# Future-proofing freight mode policies

What are the current and future developments to consider when thinking about mode choice policies? This chapter highlights some technical and organisational developments, and the possibility of more disruptive events. It examines possible policy implications based on this overview.

## Technological developments

Technological innovations in transport vehicle propulsion will impact the perceived need for modal shifts. Policies on mode choice are based on certain assumptions of the environmental impacts of each transport mode and how these will change in the future due to innovations related to propulsion.

Trucking, the transport mode that produces the highest external costs could decrease these with technological developments. One well-documented measure that does not require any further technological innovation is to allow heavier and longer trucks (Christides et al., 2009 but it raises road safety concerns that would need to be addressed. Trucks in various countries have reduced their GHG emissions by switching to sustainable biofuels and compressed natural gas (CNG). Electrification of trucks (or roads) is also rapidly advancing. Currently, electric trucks are developing in the smaller segments (up to 7.5 tonnes), but the expectation is that in a few years 44-tonne trucks will also be electrified. Tesla has announced the production of electric long-haul trucks, but these are not commercially available yet. Some operators also expect to see hydrogen-powered trucks, whereas bio-fuels and gas are considered to be transition fuels (ITF, 2021).

Rail transport already has a low carbon footprint. This is likely to decrease even further with the phasing out of diesel locomotives and the roll-out of electrification of railways in many countries – provided that electricity comes from renewable sources. In countries where railways are electrified, the main emissions from rail freight transport operations come from the so-called last mile, both in ports and the inland rail terminals. The locomotives used for long-range transport are not able to operate on the non-electrified last mile, and they must be separated from the wagons after arrival within the port area. In the port, shunting locomotives with separate drivers take over, couple to wagons and push them into the port terminals. Most shunting locomotives are diesel electric or diesel hydraulic locomotives as they need to operate independently from the overhead voltage or on non-electrified tracks. The main obstacle related to zero-carbon shunting locomotives is the market size. For the moment, manufacturers can only realise limited economies of scale, as the market for hybrid-shunting locomotives is small but there are generally no limitations related to technology: battery autonomy is going up and fully electric shunting locomotives are technically possible, as illustrated in the rail terminal in Warstein in Germany (ITF, 2021).

Short sea shipping (SSS) can decarbonise with existing technologies, in particular via electrification. Short sea shipping takes place over smaller distances, usually in regular patterns, which means that it is relatively easy to electrify. Norway has shown that it is possible to electrify ferries on a relatively massive scale: there are currently 39 electric ferries in operation, with 19 more to be planned operational in 2021 and 27 more after 2021 (ITF, 2020a). This has been achieved by subsidies from the government for charging systems in ports and for electrification of vessels. However, Norway is an exception for the moment and the move towards zero-carbon coastal shipping is much slower in most other countries.

The development of alternative fuels – such as green hydrogen, methanol and ammonia – have increased the prospects of decarbonisation of all transport modes, but differences between modes might lead to different deployment trajectories. For governments that consider mode shift to be a viable strategy for reducing greenhouse gas emissions, certain scenarios might make discussions about modal shift superfluous. – For example that all road transport is zero-carbon before rail and sea transport. Such a scenario is likely considering the much lower average lifespan of trucks in comparison to ships and rail locomotives. For this reason, it can be expected that the decarbonisation of road freight transport will take place at a faster pace than in railway transport and coastal shipping.

In some countries, this is already the reality. In Sweden, heavy trucks are the only freight transport mode that has reduced its GHG emissions between 2010-18 at a rate in line with the Swedish climate target. This consists of a reduction target of 70% within the transport sector by 2030 (Takman, Trosvik and Vierth, 2020). In such a scenario, generic modal shift policies are no longer effective instruments for emission reductions, as they could lead to a shift away from the mode that performs best in reducing emissions. A recent study on mode choice in freight transport in Sweden modelled possible GHG emissions and air pollution from modal shift policies in the future and concluded that by 2040 modal shift policies might result in net increases in GHG emissions instead of the decreases that modal shift policies aim at (Johansson, Vierth, and Holmgren, 2021).

Automation and digitalisation could lead to reduction of the costs of road transport, by reducing wage costs of drivers. Automated trucks are technically possible and already applied in various seaports. It is likely that trucks with some form of automation will be deployed in the coming years. As such, these technological developments could reverse the effect that regulations of truck drivers and rest times (such as the EU mobility package EU 2020/1054) and a shortage of drivers have on pushing up the costs of road freight transport. Automated ships and trains are also being discussed – and tested in some countries – but likely to take more time to implement than automated trucks. Automated vehicles could also increase transport safety.

At the same, many of these technologies could have an impact on the costs of the different freight transport modes. For the moment, automated, electrified and zero-carbon vehicles are generally more expensive, but the production costs could decline as technology advances and uptake increases, so that economies in scale could be realised. This can have different impacts: overall freight transport costs could increase, which – depending on the demand elasticities – might affect transport volumes. The cost developments could also be different according to transport mode, which means that the relative cost attractiveness of freight transport modes could evolve over time.

## Organisational developments

Technical innovations, like digitalisation, have given rise to new business models, such as e-commerce, the physical internet, internet of things, freight transport platforms and increasing integration of LSP and carriers. These developments can have mixed effects on mode choice in freight transport. On the one hand they could improve the visibility and co-ordination between different stakeholders and as such improve the effectiveness of intermodal transport. Growth in e-commerce has also resulted in increased warehousing close to urban centres, which provides the volumes required for intermodal transport. On the other hand, e-commerce and the reverse logistics related to it, have in practice probably resulted in an increase of transport over road. The increased application of artificial intelligence (AI) in supply chain management also requires greater scrutiny of economic power in algorithm-based governance arrangements.

Long-range train transport has received substantial impetus from China's Belt and Road Initiative (BRI) that has provided the title for huge investment in Asia-Europe rail corridors. Although not aimed at achieving mode shifts, it has increased the business case for long-range rail freight transport. The BRI has likely shifted some air cargo to rail but its effect on ocean cargo has so far been limited. However, this might change given the drastic increase of ocean freight rates since the Covid-19 crisis that have made intercontinental rail rates more competitive than ocean transport rates. The high visibility of the BRI has also resulted in the emergence and revival of competing long-range corridor development.

## Disruptive events

Extreme weather events have become more frequent. Human-induced climate change is affecting many weather and climate extremes in every region across the globe. These include heatwaves, heavy precipitation, droughts, and tropical cyclones that have all occurred more frequently over the last years. Human influence has likely increased the chance of compound extreme events since the 1950s. Compound extreme events are the combination of multiple drivers and/or hazards that contribute to societal or environmental risk. Examples are concurrent heatwaves and droughts, compound flooding (e.g., a storm surge in combination with extreme rainfall and/or river flow), compound fire weather conditions (i.e., a combination of hot, dry, and windy conditions), or concurrent extremes at different locations.

Extreme weather events are predicted to increase over the coming years. For example, due to relative sea level rise, extreme sea level events that occurred once per century in the recent past are projected to occur at least annually at more than half of all tide gauge locations by 2100. In coastal cities, the combination of more frequent extreme sea level events – due to sea level rise and storm surge – and extreme rainfall or river flow events will make flooding more probable (IPCC, 2021).

Such events will disrupt supply chains. Droughts could make rivers and inter-ocean canals unnavigable, as do extreme precipitation and river flow events. Storm surges, floodings and tsunamis will affect ports and require fall-back options for transport chains. Extreme weather events in general will likely increase the damage to transport infrastructure. Heat affects transportation infrastructure by warping roads and airport runways or buckling railways, and high temperatures reduce air density leading to aircraft take-off weight restrictions. Important transportation routes are threatened when floods exceed design standards commonly based around flood magnitudes of a given historic return period (e.g., 1-in-100 year flood events). Landslides, mudslides, rock falls, and other mass movements could block critical transportation routes. Tropical cyclones, severe coastal storms, sand and dust storms could severely damage transport infrastructure. Frequent inundation by salt water can also have significant impacts on transportation systems due to corrosion and undercutting of coastal roads, bridges, and rails (IPCC, 2021).

Covid-19 has shown the vulnerability of global transport chains. The changes in demand for freight transport, due to the lockdowns in many countries, in combination with the adaptations of transport supply by transport companies (in particular container shipping) have resulted in a disruption of supply chains, as illustrated by extremely low schedule reliability of liner shipping companies, long ship waiting times in ports, limited availability of containers and shipping prices that are seven- to ten-times higher than prior to the emergence of Covid-19. This disruption has affected places with limited spare capacity for, or alternative, transport options. It is not yet clear which, if any, of these impacts will be long lasting.

Disruptive events underline the importance of resilience and robustness in supply chains. Resilience is defined here as the possibility to bounce back and the possibility to use alternative networks and services during disruption. Robustness refers to the avoidance of direct and indirect economic losses of a transport network, which is defined as the degree to which the transportation network can function in the presence of various capacity disruptions on transport elements. An example is the port system in Chile that has multiple ports in the same bays but they differently exposed to the wind and currents to make sure that there is still effective port capacity in case a tsunami strikes one regional port. Extreme weather events could also facilitate the use of certain transport modes.

In a similar way, multimodality and an effective choice in freight transport modes could help to keep transport systems accessible. This combination could provide for more alternative options in case part of the freight transport system is disrupted. The robustness of the multimodal transport system is dependent on the interconnections and interdependencies in the system. Intermodal transport allows switching among different modes of transport at transloading terminals. At a transloading terminal two or more modalities are interconnected. If such terminals are disrupted, the freight cannot switch to a different mode of transport. Interdependency refers to situations where the three main inland freight transport modalities (waterway, road and rail) cross each other. At each crossing, a civil engineering structure is needed, e.g. bridge, tunnel, railway crossing, to efficiently use both modalities. Thus, the disruption of a single civil engineering structure (for example a bridge) can affect multiple modalities (road and waterways). This causes the interdependency between the modalities. The relation of interdependency between these two nodes implies that if either node is disrupted, the other node will be disrupted as well. An assessment of the robustness of the Dutch freight transport network showed that the degradation capacity of roads could exert a disastrous growth of the total travel time, while shifting more loads to the inland waterways could decrease the total travel time (He et al., 2021).

## Policy implications

The developments highlighted above will have mixed effects on the attractiveness of different freight transport modes. Within the road freight sector automation could eventually help to improve safety and relieve driver shortages, whilst electrification could improve its environmental performance. At the same time, growth of road freight transport will not help to alleviate congestion. Within the rail sector, electrification is already well advanced and further electrification will help to sustain its position of providing low emission, energy efficient freight transport. In the meantime, governments could support more business innovation in rail freight transport to increase its attractiveness to customers, i.e. the companies that need to ship cargo. Modal shifts to waterborne transport could help to decongest road and rail infrastructures but might decrease environmental performance if decarbonisation of this mode is not accelerated. Shifting liquid bulk transport to pipelines could mean additional infrastructure costs, but reduced safety risks. Digitalisation could help to build multimodal logistics chains if rail and SSS can develop services and products that meet customer requirements. In other words, the outlook for each mode is context-specific. This would suggest a need for integrated policy approaches, developing specific rather than generic mode shift policies, improving evaluations and stimulating fair competition between the transport modes.

### Apply integrated policy approaches

Modal shift is challenging. All elements of the multimodal chain must be aligned to achieve objectives and realise targets. This requires co-ordination and co-operation. The potential of different freight transport modes is highly dependent on local specificities, such as commodities, shipment sizes, local market conditions and geography. A way to take these specificities into account is via tailor-made corridor and networked approaches. An example of such a corridor approach is described in the case study on the freight corridor approach in the Netherlands, further on in the report. The elaboration of such corridors and networks makes it possible to stimulate an appropriate multimodal freight transport offering, with complementarities and interoperability between different modes.

The effectiveness of policy measures is largely dependent on the alignment of strategies of different tiers of government and their instruments, including non-transport measures such as spatial planning. It requires coherent intervention across modes concerning infrastructure investment, taxation, subsidies, regulation support for innovation, standards for data, and information exchange to stimulate more informed modal choices. Such integrated policy approaches – underlined in the case studies of both China and Canada – are necessary to avoid situations of conflicting incentives, contradictory policy measures or isolated measures that risk being ineffective. An example of inter-agency co-operation is the implementation scheme to promote multimodal transport in Jiangsu province, jointly issued by the provincial financial department and 23 other provincial departments, as described in the case study further on in this report.

## Specific objectives rather than modal shift as a primary goal

Modal shift targets could be considered both a political objective and a policy means. According to Björk and Vierth (2021) this could be problematic for two reasons: it might constrain political flexibility, and it might complicate efforts to evaluate the effectiveness of policy measures. The underlying reason for this is that modal shift targets rely on assumptions of relative environmental performance between transport modes. However, as indicated earlier in this report, the average environmental performance cannot be generalised; in many cases it depends on local circumstances. External costs are not automatically lower for waterborne transports than for road. Political flexibility is clearly constrained when a modal shift target needs to be achieved irrespective of the effects on negative externalities.

Therefore, it is important that modal shift is treated as a means to reduce negative external costs, rather than as a primary goal in itself when policy instruments are designed and evaluated. Modal shifts might in certain cases be desirable, but they should be considered one of several instruments towards achieving government objectives related to safety, environmental performance, health concerns and congestion (Björk and Vierth, 2021). So, for example, the focus in Sweden is on improving transport efficiency in all modes, as well as intermodal solutions.

Modal shift policies could also lead to silo-thinking. Freight transport policy measures are highly compartmentalised, with many mode-specific policy measures, e.g. different programmes to stimulate rail freight, inland waterway transport or coastal shipping. Mode-specific policies can be justified if they help to address mode-specific barriers, but only if it targets specific objectives rather than simply high aspirational goals.

Instead of targeting modal shift and assuming it will achieve objectives such as emissions reductions, alleviation of congestion and reduced safety risks, governments should formulate more direct objectives for what policies should achieve. These achievements could, for example, take the form of a specified reduction of emissions from freight transport, and develop measures to achieve these. A specific and differentiated approach to freight transport modes could increase policy effectiveness. It will formulate specific objectives to be achieved with specific instruments within a determined area and period, rather than generic instruments that are deployed without taking local specificities into account. For example, the Dutch corridor-approach, as described in a case study in this report, formulates the modal split potential per transport corridor.

## Improve evaluation of the interventions to influence mode choice

Despite a large amount of policy instruments on mode choice in freight transport, there is only a limited number of instruments that have been properly evaluated. The urgency to mitigate GHG emissions and other external costs, such as air pollution, congestion and safety risks highly increase the relevance of good policy evaluations on freight transport policies. Digital technologies could provide tools for better monitoring of policies, provided that policy makers stress the importance of strengthening policy-relevant data collection and define policies in such a way that they can be evaluated quantitatively.

This starts with clear objectives of policy measures, performance indicators and an evaluation not only on whether modal shift has been achieved, but also on which benefits this has generated in terms of emission reductions, increased safety, accessibility and resilience of the freight transport system. Such evaluations should be publicly available, so that policy makers across countries can learn which policies have worked or have not worked elsewhere. Policy makers could also move beyond periodic evaluations and insist on regular monitoring of policy measures, so that policy adaptations can be made. Very frequent monitoring of freight movements from ports is taking place in Los Angeles and Vancouver (Canada). Despite the need for regular adaptations, continuity in policy measures is important for ensuring stability for shippers and carriers.

### Create fair competition between freight transport modes

Governments should maintain a framework for fair competition between freight transport modes and work to reduce market and government failures. Climate impacts, air pollution and crash risks are external to the market and require fiscal or regulatory intervention to contain them. Governments deploy a large variety of instruments to influence the mode choice in freight transport. Policy interventions can be motivated by the ambition to create a level playing field between modes, but they are often also necessary because of previous policy interventions that created distortions to that competition. For example, many modal shift policies are attempting to address distortions in costs of transport modes caused by fossil subsidies. This is the case when countries subsidise freight rail operations and at the same time provide fuel tax exemptions for road freight. These contradictions need to be addressed. Establishing a coherent framework for inter-modal competition in would help progression toward a multimodal transport system in which all transport modes play a role according to where they perform best in terms of efficiency, environmental sustainability and safety.

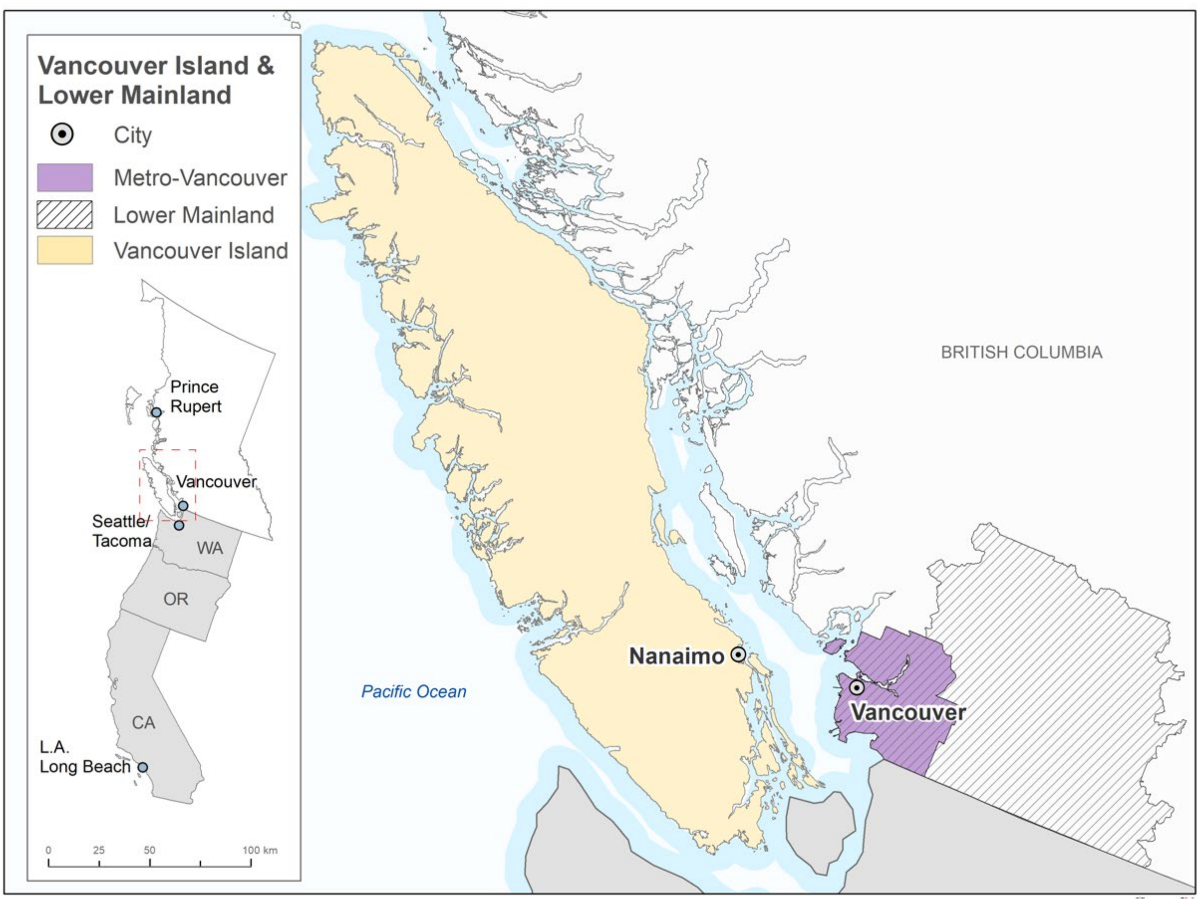
The need to decarbonise freight transport would require phasing-out fossil subsidies and make sure external costs of freight transport are better reflected in their costs. An example of the limited internalisation of external effects is evident from the toll tariffs that the road freight transport sector pays in many countries: truck toll payments often do not cover the damage caused by the trucks in terms of road deterioration for which maintenance costs are incurred.

# Case study: Short sea shipping in the lower mainland of British Columbia

Short sea shipping (SSS) is defined as the movement of cargo by water over relatively short distances, excluding trans-oceanic voyages. In the North American context, SSS is mostly used for domestic cargo movements but can also be used for cross-border movements.

This case study will focus on SSS for container movements[1] in Metro Vancouver and the Lower Mainland of British Columbia, Canada (Figure 10). Regional gateway stakeholders expressed a great interest in SSS initiatives as a modal choice alternative to regional drayage since the mid-2000s. During this period a number of smaller-scale public and private sector SSS projects have not succeeded for a variety of reasons. Most recently, however, a small-scale service that was initiated in early 2021 appears to be sustainable and have prospects for growth. Concurrently, there is an ongoing public and private sector interest in creating an environment to enable a sustainable large scale SSS within Metro Vancouver. This case study will explore the past and current SSS initiatives in the Lower Mainland and the lessons learned.

Figure 10. The Vancouver region

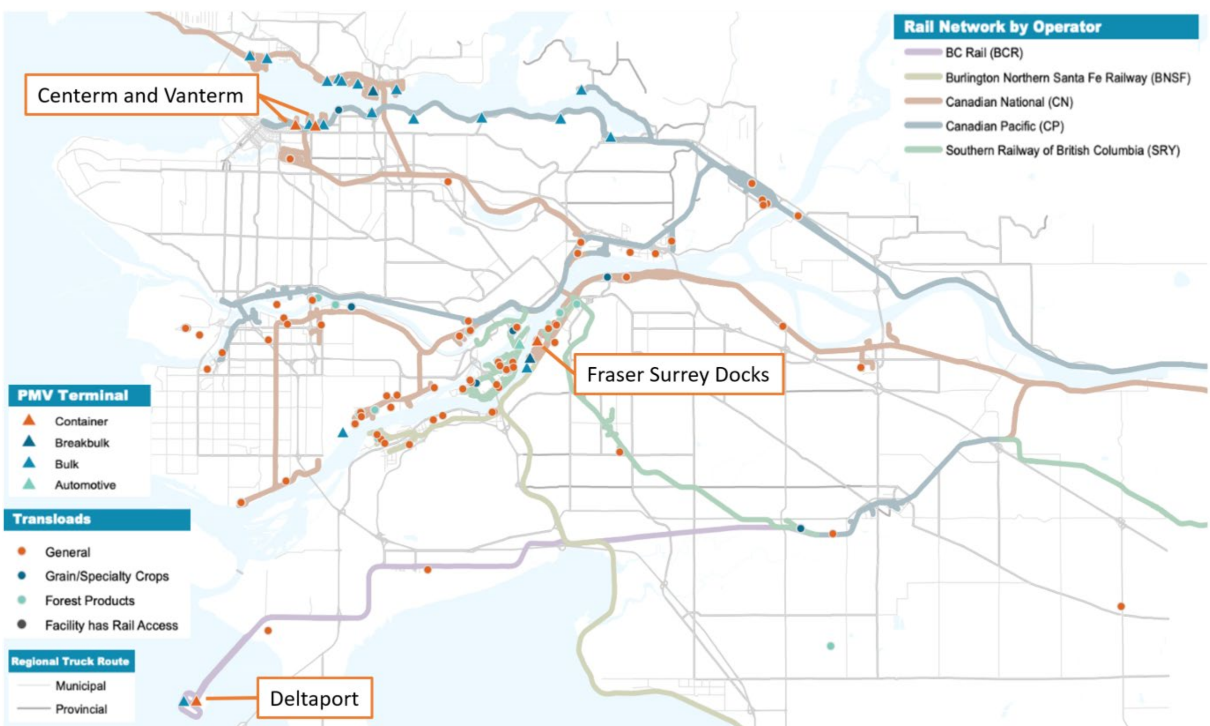



Source: Statistics Canada Census Divisions, U.S. Census Cartographic Boundary File

The Port of Vancouver is Canada's largest and most diverse port, which handled 145 million metric tonnes of cargo in 2020. This included 3.5 million TEUs (40% of national port cargo volumes). In the Port of Vancouver, import containers are generally handled through two main transloading[2] activities: (i) roughly two-thirds of import-laden containers are transported directly by rail to other parts of Canada or to the mid-west United States (ii) roughly the remaining one third of import-laden containers are handled in Metro Vancouver by truck for the purposes of transloading or local market. Export activity is roughly the inverse, with most of the export transloading undertaken within larger gateway industrial complexes in metro Vancouver.

The Port of Vancouver is located in a rapidly growing and densifying urban area, with population forecast to grow from 2.5 million to 3.5 million by 2050. The port has four container terminals located in different parts of the city: Centerm and Vanterm terminals are located on the northern part of the city of Vancouver; Fraser Surrey Docks is located along the Fraser River; and Deltaport is in the southern part of the city (see Figure 11). A complex web of trucking activity links the four marine terminals with off-dock import and export transloads in the larger gateway industrial complex.

Figure 11. The Vancouver Gateway




Source: Applied Freight Research Initiative: Freight GIS (F-GIS) (2020).

The Vancouver gateway's activity extends well beyond the waterfront and is heavily dependent on trucking (Figure 11). Goods, equipment (e.g. chassis), containers and information are exchanged through a complex network of interlocking players in the Port of Vancouver's industrial complex. The main players involved in the movement of cargo in the Lower Mainland are: the four container terminals, the shipping lines, the drayage companies, the railway operators, barge operators, transloaders, the beneficial cargo owners (BCOs) and many other logistical providers.

It is important to note that significant transloading activity happen along the southern arm of the Fraser River, which implies that most containers leaving the Centerm and Vanterm terminals have to navigate through the busy metropolis to be transloaded.

## Why is modal shift considered in the Lower Mainland?

The Port of Vancouver forecasts a 50% increase in container traffic over the next decade. However, there are some strategic issues that could inhibit this growth including terminal capacity, scarcity of industrial land and increasing constraints on trucking. At a more granular level, the gateway industry and the public sector also have specific concerns regarding the limitations of drayage trucking to support this future growth:

Table 9. Industry and public policy concerns related to freight transport in the Vancouver region

| Industry concerns | Public policy concerns |
|---|---|
| Disruptions: labour instability due to multiple work stoppages in the last decade | Environment: particulate matter, criteria pollutants, GHG emissions |
| Cost: Higher costs due to an increasingly regulated industry* | Quality of life for communities: air quality and health impacts, noise and vibration resulting from trucking |
| Access: constrained truck access to terminals especially for exports | Commuter network: congestion, road safety |
| Reliability: congestion on transportation network increases cost and reduces reliability | Cost: cost of capital investment, road wear |

Note: * In British Columbia, there are currently legislated rates for trucking, i.e. British Columbia’s truck commissioner has the authority to set trucking rates and fuel surcharges.

SSS offers the prospect to help mitigate these industry and public policy concerns. It can also allay specific trucking industry challenges by adding redundancies within the network; by offering more reliability for the movement of cargo; by reducing dependency on trucking and by optimising the use of existing infrastructure to enable a more efficient and competitive trade gateway. For all these reasons, regional gateway stakeholders have been interested in the potential of SSS since the mid-2000s. Despite this, SSS only operates at a small scale today in the Vancouver Metro area.

## Past concept development for short sea shipping

Public and private sector efforts to adopt SSS in Metro Vancouver have been slow and hindered by a number of internal and external factors. Below are two specific examples from past years that inform the current approach to develop a SSS concept.

### 2007-10: Government-led industry consultation and funding

In 2007-08, the Vancouver Fraser Port Authority (VFPA) and Transport Canada worked on a vision for the delivery of a SSS network in the Lower Mainland and surrounding areas.

In September 2008, the federal government agreed to invest up to CAD 20.9 million in five SSS projects in the Lower Mainland and surrounding area under the Asia-Pacific Gateway and Corridor Initiative

Transportation Infrastructure Fund (APGCI TIF). This was an open bidding process, where individual actors in the Gateway industrial complex secured government commitments for capital funding. However, none of these projects were delivered due to a variety of external and internal factors:

- *Internal factors:* There was a lack of acknowledgement of the complex network of stakeholders involved in the implementation of a SSS initiative. The funded projects focused on one actor in a very complex system – and this one actor was expected to take the primary financial risk while the potential benefits were dispersed among multiple actors. The SSS proposal was treated as a simple funding programme and failed to build all the necessary relations with all the players involved.
- *External factors:* Multiple external factors were unfavourable to the implementation of a SSS initiative. First, the 2008 economic recession made many investors risk averse. Indeed, many companies decided to redirect their internal priorities and to withdraw their SSS investment. Second, the cost of unionised labour was high and cost prohibitive. Finally, at that time, the differences in costs of SSS and the costs of regional trucking was marginal.

### 2014: Private initiative for a barge service

In 2014, a private initiative was started for a barge service between an off-dock terminal and a downtown marine terminal. It was intended to be a small-scale system connecting parties, but the initiative was never implemented.

- *Internal factors*: The initiative failed primarily because of a dispute between labour unions.
- *External factors*: The cost differential between SSS and trucking was still marginal.

What has changed since 2008 and 2021?

A number of internal and external factors since 2008 are driving the need for alternative constructs to move goods through the Port of Vancouver industrial complex, suggesting there is opportunity to continue developing a SSS concept in the Lower Mainland. Here are a few:

Table 10. External and internal factors that might drive short sea shipping in the Vancouver region

| External factors | Internal factors |
|---|---|
| 1. Growth in container trade<br>Over the last decade, container traffic has increased by 40%. Forecasts suggest an increase in traffic of 50% in the next decade.<br>The current construct for gateway operations is stressed, creating opportunity for new gateway traffic patterns such as SSS. | 1. Trucking Regulatory<br>After a work stoppage in 2014, a more rigidly structured regime for drayage was created[3] that included a regulatory and oversight role for the provincial government. This regulated system has led to convergence of the cost of trucking versus SSS. |
| 2. Demographic forecasts<br>An additional 1 million people will live in the Lower Mainland by 2050 (40% increase).<br>This will be accompanied by increased road congestion in urban centres, with commensurate effect on trucking. | 2. Gateway users seeking alternatives<br>Significant disruptions have hindered container movement in the past years: 2014 truck work stoppage, 2020 rail blockades, Covid-19 surge in demand and 2021 wildfires. |

| External factors | Internal factors |
|---|---|
| 3. Limited industrial land<br><br>The metropolitan area of Greater Vancouver had an industrial land vacancy rate of only 0.7% in Q1 of 2021, the lowest rate of North America, and limited land to further support off-dock container activity.<br><br>SSS can give access to industrial land and create opportunities for partnerships. | 3. Receptiveness to innovation and technology<br><br>Arrival of a marine terminal operator that is supportive of SSS and has multiple properties in Metro Vancouver.<br><br>Increasing acceptance of semi automation. |

## Current initiatives

Given the changes since 2008, highlighted in Table 10, efforts have been made to study and deliver a SSS system in Metro Vancouver. In 2017-18, Transport Canada led a scoping study which included a jurisdictional scan of successful operations; the examination of possible models and of their viability; and a review of stakeholder interest. The outcome of this study suggested that SSS would be cost comparable to existing transport options and potentially viable in the long term.

As a follow-up to the 2018 study, Transport Canada and the Port of Vancouver analysed the viability of, and provided preliminary recommendations on possible operating models for SSS in the Lower Mainland in 2018-19. The analysis identified two viable options: a focused route i.e. a scheduled service operated by a third party that would run between a terminal and a cluster of cargo owners; or, a common user expansion terminal i.e. a terminal extension up the Fraser river from the existing terminals, which would include direct access for trucks, rail and on-site warehouse /logistics facility.

Following this study, the Port of Vancouver is leading a CAD 3.2 million Short sea shipping concept development project with Transport Canada as a funding partner, making a CAD 1.6 million contribution from Transport Canada's National Trade Corridor Fund. The purpose is to further develop SSS to a stage where a confident investment decision could be made by stakeholders.

In 2021, a SSS service focusing on export transloads linked marine terminals run by the same operator with an end-to-end view of the system in Metro Vancouver. This private sector initiative is still small scale, but with potential to grow.

## Impacts

A modal alternative to SSS could reduce, relocate and/or replace trucking activity that is currently inefficient.

- *Replace* the current transportation activities by the desired modal mix.
- *Reduce* certain inefficient transportation activities and the negative externalities associated with the current modal mix.
- *Relocate* the transportation activities to a more optimal location.

The SSS project in the Lower Mainland would probably result in a mix of replacing, reducing and relocating trucking in different locations, which would lead to the following benefits:

1. Managing the cost of container transportation through the gateway

Short sea shipping is not necessarily cheaper in terms of direct costs than shipping a container by truck. Indeed, SSS has a different cost profile than trucking, notably with higher fixed cost component associated with the loading and unloading of the barge, but also with a smaller variable cost component. In scenarios where a container requires trucking before or after barging, the direct costs will almost certainly be lower for trucking.

However, indirect costs must also be taken into consideration. In the long term, service users will be more comfortable changing their logistics model to adopt SSS instead of trucking. This shift can be expected to reduce inefficiencies such as chassis movements, unnecessary third legs and storage costs. There are also indirect financial and non-financial benefits to the gateway related to the reduction of truck traffic. Those include reduced road congestion, reduced road and bridge maintenance and reduced health care costs linked to air pollution.

2. Increasing the gateway capacity and resilience

A SSS initiative within the Lower Mainland is also expected to increase the gateway capacity and resilience in three main areas. First, a SSS will provide another transportation link through and from congested marine terminals. This will therefore increase the capacity of the gateway. Second, a SSS service will connect the terminal to additional rail links. Additional rail access points can become crucial in the advent of service failures or access challenges. Finally, SSS can become an important player in the redistribution and access to empty containers. Container imbalances is currently an important challenge in Canada and could become a threat to gateway capacity and resilience in West Coast ports.

3. Generating an efficient use of scarce industrial land

SSS has been identified as a solution to the scarcity of industrial land in the Lower Mainland. The Lower Mainland is surrounded by mountains, the ocean, the US border and the Agricultural Land Reserve[4], which means new industrial land cannot be created easily. Moreover, current and former industrial lands have been rezoned to meet community housing and transit infrastructure needs. With demand rising, the Lower Mainland could run out of land for new industrial development between 2035 and 2045.[5]

SSS could mitigate the shortage of industrial land. Indeed, SSS can support the optimisation of goods movement to and from facilities or regions where industrial land is cheaper and less constrained. SSS would also create more efficient use of the current industrial land by facilitating more efficient container throughput and additional trade activities using limited land and transport infrastructure.

4. Decrease emissions, criteria pollutants and particulate matter

Additional tug and barging operations would lead to a decrease in commercial trucking activities in Metro Vancouver. There is a consensus that a mode shift towards SSS would lead to a multitude of positive externalities including reduced greenhouse gas emissions, road congestion, and road wear and tear. SSS could provide a less carbon-intensive alternative than trucking for the movement of goods.[6] However, some concerns have been raised regarding underwater noise and pollution of a mode shift towards SSS. An environmental impact assessment and consultations with Indigenous groups will be necessary in the concept development to address these concerns.

## Lessons learned

Three lessons can be learned from this case study of SSS in the Lower Mainland. These lessons are applicable to SSS operations within growing urban centres with transloading activities.

### 1. SSS requires a system perspective

In Metro Vancouver, the implementation of SSS is complex as it requires each stakeholder to conduct an end-to-end assessment to decide if SSS fits into their business model and corporate strategies. Indeed, the main challenge to successfully implement a modal choice policy is to convince all the players that the modal choice alternative is a valuable project to invest in and to make this project more attractive than the current model.

To capture this system perspective, the following considerations are crucial:

- An end-to-end assessment of stakeholder implications. Stakeholders will not look specifically at the segment of the cargo movement where SSS is involved but will look at the end-to-end cargo movement and will assess how a modal alternative would impact their business based on their business model. For example, for marine terminals, on one hand, SSS would provide flexibility in optimising their existing footprint, while on the other hand it would increase complexity on docks by adding co-ordination challenges between modes. Table 11 provides a complete list of players involved in SSS and their roles and considerations.
- The value of a modal choice model is determined by direct and indirect costs as well as reliability. SSS and trucking have different cost profiles for direct costs (fixed and variable costs) and indirect costs. Moreover, as the SSS is a scheduled timed service, it can offer more reliability since it is not affected by urban road construction, and the off-dock location can be used as a buffer for arrival at terminals.

### 2. The risks should be distributed amongst all the players

While stakeholders in the gateway might be supportive of the implementation of a SSS initiative, risks might not be equally distributed among them. For example, in one of the attempts to implement SSS in the Lower Mainland, most of the financial risks were expected to be held by the terminal operator, while the benefits spread among multiple actors. To ensure its sustainability, a SSS initiative must be attractive in terms of risks and benefits for all the interconnected partners. For this, SSS must clearly demonstrate financial, efficiency and reliability benefits.

While a SSS initiative is designed for a group of stakeholders, naturally stakeholders will look at a SSS proposal through their individual business-model lens. In the end, the players will often choose the cheapest and most reliable shipping option. Therefore, both the group and individual needs must be considered, since the participation of all players is needed to implement a successful SSS initiative.

### 3. Considering labour and union dynamics early on is crucial

The long-term viability of a SSS service can depend on labour and union. In the first stages of the concept development of SSS, players will want to see cost certainty of labour not to be more expensive than in trucking. The following considerations for policy-makers are crucial early on in the process:

- Assessing the views and interests of the labour unions in SSS
- Meeting with SSS operators to discuss their labour options and strategy

Table 11. Lower Mainland's SSS players

| Player | Description | Role |
|---|---|---|
| Marine Terminals | Marine Terminals possess the infrastructure used by tug and barge operators, and they also decide which shipper can have access to those infrastructure when there is limited capacity and competing services. The Port of Vancouver has four container terminals. | Terminals have a major role to play in SSS initiatives. Adding SSS services at terminal increases the complexity of their operations (limited capacity at the wharf, increased costs if ocean vessels or barge services are delayed or cancelled) but would also generate significant benefits such as optimising terminal storage space, providing flexibility in existing footprint and reducing congestion on docks. |
| Tug/Barge | A tug is a marine vessel that pushes or tows other vessels such as barges which transport cargo. | Tug and barge operators would be operating SSS services. |
| Beneficial Cargo Owners (BCOs) | The party that takes possession of the cargo at the final destination (the importer of the cargo). | BCOs could benefit from the implementation of a SSS initiative through higher resilience of the gateway, higher fluidity, and lower carbon emission for the transportation of their cargo. BCOs will however consider if SSS would create any challenges that would make it difficult for them to receive or return containers (detention and demurrage charges). |
| Shipping Lines | Businesses transporting cargo using container ships. | For these businesses, containers are a major capital asset, there is therefore a strong emphasis on maintaining control on their container supply and SSS could help to optimise container cycle times. SSS would however change how they allocate containers to customers, demurrage and detention, and contracts with terminals and rail. |
| Off-docks | Where containers are stored, stuffed and de stuffed outside of the port premises, before they are loaded or offloaded from a ship. Off-docks can also be seen as the connection node between marine terminals and BCO. | Import: Off-docks of the import side are primarily interested in unloading the contents of a laden import container and evacuating the emptied container to make room for other laden import container.<br><br>Export: Off-docks of the export side are primarily interested in securing empty containers to meet their business demand. |
| Unions | | Unions can have a decisive role in the implementation phase of a SSS initiative. Two main issues could arise: high wages negotiated by the union could make the SSS project cost prohibitive, and rivalry between unions involved could lead to a union not supporting a SSS project. Engaging early on with unions to avoid labour issues is therefore critical. |
| Trucking | There are over 70 drayage companies in the Lower Mainland. | The adoption of a SSS initiative will optimise truck movements where they are currently inefficient in the Lower Mainland but would also price out smaller players due to increased costs for improvements or to meet new standards. There are currently legislated rates for trucking. This is helpful in providing a benchmark for SSS costs. |
| Railways | In Canada, most of the freight arriving by marine links is then transported by railways. In 2020, 69% of the import containers which arrived at the Port of Vancouver departed the marine terminal via rail. | Railways would benefit from a SSS initiative in the Lower Mainland through better fluidity of containers to existing rail access point and the creation of additional rail link access which can become crucial to |

| Player | Description | Role |
|---|---|---|
| | There are five railway operators in the Lower Mainland. | increase the gateway’s resilience and the network capacity. SSS may however overlap with private rail shuttle initiatives planned between a marine terminal and intermodal rail yard. |
| Indigenous Groups | | In the Lower Mainland, consultation with Indigenous groups will be necessary notably to address concerns regarding the impacts of SSS on marine life, increased vessel traffic and potential decline in water quality. |
| Port Authorities | Canada Port Authorities have the wider responsibilities of enabling international trade, setting their own fees and maintaining and dredging commercial shipping channels. They also act as landlords by leasing their port operations to private operators. | The Vancouver Fraser Port Authority is currently exploring development of a dedicated common user SSS terminal, while also not precluding existing private sector progress on SSS. |
| Federal Government | | The role of the public sector in SSS is to create the conditions for the industry players to participate and to collaborate. The public sector has the unique ability to transcend private sector interests and take on risk that no individual private sector stakeholder would be able or willing to, providing private sector stakeholders with the conditions to experiment and innovate within their operations. |
| Other Community Groups | This includes cities, public transport authorities, etc. | In the case of the Vancouver region, cities and public transport authorities would indirectly benefit from a SSS initiative via reduced trucking traffic and urban congestion, reduced wear and tear of road infrastructure, and reduced air pollution. |
| Other players | This includes industry associations, etc. | Their role will depend on the SSS model and design adopted. |

# Case study: Mode choice in freight transport – Jiangsu province in China

Promoting the adjustment of transport structure is a major task deployed by the State Council. Moreover, transport structure adjustment is an important part of the critical battle against pollution.

In September 2018, the State Council issued the three-year action plan to advance transport structure adjustment. Objectives and tasks are stated in this action plan. In addition, this plan provides the fundamental criterion of transport structure adjustment and shows the strong determination to promote this work from Central Committee and State Council in China.

Jiangsu Province is in the eastern part of China. With a GDP of CNY 10.27 trillion in 2020, it is one of the highest-performing provinces with regards to comprehensive development in China.

It has also formed a comprehensive modern transportation system, integrating road, railway, water, air and other transport modes. In 2019, Jiangsu's freight volumes were 75.01 million tonnes by rail, 1 645.78 million tonnes by road and 906.7 million tonnes by waterways.

Jiangsu Province has also formulated action plans and subsidy programmes for transport structure adjustment, which have achieved good results. Therefore, it is typical to choose the case of transport structure adjustment in Jiangsu province to represent the case of China.

In February 2019, the General Office of Jiangsu Provincial Government issued an implementation plan for promoting transport structural adjustment in Jiangsu province.

The implementation plan aimed to promote transport structural adjustment through seven actions. They are freight railway capacity expansion, waterway transport upgrade, speed-up of multimodal transport, high-quality development of China-Europe freight trains, road freight management, urban and rural green distribution, and information resource integration.

The targets of this plan are as follows. By 2020, the provincial transport structure would be optimised remarkably and the bulk cargo traffic volume undertaken by railway and waterway would increase significantly. The port collecting and distributing volume, intermodal container volume and inland container volume would increase sharply. The overall work of transport structural adjustment would achieve remarkable results and build a model for transport structure shift along the Yangtze River Economic Belt.

Under this action plan the volume of cargo undertaken by rail would increase by 19.45 million tonnes compared to 2017, an increase of 34.2%. The volume of multimodal freight transport and the volume of containerised rail to water transport at key ports would increase by more than 30%. Inland river container transport capacity would reach 500 000 TEU. The proportion of railway and waterway transport for key enterprises such as steel, electrolytic aluminium, electric power and coking shall exceed 50%.

## Instruments and approaches

### Subsidies

The provincial transport department and Finance authority issued a joint subsidy scheme for transport structure adjustment in Jiangsu province. The goal of this scheme is to promote a modal shift from road to waterway and from road to rail with regards to bulk cargos and containers. In addition, it aims to reduce road traffic, increase railway and water traffic, and enhance transport organisation simultaneously so that it could provide a strong support for high quality economic development.

The subsidy scheme determined three areas for modal shift in important enterprises: shifts from road to rail and road to waterway, intermodal trains, and modal shift from road to rail and waterway in key ports. This gave rail and water transport prices a comparative advantage as a result. The total budget of this special subsidy funds is CNY 120 million.

Three types of enterprises could apply for the subsidies in accordance with this scheme. The first are enterprises that shift road transport to railway as to bulk cargos. The second, operators who engage in the shipment of the point-to-point freight trains. The third are key ports that implement modal shift from road to rail and waterway and have marked achievements. Above all, each should operate in accordance with law, have good credit, perform statistical obligations, and have no history of major safety or environmental liability accidents.

The subsidy criteria in accordance with this scheme, are as follows. A subsidy of CNY 3 per tonne will be provided for the annual increment of railway transport volume of bulk goods. For road-rail-waterway intermodal trains, the subsidy for container trains is CNY 200 per TEU, and the subsidy for shed car trains is CNY 500 per vehicle. Concerning modal shift in key ports, a subsidy of CNY 3 per tonne will be given to the incremental volume of bulk cargo railway transport at major coastal ports. In addition, the subsidy for container road barge from Taicang Port of Suzhou Port to railway freight of Suzhou West Railway Station is CNY 600 per TEU, and the subsidy for waterway barge is CNY 800 per TEU.

### Exempted and reduced charges

To promote container transport there are exemptions from transport tolls. All the container transports in and out of Nanjing port, no matter if empty or full, are exempted from tolls in all the provincial highways and ordinary road toll stations. In addition, railway transport fees are reduced to promote the railway transport.

### Infrastructure

From 2018-20, the railway construction investment exceeded CNY 140 billion in Jiangsu province. The Lian-Yan railway, Xu-Su-Huai-Yan railway, Lian-Huai-Yang-Zhen railway and other major projects were built successively. The transport department and office of natural resources requested an acceleration of construction to promote the construction of industrial railways, and to innovate the mode of industrial railway operations.

The comprehensive capacity of coastal ports along the Yangtze River has reached 2.12 billion tonnes and there are eight ports whose capacity exceeds one hundred million tonnes currently. These two indexes are ranked high among China’s ports.

Channels are also being cleared to create high-grade waterways. A basic two longitudinal and five horizontal” waterway trunk line network currently connects a 1 000-tonne network of channels.

Subsidy measures for hub station construction guide and promote the construction of freight parks. Twenty-three logistics parks have received CNY 178 million. At present, the province has built 40 intermodal freight hubs, 13 have been built since the end of 2017.

## Digitalisation

Digitalisation can deepen freight network development. Efficient matching of supply and demand logistics can be enhanced by active application of cloud computing, big data, Internet of things, new technologies, artificial intelligence and block chain. A total of 80 freight enterprises receive this type of digital service in the Jiangsu province.

The visualisation and construction of 36% digitally connected logistics parks have had great success in Jiangsu province. The shipping information management system, inventory management system and vehicle real-time scheduling system has been adopted by 58% of these parks. In addition, more than 70% of logistics enterprises in the transport sector use the positioning system and vehicle-sensing equipment.

## Co-ordination mechanisms

A conference system to promote transport structure adjustment was established in Jiangsu province. In this system, the Vice Governor convenes communication between 29 government departments, including the provincial development and reform commission, who constitute the membership. They all join forces to promote transport structure adjustment.

Transport structure adjustment was included in the 100 annual critical works by the Jiangsu provincial government. Special meetings are held to further this agenda.

In August 2019, the Transport department and China railway Shanghai bureau agreed to comprehensively deepen co-operation to formulate policies and measures of modal shift from road to rail via a port, an enterprise or even a project. Moreover, the transport department and each cargo centre assisted to push modal shift from road to rail. The intensive cooperation between Nanjing transportation bureau and the Nanjing cargo centre was an example, which raised railway capacity 600 000 tonnes per year.

Lianyungang port group strengthened their co-operation with central Asian countries such as Kazakhstan and Uzbekistan for a China-Kazakhstan connection to promote the development of international multimodal transport. It also formed the renowned “One park and Three sites” chain layout which includes Lianyungang core area, Xinjiang Huoerguos depot and the east gate logistic park of Kazakhstan.

## Demonstrations of typical projects

The further development of multimodal transport in Jiangsu province was supported by a scheme issued by the provincial financial department and 23 other departments.

Since 2016, the transport department in conjunction with the Development and Reform, Industry and Information have carried out a multimodal transport construction project demonstration. A total of CNY 8.2 billion has been invested in 22 demonstration projects and 116 demonstration lines were opened. The multimodal transport volume exceeds 170 million tonnes and the multimodal container transport volume exceeds 3.7 million TEU for these projects. Demonstrations made by this project drove creation of the hub of multimodal transport lines, terminals, transport organisation mode and information systems, and related service companies.

To build a combined river-sea container transport system, the provincial development and reform commission and seven other units introduced the action plan for the development of inland containers in Jiangsu province from 2018 to 2020. From 2018 to 2020, a special fund was allocated for inland container development to support the open or encryption-container routes.

A three-tiered urban distribution network was formed in Suzhou, which included an integrated logistics centre, a public distribution centre and the connections to the distribution network. As a result, transport costs for cargo distribution (in tonne-kilometres) fell by an average of 12%.

## Impacts of modal split in Jiangsu

In 2019, the railway freight volume is expected to exceed 83 million tonnes in Jiangsu province, with a year-on-year increase of 7.2%, which has had greater improvement than last year.

The ratio of total social logistics costs and GDP fell to 13.8% in Jiangsu province in 2019. This was a decrease of 0.1% points compared to 2018 and 0.9% points lower than the average level of China in 2019.

In 2019, the ecological and environmental quality of Jiangsu Province improved steadily, and the ambient air quality continued to meet the standards. The proportion of days with good ambient air quality was 71.4% in Jiangsu province in 2019. The proportion of days with good air quality in 13 cities ranged from 59.2% to 80.8%. In addition, the concentration of particulate matter, sulphur dioxide, nitrogen dioxide and carbon monoxide among major pollutants decreased year-on-year. Among them, the average annual concentration of $PM_{2.5}$ in Jiangsu province was 43 micrograms per cubic metre, down 8.5% from 2018. In contrast, the concentration of ozone increased year-on-year.

## Policy implications

In 2008, a comprehensive transport management system that covered road, railway, waterway, and aviation was formed in Jiangsu province. This is one of Jiangsu’s most innovative transport structure adjustments as it made combining all kinds of separate transport modes into an interconnected network a reality.

A system of joint conference to promote transport structure adjustment was established in Jiangsu province. In this system, the vice governor convenes over 29 government departments to join forces to promote transport structure adjustment.

Transport structure adjustment was included in the 100 annual critical works by the provincial government and deploy it by a special meeting.

# Case study: The freight corridor approach in the Netherlands

This case study explains the purpose of and thoughts behind the freight corridor approach in the Netherlands. The freight corridor programmes in the Netherlands are still a work in progress. It is therefore not yet possible to evaluate the freight corridor programmes on the effectiveness on influencing the modal split of freight transport.

## What is a freight corridor?

The main components of a transport corridor are usually a seaport, waterways, road and rail networks in the hinterland, inland ports or bulk ports and border controls. Besides land corridors, there are also maritime corridors, with short sea shipping and aviation corridors. In a corridor, all modes of transport follow the same spatial orientation and serve the most important agglomerations and economic centres within their route. A distinction can be made between corridors according to their scale, from corridors within and between regions to corridors that stretch and connect entire continents, such as the silk route from China to Europe. In addition, there are differences in the approach to the corridors, from narrow, meaning only the co-ordination of and developing the infrastructure, to very broad, in which co-ordination of spatial, trade and economic developments are also part of the corridor approach.

Hope and Cox (2015) distinguish several stages in the development of a corridor from narrow to broad. The successive stages are (1) transport corridor, (2) transport and trade facilitation corridor, (3) logistics corridor, (4) urban development corridor and finally (5) economic corridor. These stages are recognisable as ideal types, but it is not necessarily the case that they are all complete. This classification is therefore more of a typology of different types of corridors than a sequential development path that corridors go through.

A corridor is more than the co-ordination and co-operation between governments. It is a combination of private and public activities, in which the private sector organises trade and transport while the public sector facilitates this with infrastructure and trade agreements. The division of tasks between the private and public sectors can be represented schematically as follows.

Corridors start as natural transport routes and investments in physical infrastructure for one or more transport modes to then become a transport corridor. The next evolutionary step requires the development of the soft infrastructure of transport services and transport logistics. The development into a fully-fledged economic corridor requires a broader approach and investment in the regions served by the corridor. Srivastava (2011) further notes that corridors must stimulate economic growth to be viable, and that corridors in themselves do not create economic strength, but channel, focus and enhance the potential for economic growth. A corridor that connects two nodes but between which there is no growth potential is also of limited interest. The stops along a corridor are more interesting than connecting the endpoints.

Figure 12. Multi-lateral corridor agreements in a public and private sector context


Source: COMCEC (2017).

Building a transport corridor and expecting development to follow automatically is unlikely to be the way it works (COMCEC, 2017). It is more likely that the transport corridor, connecting the right places, becomes the mode of a series of accessibility benefits that will lead to further positive feedback. This process, also called circular and cumulative causality, gives rise to the idea that growth is concentrated on corridors connecting places that are highly interactive. The prerequisite is that there is a common set of objectives around which political adhesion can exist. In some cases, this may be driven by the fact that landlocked countries demand secure trade routes; in other cases, it may be economic and social cohesion, as in the European Union, but a driver for political integration is a prerequisite.

The administrative elements of corridors typically follow a similar pattern. A memorandum of understanding is signed that establishes a set of common objectives, which have no legal force, to an international treaty that commits governments to a set of economic, financial and legal obligations that must be ratified domestically. An essential part of this process is always the creation of a transport corridor co-ordinating organisation. Such an organisation can take different forms, for example an independent entity or a board of participating members.

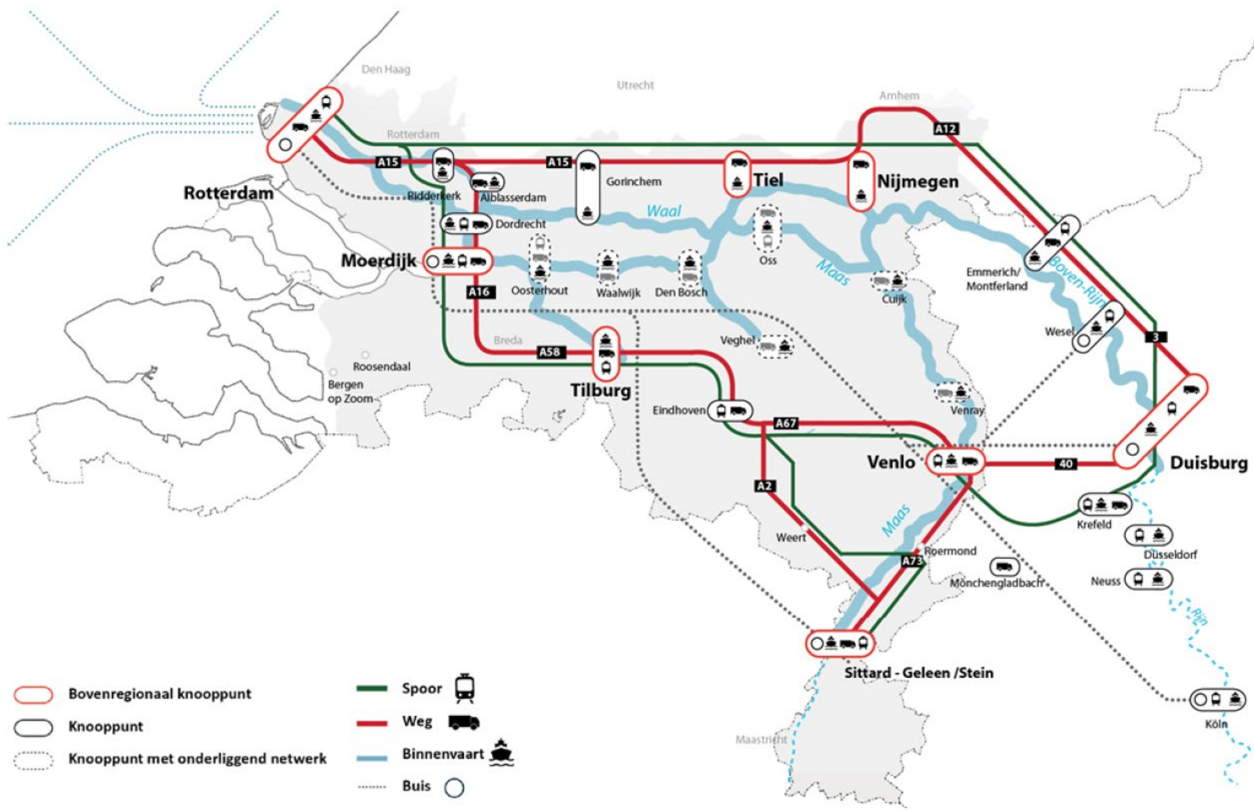
## The freight corridor approach in the Netherlands

The Netherlands, situated by the North-Sea and the Rhine-Meuse-Scheldt Delta within its borders, is an import linking point for global flows of goods from and to North-Western Europe. Three of the twelve European TEN-T corridors run through the Netherlands, namely the North Sea-Baltic Corridor, Rhine-Alpine Corridor and the North Sea-Mediterranean Corridor. As part of the implementation of the TEN-T corridors, the Dutch Ministry defined an international core infrastructure network as part of the mobility policy in the Netherlands, laid down in the Structuurvisie Infrastructuur en Ruimte (SVIR) policy document (Ministry of Infrastructure and the Environment, 2012). This network contains the relevant cross-border hinterland connections for freight transport to and from the economic centres in the Netherlands. The SVIR subsequently promised that the central government, together with the freight transport sector and regional authorities will develop a national core network, including a shared vision on container terminals in the Netherlands. To develop this national core network, it was decided in 2013 to start with two most important freight transport corridors within the Netherlands (see Figure 13). The focus was to identify the options and obstacles in optimising freight transport within these corridors:

- T*he East freight transport corridor (Rotterdam – Arnhem / Nijmegen – Germany).* This corridor is part of the TEN-T Rhine-Alpine corridor. Parts of this corridor are also part of the North Sea-Baltic and North Sea-Mediterranean corridor. The Rhine-Alpine Corridor is one of the busiest routes for freight transport in Europe, which connects the seaports of Rotterdam and Antwerp with Germany, Switzerland and Italy. This corridor includes the modalities road (A15), rail (the Betuwe freight railway line) and inland waterway (the Waal).
- *The South-east freight transport corridor (Rotterdam – Noord-Brabant / Limburg – Germany).* This corridor is also part of the European Rhine-Alpine corridor. Parts of the waterways in the corridor are also located on the North Sea-Mediterranean corridor: the ports of Rotterdam and Moerdijk (which is also located on the North Sea-Baltic corridor) and the inland shipping on the Maas river to the south. This corridor is comprised of the modalities road (A16 / A58 / A67), rail (the Brabant route) and inland shipping (the Maas and the Brabant canals).

To develop these two freight corridors a study started in 2014 to investigate the challenges, meaning the bottlenecks but also the opportunities to improve freight transport within these corridors (Ministerie van Infrastructuur en Milieu, 2017). This study was followed by a policy programme in 2017 to set up project plans for the challenges identified in the 2014 study. The purpose of this programme is to optimise freight transport using existing and planned infrastructure and multimodal nodes. It is about implementing smart and solutions other than infrastructure measures and is intended to keep the Netherlands, and the seaports in particular, accessible without having to invest in new or expanding existing road infrastructure. The programme focuses on a more efficient use of space and the available capacity within the total transport system. This mainly concerns reducing the overload on the road by a modal shift of freight transport to water, rail and pipelines. The robustness of the transport system requires a solid modal shift instrument to ensure a good flow in changing circumstances (e.g. managing blockages, large-scale maintenance or drought). A modal shift also helps to reduce the high management and maintenance costs of the road network. This freight corridor programme focuses on the spatial and economic development of multimodal logistics hubs and their importance in making better use of rail transport and inland shipping.

Figure 13. The multimodal nodes and infrastructure in the East and Southeast corridor




Note: English translation of Dutch key, "Bovenregionaal knooppunt" = supra-regional node; "knooppunt" = node; "knooppunt met onderliggend network" = node with underlying network; "spoor" = rail; "weg" = road; "binnenvaart" = inland navigation; "buis" = pipeline.

Source: Programmaraad Goederenvervoercorridors Oost en Zuid-Oost (2021).

In 2020, the Ministry of Transport and Waterworks together with the provinces of North Holland, South Holland, North Brabant and Zeeland and the ports of Amsterdam, Rotterdam, Moerdijk, and North Sea Ports began to investigate the feasibility and need for a programmatic approach for the freight corridor South.

- The South freight transport corridor (Amsterdam, Rotterdam, Terneuzen to Belgium). This corridor is part of the North Sea-Mediterranean Corridor and is connected to the Rhine-Alpine Corridor and the North Sea-Baltic Corridor. The corridor connects the main seaports in the Netherlands (Amsterdam, Rotterdam, Moerdijk, Vlissingen, Terneuzen) with those in Belgium and further abroad. This corridor comprises the modalities road (A4, A17 and A16), pipelines (pipeline corridor Rotterdam-Antwerpen), rail (Rotterdam-Antwerpen), short sea and inland shipping (North and South Holland canals, midden-Zeelandroute and Schelde-Rhine canal).

The fourth corridor, namely the North freight corridor, is in traffic volume smaller than the other three freight corridors. There are no plans to develop a corridor programme for the North corridor but there are initiatives, mainly private, to develop multimodal freight transport by rail and water.

The basic idea behind the freight corridor approach is that it will be better achieved through private and public co-ordination and co-operation. This joint approach will assist the common goals of economic development, sustainable handling and transportation, and the efficient use of available infrastructure by freight flows in the freight corridors. The freight corridor programmes focus an integrated approach towards infrastructure use and spatial and economic development. Through cooperation, coordination, spatial concentration and bundling, inland shipping and rail can become more attractive, and sufficient volume is created, making the corridors more attractive places to locate, while innovations, such as sustainable charging infrastructure (clean energy hubs) become feasible. More freight by rail and inland shipping would help to avoid congestion on the roads and reduce the impact of freight transport on the environment.

The freight corridor programmes in the Netherlands are joint programmes by the national and regional governments to optimise the freight corridors from the port of Rotterdam to the German and Belgium borders in terms of connectivity, and accessibility, economic growth and sustainability. Only the East and Southeast freight corridors have their programmes ready. In 2021 the Toekomstagenda Corridor ontwikkeling 2030 (*Future Agenda Corridor Development*) was published (Programmaraad Goederenvervoercorridors Oost en Zuid-Oost, 2021). There are some aspects of the freight corridor programmes that needs to be explained.

First, it concerns national programmes, yet the corridors are part of the international TEN-T corridors. For example the freight corridor East requires consultations with the German region Nordrhein-Westfalen, but the programme focuses fully on the challenges and actions required on the Dutch side of these corridors.

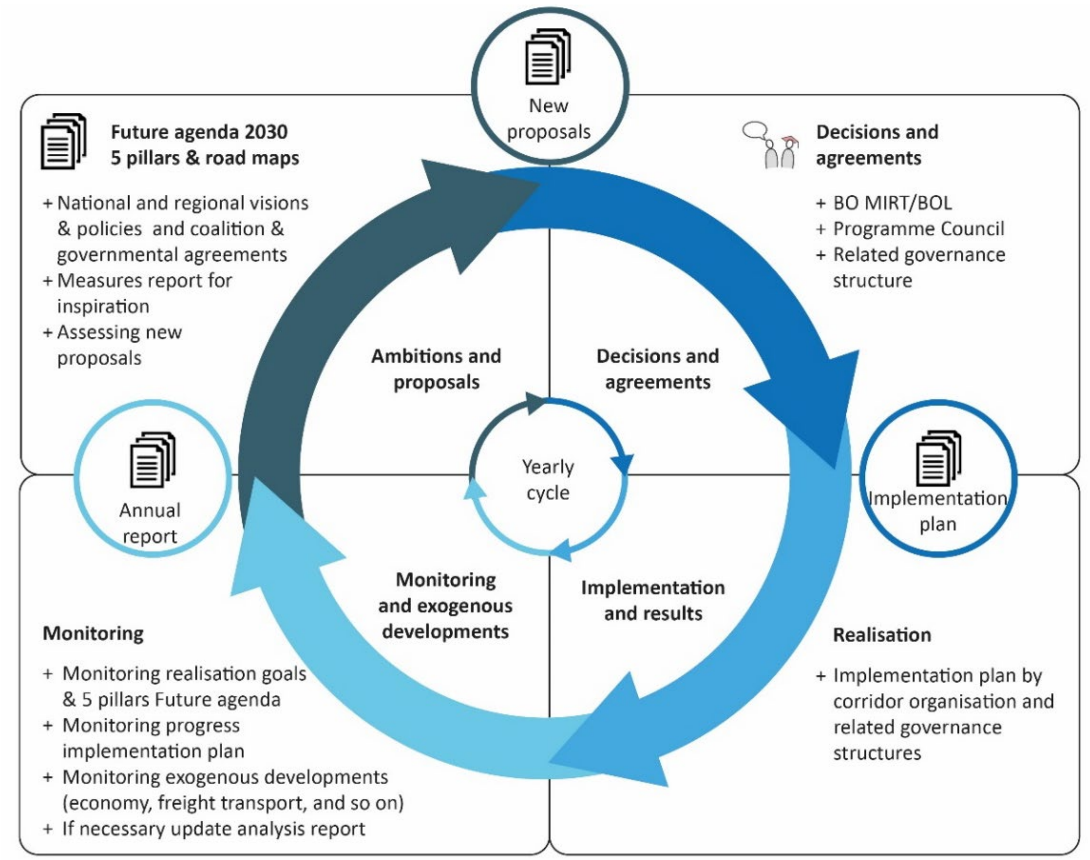
Second, the focus of the freight corridor programmes are on optimising the freight transport system. The corridor approach combines economic and sustainability goals but the focus is not on stimulating trade, like in other international corridors. The focus lies on a better performance of the multimodal freight transport system within the corridors. The freight transport system is not used optimally and therefore it is neither sustainable nor performing economically. Optimising the freight transport system means using the available capacity on the waterways, rail and pipelines and a better use of road transport capacity by bundling and higher load factors. Optimisation will make freight transport more sustainable and makes the introduction of new sustainable technologies easier. It will also generate economic benefits, which will make the corridors more attractive to businesses.

Third, the freight corridor programmes are based on an integrated approach, meaning a broad scope and a coherent approach. In order to make a modal shift possible all conditions for intermodal transport must be right, the intermodal chain is as weak as the weakest link. Possible components of freight corridors are: multimodal terminals at the origin and destination, the connecting infrastructure, the pre- and end-haulage by road and the multimodal transport services by rail and waterborne. Additional components to consider in the integrated approach are: the spatial planning of terminals, the industrial areas around it and the location of distribution centres. In the corridor programme East and South-East, the corridor partners have agreed to take a more active approach to cluster logistics activities. The availability of sufficient space near multimodal terminals for expanding business development is an important factor in the process of optimisation. All actions are considered and implemented in conjunction to maximise coherency within the programme.

Because of the integrated approach, co-operation and co-ordination is needed between all parties in the logistics chain and the authorities responsible for infrastructure planning and spatial planning.

Finally, the approach is based in adaptive programming. The corridor programme is not a solid blueprint with fixed dates on which actions have to start and finish. Adaptive programming is a more flexible approach, responding to problems and opportunities when they occur in light of what the actors want to achieve in the longer term. Figure 14 reflects an annual process for this programming of project monitoring, discussion of new actions, decision making and summarising decisions and agreements made within a framework of set ambitions and route maps.

Figure 14. Yearly cycle of monitoring, reporting, decision making and realisation for transport corridor development




Source: Programmaraad Goederenvervoercorridors Oost en Zuid-Oost (2021).

## Designing the freight transport corridors

To create the East and South-East corridors the challenges for them were first defined (Ministerie van Infrastructuur en Milieu, 2017).

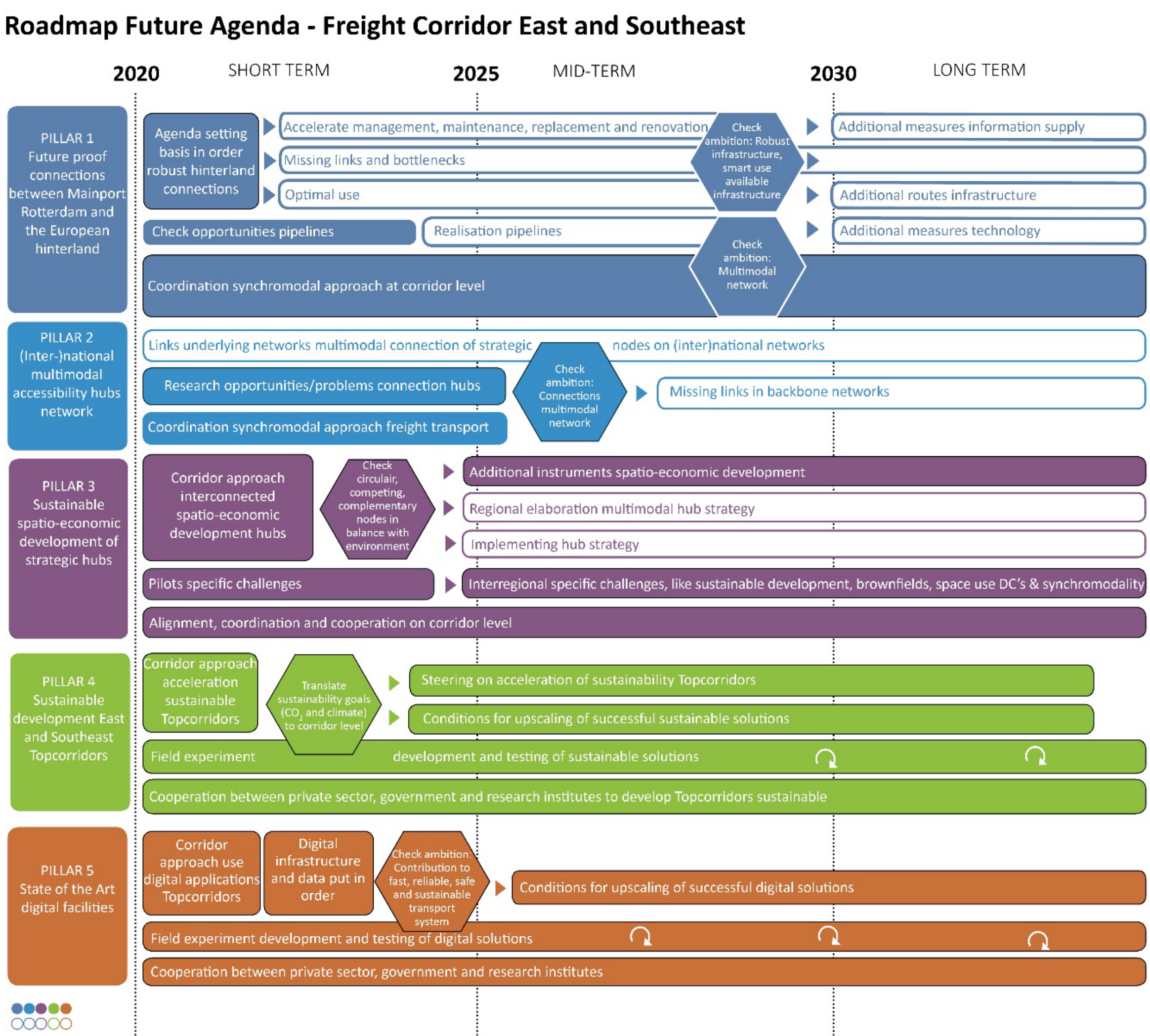
The second step was to get commitment and willingness to co-operate and to have consensus on the purpose and the scope of the programme, on the road maps and finally on the adaptive process and organisation of the programme until 2030. This is all laid out in the Future Agenda for the East and South-East corridor (Programmaraad Goederenvervoercorridors Oost en Zuid-Oost, 2021). This agenda provides direction for the period up to 2030 with a joint and coherent future perspective for five pillars and for each pillar a roadmap for the short (up to 2025), medium (2025-30) and long term (after 2030). The five roadmaps are:

- Future-proof connections between Mainport Rotterdam and the European hinterland
- International multimodal accessibility of strategic multimodal nodes

- Sustainable spatial-economic development of strategic multimodal nodes
- Making the East and Southeast top Corridors more sustainable
- State of the art digital facilities

The strategic multimodal nodes are those areas which have the most extended multimodal transhipment facilities and largest spatial concentration of logistic centres within a freight corridor. In the case of the East and Southeast corridors, the multimodal nodes are: Moerdijk, Tilburg, Tiel, Nijmegen/Arnhem, Venlo en Sittard-Geleen/Stein.

Figure 15. The five pillars and their roadmap as part of the future agenda




Source: Programmaraad Goederenvervoercorridors Oost en Zuid-Oost, (2021).

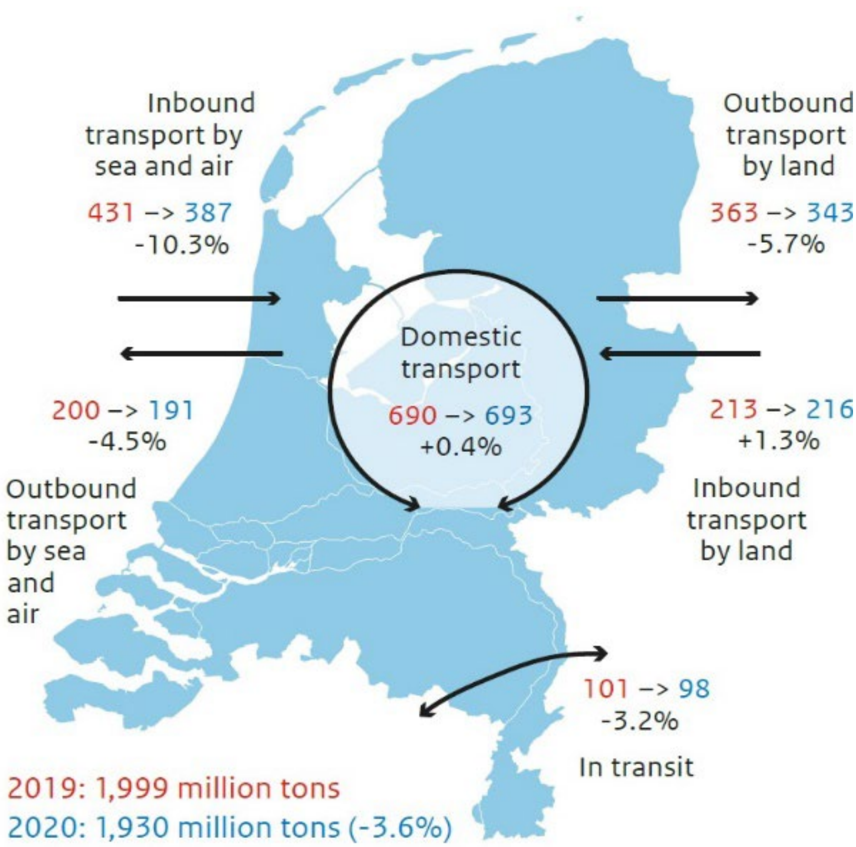
Four of the five roadmaps are directly aimed at influencing the modal split. Pillar 1 and 2 focus on the multimodal connections and infrastructural accessibility of the multimodal nodes. Pillar 3 is about spatial clustering at the nodes around multimodal terminals. Pillar 5 is about the digitalisation of the information supply around multimodal transport. The corridor programme aims to shift 5 million tonnes and 0.7 million TEU from road to rail and waterways until 2030.

## Modal split in the Netherlands

The annual transport volume of all modes of transport, including sea and air is almost 2 billion tonnes per year in the Netherlands. About one-third of the total transport volume consists of transhipment within the Dutch seaports, another-third is domestic freight transport and the final-third are international inland transport flows going in or out of the Netherlands. These figures show that the international transport flows exceed domestic flows in total volume. Hence an important part of the infrastructure available for freight is designed and even dedicated, like the Betuwe railway line, to accommodate these international transport flows.

Figure 16. Freight flows to, within and from the Netherlands in weight in 2018

*in million tonnes*



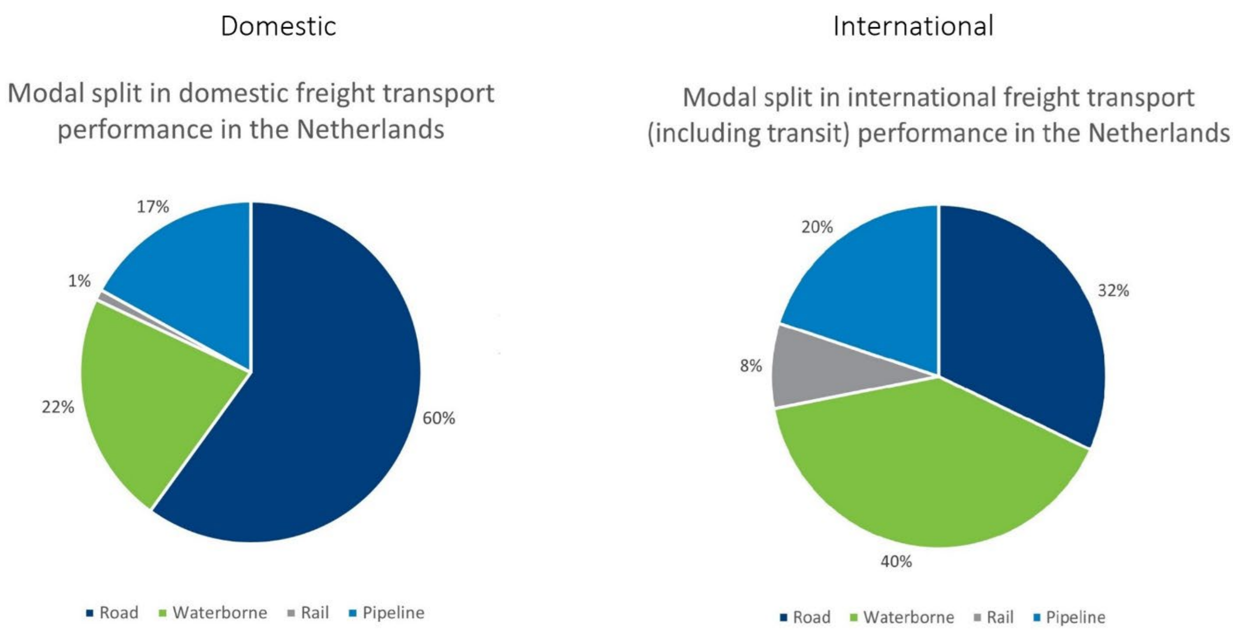

Source: KIM (2019).

The main modes of inland freight transport are road, waterborne, pipeline and rail transport. The annual transport performance of inland freight transport was about 132 billion tonne-kilometres in 2019 in the Netherlands and dropped to 126.7 billion tonne-kilometres in 2020.

Road and inland waterway transport together account for around three fourth of the tonne-kilometres in freight transport in the Netherlands. The main difference between domestic and international transport is that road transport dominates domestic, whereas inland navigation dominates international transport. The share of rail transport is negligible for domestic transport and fairly modest for international transport. In domestic freight transport, waterborne and rail can only compete with road transport in the areas of container transport and bulk transport. In international freight transport, these modalities have a much larger share compared to road. Waterborne and pipeline transport indeed have a relatively high share in freight transportation in the Netherlands compared to other countries. This is supported by the many waterways in the Netherlands, and the large volume of maritime containers and fossil fuels moving through the Netherlands.

Figure 17. Modal split of Dutch domestic and international inland freight transport in 2018

*in tonne-kilometres*




Source: CBS database.

The expectations are that freight flows – combining domestic and international transport – will keep growing in the longer term. In 2018, almost 115 billion tonne-kilometres were transported in the Netherlands by road, rail and waterways. In the low-economic growth scenario this increases by 4% to 120 billion tonne-kilometres by 2040 and by 23% to 142 billion tonne-kilometres in the high-economic growth scenario (Dat.mobility and Districon, 2021). Both scenarios calculate the potential further modal shift to waterway or rail modes by 2040 per freight corridor. The potential modal shifts for rail and inland waterway navigation should not, however, be added together as the total potential shift for the Netherlands. This is because part of the goods can be transported by both modes and are added to the volume of both modalities.

Table 12. Modal shift potential in 2040 of rail and barge

| | Rail | Barge |
|---|---|---|
| Corridor East | 9-10 million tonnes (Mt) | 6.6-8 Mt |
| Corridor South | 12-14 Mt | 17-19 Mt |
| Corridor North* | 15-18 Mt | 14-18 Mt |
| Corridor South-east | 6.6-8 Mt | 8-10 Mt |

Note: * there is no freight corridor programme developed for freight corridor North but it is recognised as one of the four freight corridors in the Netherlands.

Source: Dat.mobility and Districon (2021).

## Modal split policies in the Netherlands

The Netherlands included an active modal shift objective in its national traffic and transport policy in 1990. It stipulated that approximately 65 million tonnes of growth in road transport should be shifted to inland shipping and rail by 2010 (Jonkeren, 2020). This modal shift objective was elaborated in an action plan in 1996. However, this modal shift objective was abandoned in 2001. The argument was that all modalities are necessary for the entire logistics system to function. The focus is then on stimulating transport by rail and waterways and better utilisation of road transport capacity by bundling and higher load factors through better logistics chain management. The concept of Synchromodality (Topsector Logistiek, 2011) is being developed for this purpose. In the freight transport agenda, the Ministry of Infrastructure and Water Management (2019) announced that it will focus on promoting modal shift with actions that tie in with earlier programmes concerning rail freight transport and inland shipping in the coming years. The freight transport corridors play an important role in this. The ministry indicates that it will focus on modal shift in co-operation with the logistics sector and the governments concerned.

## What are the influencing factors for modal split in this case study?

These roadmaps in the corridor programme will influence the modal split for the Netherlands. They explain which steps are required to achieve modal shift.

*Improving multimodal connections and infrastructural accessibility* of the multimodal terminals will reduce transport times and traffic, and can make larger transport volumes possible. Shorter lead times and economies of scale make multimodal transport more attractive in the competition with road transportation. The roadmap future-proof connections between Mainport Rotterdam and the European hinterland focuses on catching up and accelerating measures for management and maintenance, replacement and renovation of the existing connections, ensuring that freight transport is hindered as little as possible during implementation and, where necessary, making additional investments in missing links and bottlenecks. Pipeline transport is also examined as an alternative mode in the roadmap. The Netherlands are considering the expansion of the pipeline route Rotterdam – Chemelot – Ruhrgebiet as a result. The roadmap "International multimodal accessibility of strategic multimodal nodes" focuses on the improvement of railway yards, quay walls and the access of inland ports.

*Spatial clustering of logistic facilities at multimodal terminals* works two ways. First, the spatial clustering near a terminal ensures shorter distances in the pre- and end-haulage. This reduces the costs of transport to and from the terminal. This makes multimodal transport cheaper but also makes it more attractive to shift from road transport to multimodal transport. For example, in the Netherlands, the general distance limit is that companies at a distance of more than 25 km from a terminal are unlikely to use multimodal transport. When companies are located at the same industrial area as the terminal, the containers are often transported from the terminal to the company using the company's own tractors. The pre- and end-haulage costs are thus reduced to a minimum. Second, when more companies establish themselves around a terminal, the demand for multimodal transport will increase. The volume of multimodal transport will increase and therefore the quality of the service, in terms of frequency, will improve. Larger scale means economies of scale and unit costs will decrease. A condition is that the space to grow must be available. In the roadmap “Sustainable spatial-economic development of strategic multimodal nodes”, a joint policy is drawn up to facilitate and direct expansion and new branches at nodes. Its goal is to accommodate inter- and nationally oriented logistics activities (distribution), manufacturing industry and the agro-food sector with a preference for intermodal supply and transport.

Many shippers are not familiar with multimodal transport. The information exchange between carriers and shippers is often not designed for it and multimodal transport often requires bundling of different loads. The roadmap Digitalisation of the information supply around multimodal transport focuses on efficient exchange of logistical digital data and information, in order to make it easier to use multimodal transport services within the corridors. This should make multimodal transport more accessible, easier to organise and more efficient. For example, the short-term focus of the corridor partners is the roll-out of the Connected Transport Corridor (CTC) approach. Part of this is setting and creating the necessary preconditions to stimulate digital platforms for real-time data exchange and other digital system solutions (applications) that can be tested within the corridors and that successful applications can be scaled-up at corridor level. This also offers perspective to developers and other market parties.

## Future modal shift

The Netherlands aims to shift 5 million tonnes and 0.7 million TEU from road to rail and waterborne modes by 2030. The development of transport corridors will be crucial to achieve this. The corridor programme in the Netherlands is based on a yearly cycle of reporting, decision making and realisation. It will be important to monitor the modal split and the progress within the agreed actions to achieve programme goals as part of this yearly cycle. This ongoing interaction helps to fine-tune or adjust measures as needed and to improve the modal split within the freight corridors.

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# Notes

1 Transborder SSS will not be covered in this case study. Cross-border SSS operations is a different market with its unique set of market drivers, public policy goals and levers, and operational circumstances that fall outside of the scope of this case study.

2 Transloading refers to the unpacking and reorganising of cargo shipment, which often facilitates the switch from one mode to another as part of the end-to-end transit to its final destination. Ex: A 40 feet container arriving at the Port of Vancouver can be unloaded at a transloading facility and repackaged into domestic containers or trucks.

3 The Office of the Container Trucking Commissioner was created in 2008, which provided more direct oversight on drayage.

4 The Agricultural Land reserve is a provincial zone in British Columbia in which agriculture is recognised as the priority used. It protects approximately 4.6 million hectares of agriculturally suitable land, some of which surround the Metro Vancouver area.

5 Source: "The Changing Nature of Industry and Industrial Land Demand in Metro Vancouver: Discussion Paper", June 2019, Wollenberg Munro Consulting. Document prepared for Metro Vancouver and released online in September 2019.

6 Note that the magnitude of the impact would depend on the fuel source and on innovation.

## Mode Choice in Freight Transport

This report examines why freight carriers and shippers choose one transport mode over others. It analyses the main determinants for using road, rail, inland waterways, coastal shipping or pipelines to move goods and assesses government policies to influence it. The study also reviews how shifting freight to more sustainable modes could reduce the contribution of goods transport to climate change and provides recommendations for more effective policies. The role of mode choice in alleviating congestion and making goods transport safer is also addressed. Three case studies from China, Canada and the Netherlands highlight modal-shift policies.

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