Freight modal shift in Sweden – means or objective?

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Abstract

Modal shift within the freight transport sector has been promoted by policy makers as one of the means to achieving climate and environmental targets for several decades. The European Union has also had modal split objectives in place since 2011. In the Green Deal the ambition of shifting freight away from road transports is repeated. Even though the literature on mode choice is well established, there is less consensus about the volume of freight with potential to shift and, more importantly, the actual contribution of modal shift to achieving environmental and climate objectives. Based on a literature review to determine the potential of freight modal shifts within different segments in Sweden, this paper discuss the underlying assumptions explaining how freight modal shift is interpreted both as a political means to achieving overarching policy objectives *and* as a policy objective in itself.

Keywords
Freight modal shift, policy instrument, transport, climate, environment, impact, economics

JEL Codes
R4, D04, D62

Freight modal shift in Sweden – means or objective?

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[Abstract: Modal shift within the freight transport sector has been promoted by policy makers as one of the means to achieving climate and environmental targets for several decades. The European Union has also had modal split objectives in place since 2011. In the Green Deal the ambition of shifting freight away from road transports is repeated. Even though the literature on mode choice is well established, there is less consensus about the volume of freight with potential to shift and, more importantly, the actual contribution of modal shift to achieving environmental and climate objectives. Based on a literature review to determine the potential of freight modal shifts within different segments in Sweden, this paper discuss the underlying assumptions explaining how freight modal shift is interpreted both as a political means to achieving overarching policy objectives *and* as a policy objective in itself.]

1 Introduction

Freight transport is contributing to several environmentally damaging externalities, including emissions of CO_2, NO_x, SO_x, VOC, and PM.[1] Historically, these effects have on average been higher per ton kilometre (ton-km) for road transport compared to rail and waterborne transports (Nocera, Cavallaro and Galati, 2018). Especially for long distance freight transport, policy makers in many countries and regions, including the EU, the US, and Japan, have set up modal shift objectives to shift away from road. These policy objectives are often motivated by overarching societal objectives related to emission reductions, health and road safety (Tao, Wu and Zhu, 2017; Pinchasik *et al.*, 2020). The modal shifts objectives thus rest on an implicit assumption that steering towards the realization of modal shift targets is contributing to the realization of other societal objectives. In Sweden modal shifts of freight transport from road to rail and shipping is one of three overall priorities in the "National freight transport strategy" that was adopted in 2018.[2] The strategy sets the overall policy focus for freight transport and logistics to fulfill the Swedish transport goals, contribute to a competitive business sector, and *promote a modal shift of freight transport from road to rail and sea transports*. There are three policy instruments explicitly targeting freight modal shifts; two compensation schemes targeting sea and rail freight transports, respectively, and a national promotor for shortsea shipping and inland navigation.

Despite the policy ambitions, there is little realization of modal shift in most countries. Particularly rail freight infrastructure is lagging throughout Europe, and the market share of rail freight is decreasing within the European Union (Islam *et al.*, 2015; Kaack *et al.*, 2018). In Sweden, freight transports are largely dominated by heavy truck. The share of freight transport by road, in ton-km, is increasing on the expense of both rail and shipping (Vierth *et al.*, 2020). Similar developments are seen in other Nordic countries (Pinchasik *et al.*, 2020). In general, several political trends are rather contributing to strengthening the importance of road for freight transports in Europe. Political decisions such as increased weight and length allowances[3] for heavy trucks (Vierth, Lindgren and Lindgren, 2018) directly contribute to keep road costs low. Automatization and digitalization could for example imply that driver wages will constitute a smaller share of total road transport costs. If that is the case, the expectation that regulations of driving and rest times and the shortage of drivers could dampen the cost advantage for road, only has temporary effects. From a climate perspective, the CO_2 standards for heavy trucks that were enforced by EU in 2019 (EU 2019/1242) further incentivize innovations and the uptake of low-emission vehicles. During the introduction phase, the standards will probably lead to more costly vehicles, but in the longer term the regulation will affect the relative environmental performance between modes in favor of road. In fact, heavy truck is the only transport mode in Sweden that has reduced its greenhouse gas emissions, between 2010 and 2018, at a rate in line with the Swedish climate target of a 70 % reduction of GHG emissions within the transport sector by 2030. This is partly driven by the increased usage of HVO (Hydrogenated vegetable oil) in the fuel mix (Takman, Trosvik and Vierth, 2020). Still, freight transports by road are on average generating CO_{2e} emissions per ton-km that are much higher than transports by sea, and particularly by rail (see Table 1). On the other hand, of all other air-borne emissions, freight transport by sea is generating the highest emissions per ton-km. This

[1] Carbon Dioxide (CO2), Nitrogen (NOx), Oxides of Sulphur (SOx), Oxides of Volatile Organic Compounds (VOCs) and Particulate Matter (PM).

[2] Efficient, high-capacity and sustainable freight transport – a national freight transport strategy - Government.se

[3] Since July 2018, Sweden allows heavier trucks of up to 74 tons in about 20% of the state-owned road network. The road network in which heavier trucks are permitted, will gradually be expanded to reach about 70-80% of the strategic road network by 2029 (Swedish Traffic Authority, 2020).

can be explained by the successively stricter environmental requirements (Euroclass) on new trucks (EU, 1987), whereas corresponding requirements for sea transports have been implemented much later.

Tabel 1. Average air emissions per freight transport mode and ton-km on Swedish territory based on statistics from year 2017.

	CO_{2e} kg per ton-km	**NOx g per ton-km**	**SO_2 g per ton-km**	**HC/VOC g per ton-km**	**PM g per ton-km**
Road	0,0648	0,2255	0,0002	0,0052	0,0049
Rail	0,0020	0,0239	0,0000	0,0020	0,0009
Sea	0,0286	0,6558	0,0178	0,0267	0,0089

Source: Johansson, Vierth and Holmgren (*forthcoming*)

Technical innovations such as increased battery efficiency, electrification and alternative fuel sources, and automatization of vehicles will affect the development towards less climate impact within all modes. These trends could also improve conditions for multimodal transport solutions through organizational innovations and business models taking advantage of load standardization, digitalization, data-sharing, and innovations (Kaack *et al.*, 2018; Swedish Transport Administration, 2018; Ambra, Caris and Macharis, 2019; Johansson, Vierth and Holmgren, 2021). However, as the road sector has a faster vehicle turn-around, the road sector is likely to implement these technologies much faster than for example sea transports. The political ambition to realizing modal split targets will depend on assumptions about how the relative environmental performance, and/or other external effects, of different modes develop over time.

In this paper, we part from previous white and grey literature and official statistics to summarize the i) potential of realizing freight modal shifts in Sweden, and ii) the potential contribution of realized modal shifts in contributing towards realization of climate and environmental objectives. Based on the findings we discuss the implications of treating modal shifts as a political objective rather than a means among many potential means to achieving societal objectives. To limit the scope, we concentrate on longer-distance freight transport chains[4] including road, rail, and sea (shortsea and inland waterways) transport. Although this paper is focusing on Sweden, it has relevance from a European perspective. Modal shift objectives in Europe are mostly influenced by the Transport White Paper[5], specifying that 30% of road freight transport over 300 km should shift to more energy efficient modes by 2030, and that more than 50% should shift by 2050. Union-wide policies to support certain transport modes and promote multimodality have been introduced, including TEN-T, Motorways of the Sea, and the Combined transport Directive (92/106/EEC). Similarly, the policy toolbox available for EU countries and parties are influenced and restricted by common state aid policy.[6]

The remainder of this paper is organized as follows. Section 2 provides background on general findings on freight transport mode choice and common methodological approaches used to study policy impact on the freight transport market. Common policy instruments, in general and specific for Sweden, used to incentivize modal shift are discussed in section 3. Section 4 further zooms in on the Swedish freight transport market and the potential for realizing modal shift. Section 5 discuss the three explicit modal shift policies introduced in Sweden and their potential contribution to realizing modal shift and, where possible, their environmental contributions. Section 5 concludes the paper.

[4] Although important, the increasing pressure on urban freight transport driven partly by the rise of e-commerce is therefore not covered here.

[5] White paper 2011 | Mobility and Transport (europa.eu)

[6] Most prominently Community guidelines on State aid for railway undertakings (2008/C 184/07), and Community guidelines on State aid to maritime transport C(2004) 43.

2 Background and literature

Freight transport market

One way to understand how policy instruments may influence freight modal split is by applying a stylized representation of the market represented by the available transport solutions (supply), the choice (demand) for transport, and the boundaries defining the market such as geography, the overall policy framework, and technical and demographical trends.

The modal supply, both in terms of availability of transport solutions and the capacity of existing supply, depends on infrastructure and geography (Fowkes *et al.*, 2004; Brogan *et al.*, 2013). Longer coast promotes shipping, whereas mountains may restrict transport by rail. Road and rail transports are constrained by network capacity, whereas sea transports are constrained by ports, fairways, and the hinterland infrastructure. The supply of multimodal transport depends on the quality of the nodal and modal infrastructure in terms of linkages between terminals, ports, dry ports and airports (nodes) and roads, railways, and waterways (modes) (Ng *et al.*, 2018).

Firm's mode choice, e.g., the modal demand, is covered extensively in the literature (Holguín-Veras *et al.*, 2021). The most influential parameters are transportation cost, transit time, and reliability. These parameters depend on the character of the goods (setting the boundaries for the available transport alternatives), goods flow (determining trip frequency and regularity), and load factor. Beyond these central criteria, there are other aspects such as service quality, security, sustainability, etc. that influence decision makers to varying extents in different segments (Flodén and Woxenius, 2017).

Transportation cost includes the shipping cost from origin to destination and other services such as handling cost and insurance paid to the carrier to cover the transfer of risk (Brogan *et al.*, 2013; Lindgren and Vierth, 2017). Elasticity studies is one way to study how responsive transport demand is to changes in transport costs and time. The magnitudes of own- and cross-price elasticities can therefore indicate to some extent the potential effect of policy instruments on modal shift.

Transit time is impacted by distance, number of transfers, drayage operations, container loading, and local deliver, etc. Time in transit is generally considered by shippers' in all segments, with time variability ranging from a few minutes to several weeks depending on for example transport distance and type of commodities (Brogan *et al.*, 2013). The importance of time relative to cost differ between different segments and transport distances (Nealer, Matthews and Hendrickson, 2012; Steer Davis, 2015). Road generally has a time-related cost advantage for shorter distances while rail, and particularly sea transports, become more competitive over longer distances. Road and air transport tend to be used by commodities that are time-sensitive such as food products and post, as well as goods with high value-to weight ratio such as computers and electronics, or high damage costs such as furniture (Feo, Espino and García, 2011; Nealer, Matthews and Hendrickson, 2012; Brogan *et al.*, 2013; Lindgren and Vierth, 2017). In some segments, there is a trade-off between transport and inventory costs. More reliable, and therefore expensive, transport services allow for transport chains meeting just-in-time or just-in-sequence requirements along the transport chain. In other segments, longer time in transit may be more acceptable. Sea transports have a comparative advantage for time insensitive goods for which longer time in transport can be used as a moving inventory to avoid large storage costs (de Jong and Johansson, 2009; Windisch and de Jong, 2010). How the Covid pandemic is influencing the importance of time for mode choice is still too early to determine.

Reliability of transport is including both the degree of predictability and certainty of transport time. It is affected by factors such as maintenance of infrastructure, congestion, accidents and mismanagements, but also by extreme weather or natural disasters (Kaack *et al.*, 2018). Reliability is of increasing importance for just-in-time and just-in-sequence supply chain strategies, as well as for shippers of urgent deliveries or in cases of limited-service frequency (Fowkes *et al.*, 2004; Steer Davis, 2015). To meet reliability requirements, multimodal transport schedules often have built-in slack time to account for unexpected changes in travel time (Brogan *et al.*, 2013).

There is a range of other mode choice criteria, depending on the segment. Security, or damage risk, refers to the likelihood that goods will be damaged or lost during the transportation process, which can result in high costs for firms (Lindgren and Vierth, 2017). For transportation of high-value goods, such as luxury cars, security may be such an important factor that shippers only trust a few carriers in terms of protection of the shipment (Kaack *et al.*, 2018). Moreover, the availability of value-added services in nodal infrastructure, such as storage space, recharging points, repairing facilities and transport service providers impact on mode choice, as well as the compatibility of infrastructure to the characteristics of different modes (e.g., capacity and dimensions of quay cranes). Other factors that relate to the attractiveness of transport service include the possibilities to track cargo, availability of certain conditions such as refrigerated cargo, service help desk, etc.

In recent years, transport companies are confronted with higher demand for environmental certification and increased scrutiny of their environmental impacts, for example with regards to pollution, land use and climate change (Brogan *et al.*, 2013). Environmentally efficient transport is, however, less of a priority in relation to price and time aspects. A repeated survey with Swedish companies shows that this low ranking of environmental aspects in transport purchase decisions is stable over time. Trucks with low emission standards is the environmental attribute regarded as most important. As stricter environmental requirements are introduced, there could be a potential to differentiate the transport service market to accommodate companies making efforts to greening the transport chain (Lammgård and Andersson, 2014).

Finally, freight transport is largely impacted by the globalization of markets and of demographical change (Transport Analysis, 2020b). The impact of different trends on freight transport demand, and how they interact with introduced and planned policy instruments, is hard to forecast. In Sweden, both high-technological services and production of raw material are economically important industries (Transport Analysis, 2017c). The development of these industries affects the transportation demands in different segments, including the suitability of different modes.

Common methodological approaches

A variety of methodological approaches is used to describe and predict mode choice, as well as to explain the drivers behind mode choice. Market share models is one common approach using aggregate average data variables to explain the drivers behind differences in the market share of a particular transport mode. The market can be defined in various ways, e.g., on geographic scale, on a set of commodity types, or a combination of both. These types of models can be used to evaluate the overall effect of a policy instrument on modal split. Another approach is to use micro-level data on the shipment level to explain the determinants of a given freight mode decision, for example by evaluating the impact of transit times or freight rate on mode choice. There are also some efforts within behavioural economics and game theory to capture important variables influencing mode choice that available data and standard econometric models fail to capture (see e.g. Hensher and Puckett, 2005, 2007; Hensher, Puckett and Rose, 2007).

Network models are often used to forecast transport flows and demand. The results can be used as input to infrastructure planning and investments, as well as to study the impact of policy instruments. The modelling of freight transport decision-making is less advanced than for passenger transport. One reason is that the representation of the freight transport market decision-making is much more complex compared to passenger demand (Liedtke, 2009). Whereas the passenger is the central decision maker in the passenger transport market, freight transport decisions involve several actors (shipper, carriers, intermediaries, and operators, as well as infrastructure managers and authorities). The logistic solution may involve a combination of several modes, often determined by logistics service providers and carriers (Jensen *et al.*, 2018). Efforts are made to improve system models underlying planning and policy evaluation of the freight transport market. One of the major developments in the last decade is the development towards including micro-level logistics decisions in the national transport models. This development has improved the models' capacity to study for example policy effects on firm-level behaviour and how it impacts on the aggregate dynamics of freight demand and supply (Ben-Akiva and de Jong, 2013). The mode choice is modelled at the disaggregate level of the firm given costs associated with transport, inventory, and intermediate points such as transhipment terminal. The models can include one or several logistics decisions at the disaggregate level, including shippers' choice of shipment size (frequency of transports); shippers' choice of loading unit (e.g., container or not); shippers/forwarders' choice of transport mode(s) in the transport chain, forwarders/carriers' choice of transshipment terminals; and forwarders/carriers' choice of return transports (Ben-Akiva and de Jong, 2013).

In Sweden, the national freight transport model, SAMGODS, includes a logistics model. The estimation of firms' transport demand of different size in different zones inside and outside the country are based on the Commodity Flow Survey (de Jong, Ben-Akiva and Baak, 2010; Bernhardsson and Rosklint, 2016). The Swedish Commodity Flow Survey (CFS) is the most comprehensive set of information of the Swedish freight transport market. The survey is conducted about every five years and covers information necessary to describe the shippers' choice of e.g., unimodal and multimodal transport chains. Part of the information is collected from a stratified sample of shippers and carriers, part of the information is collected from agencies, industry, and a few individual firms. The Swedish CFS data enables studies with a comparatively large number of observations (Holguín-Veras *et al.*, 2021), which makes it a unique data set in Europe. The CFS data has been used in econometric studies to estimate mode and shipment size, as well as mode and shipment size elasticities (see for example Jong and Johansson, 2009; Windisch and Jong, 2010; Jensen *et al.*, 2018; Abate *et al.*, 2019; Vierth *et al.*, 2020).

Other sources that could be used for following up the freight transport market include the transport statistics[7] (published by Transport Analysis) and the Transport Purchasing Panel[8]. The yearly transport statistics are based on information from firms performing road, rail, sea, and air transports. In contrast to the CFS data, they do not include information about transport chains necessary to study the development of multimodal transport. In multimodal chains, the transport statistics count the same ton cargo several times. The Transport Purchasing panel is a public-private initiative collecting data every second year through a survey covering manufacturing and wholesale companies with more than 100 employees.

Policy instruments

There are different attempts to classify policy instruments promoting modal shift (Pinchasik *et al.*, 2020). Here, we focus on policy instruments within the categories economic (subsidies and taxes), administrative (regulations and infrastructure), and information (research, innovation, dissemination) that seek to strengthen the relative competitiveness of rail and sea transport (sometimes referred to as pull measures) or making road transport less attractive (push measures). Takman et al. (2020) include as well the categories "investments in infrastructure" and "research" in their world-wide (although biased towards Europe) overview of freight transport policy instruments.

Whether a policy instrument is effective is evaluated in relation to the policy objective. The effectiveness depends on the extent to which the policy accurately targets the intended actors, as well as affect their incentives to act in the desired way, and their opportunities to change behavior (Holguín-Veras, 2002; Le Pira *et al.*, 2017). Whether a policy is efficient from a social point of view, depends on the degree to which it induces individual actors to make choices that better align with society's overall interests, including for example environmental and health concerns. From an economic theoretical point of view, and in line with the polluter pays principle, transport policies designed to internalize the external costs of respective transport modes would steer towards a more efficient transport system with respect to both

[7] Statistikportalen (trafa.se)

[8] https://www.chalmers.se/en/centres/lead/TransportPurchasingPanel/Pages/default.aspx

modal distribution and transport demand. Such policies are technique neutral. In this context, that implies that they do not favor any mode but rely on price signals to steer actors towards efficient technology development and implementation. The introduction of modal shift as a policy objective, rather than one of many policy instruments, is hence inefficient from a societal point of view. A modal shift objective is not technique neutral per definition.

At the same time, even though general economic policies, such as the carbon tax, are promoted as a cornerstone in transport policies, full-scale implementation is seldom feasible in the intermediate future due to political constraints and multiple interacting market failures (Mandell, Nilsson and Vierth, 2014; Rodrik, 2014). In the maritime sector for example, where CO_2 emissions make up a large part of the non-internalized external costs related to shipping, carbon pricing remains an unused potential (Nikolakaki, 2012; Parry *et al.*, 2018).[9] Policy makers often use a combination of general and more specific instruments to steer actors to act in ways desirable for target achievement, for example by combining policy instruments promoting modal shifts with technical requirements and carbon pricing. In this regard, the treatment of modal shift as an objective may be a political means to envision the direction of desirable future development.

The consequence of modal shifts being interpreted both as a political objective as well as a policy means, is firstly that it constrains political flexibility, and secondly that it complicates the possibility to evaluate its effectiveness. The modal backshift discussion is an example of this. Modal backshift refers to policies that negatively affect the relative competitiveness of alternative modes to road and thereby may induce substitution effects. If the political ambition is to reach a certain modal split target, a policy instrument that is inducing (or predicted to induce) modal backshift is ineffective as it moves the transport sector further away from that target achievement. However, if modal shift is a means to achieving an efficient transport sector, modal split constraints are non-binding, and the effect of the policy instrument must be determined in relation to realizing transport efficiency from a societal point of view.

Economic instruments

Taxes and fees are levied on the transport market motivated by different political objectives. Very generalized, some taxes are motivated to internalize externalities (e.g., carbon tax - in line with the polluter pays principle), some are motivated to finance parts of the infrastructure necessary for the operation of the traffic mode (e.g., energy tax, pilot fees, rail fees, and road fees for heavy vehicles - in line with the user pays principle), and some are introduced because of its fiscal qualities. For road and rail, external costs are dominated by costs related to infrastructure. For maritime transport, environmentally harmful emissions dominate the external costs. In Sweden, taxes and fees have remained relatively constant for trucks the last ten years. For sea and rail transport the costs have almost doubled during the same period in line with the effort to increase the fees until they correspond to the social marginal costs related to sea and rail transports (Johansson, Vierth and Bondemark, 2020).

Within the EU, the design of fuel taxes is restricted by the energy tax directive (Directive 2003/96/EG), and the Eurovignette directive (Directive 2011/76/EU) regulates the way taxes and fees can be levied on heavy vehicles. In Sweden, Denmark, the Netherlands, and Luxemburg a time-based eurovignette is levied on heavy trucks, whereas in for example Germany, Austria, and the Czech Republic the eurovignette is distance-based (Transport Analysis, 2020a). The European Commission (2017b) has disregarded time-based eurovignettes as cost-inefficient as they are not directly linked to the external effects of road wear, noise pollution, and traffic security. Amendments to the directive are under negotiation. The current proposal is that all eurovignettes should be distance-based rather than time-based (SOU, 2017). The Swedish government has commissioned a special investigator to analyze the design of a new alternative system to the current eurovignette fee for road freight transports that should

[9] The discussions of regional or global emissions trading systems, discussed above, could change this.

contribute to the realization of environmental and climate targets. The results should be presented in September 2021.[10]

The Swedish fairway dues system is an example of a fee motivated both to internalize external costs and to finance the operations of the Swedish Maritime Administration (SMA). This is different from the road sector, where the maintenance of the road infrastructure is financed through general taxes. The SMA is responsible for maintaining fairways, pilotage, ice breaking and rescue service, as well as to reduce the impact of shipping on the environment. The Swedish system is comparatively unique as the fairway dues are differentiated based on environmental performance considering CO_2, NO_x, SO_x and PM emissions, as well as chemical use and waste management. The current system implements frequency rebates for ships that call a port more than five times a month. The discount system implies that the first call per month is the most expensive, which can be a barrier for a shift from road to sea transport (Lindé, Vierth and Cullinane, 2019). In 2019, only 8 % of the ropax-ferries' calls (that carry passengers and freight) paid fully. For cargo vessels, the corresponding numbers ranged between 40–80%. The implication is that the current model indirectly favors high-frequency passenger transport (Johansson, Vierth and Bondemark, 2020).

Some tax designs, and tax exemptions, are politically motivated to affect the competitiveness of different modes or sectors within the industry. Sea and rail freight transport in Sweden are for example exempted from energy- and carbon taxes. Similarly, energy and carbon taxes are lower for diesel which is the main fuel used for truck transports.[11] Ships can apply for refund for electricity usage at berth and in port. The purpose is to incentivize usage of electricity instead of auxiliary engines often running on fossil fuels in port (Swedish Tax Authority, 2020).

Subsidies for freight transport are often politically motivated to reduce the differences in costs between road and alternative transport modes, as the higher costs for these alternatives are perceived as the main barriers for their uptake. In principle, EU law (EUF Treaty, article 107.1) does not permit state aid to commercial activity. However, exceptions can be made to facilitate development of certain industries or regions, if it does not adversely impact trade (article 107.2-3). For example, in 2004, the Community guidelines on State aid to maritime transport (2004/C 13/03) was issued, all state aid favoring maritime transport must follow the guidelines. State aid can be granted for a shipping service within EU territorial water for a period of maximum three years. The service must facilitate to shift transport partly or fully from road to sea, and aid can only be issued to a pre-specified service which environmental effects are pre-determined. In Sweden, Norway, UK, and Italy, subsidy schemes targeting modal shift to maritime transport, so-called eco-bonus, have been introduced based on these guidelines. The exact design differs between countries. In Sweden, the subsidy is directed to shipping companies offering new or improved short-sea services that are replacing road transport (Transport Analysis, 2019a). The current environmental performance is calculated using the NTM Calculation Tool administered by a Swedish NGO. The unit values in the Swedish CBA guidelines are applied (ASEK[12]). In Italy, the eco-bonus scheme is broader and operators that combine road with maritime transports qualify for economic compensation (Tsamboulas *et al.*, 2015).

Another example of a subsidy is the environmental compensation for freight transport on rail, administrated by the Swedish Transport Administration since 2018. Similarly to eco-bonus, the Community guidelines on State aid for railway undertakings (2008/C 184/07) adopted in 2008 affect the design. Compensation that corresponds to the external costs that can be avoided by transport by rail can be issued. In Sweden, the subsidy is motivated as a means to strengthen the competitiveness of rail and contribute to modal shift. The compensation is paid out retroactively in relation to the ton-km

[10] Nytt miljöstyrande system för godstransporter på väg - Regeringen.se

[11] Energiskatt, koldioxidskatt, svavelskatt | Rättslig vägledning | Skatteverket

[12] ASEK, Analysmetod och samhällsekonomiska kalkylvärden - Trafikverket

performed and the calculation of the external costs are based on the Handbook on the external costs of transport.[13] (In section 4, a more detail account for eco-bonus and environmental compensation for rail are given).

Marco Polo and Motorways of the Sea are examples of subsidy programs at the European level aiming at shifting freight transports off the road and promoting multimodal transport chains including shortsea shipping, rail, and inland waterways in different combinations. The effectiveness of these programs has been questioned. The Swedish Maritime Administration together with public, private, and academic partners ran the project MonaLisa and MonaLisa 2.0 with EU-funding under Motorways of the sea during 2012-2015. Using insights from air traffic management, the project aimed at improving interoperable vessel traffic management including environmental performance and just-in-time deliveries. The main outcome of the project was the development of a route planning and route information sharing tool integrating seaborne and shore-based information as well as environmental and maritime spatial planning information. The aim of the validation project was to collect sufficient data for manufacturers to continue developing the services of the tool. However, the scientific review of the project (Dahlman, 2019) noted that the effects on optimized route choice, improvement of environmental performance, maritime safety, or competitiveness with other modes was hard to assess as there was no collection of baseline data. One of the more fundamental problems identified was that many of the services developed and tested were not based on an assessment of user need, implying that many of the services would not reach commercialization. It was concluded that continued political and financial support is essential for large-scale implementation of the traffic management tool. The general evaluation of Motorways of the Sea suggested that projects have contributed to a modal shift from road to sea to some degree, but that the data on environmental effects is too scarce to evaluate (European Commission, 2017a).

In their evaluation of the Marco Polo programs, the European Court of Auditors (2013) recommended the European Parliament and Commission to discontinue this form of top-down EU funding for freight transport services. The assessment was that it leads to insufficient market uptake (few applications), low evidence of impact on achieving objectives (little impact in shifting freight off the roads, and no data to assess the expected benefits of diminishing the environmental impact of freight transport, easing congestion, and improving road safety), high administrative burden, and low additionality (13 of the 16 beneficiaries audited confirmed that they would have started and run the transport service even without the EU funding). The auditors also found that the management of the Marco Polo funding scheme improved over time in terms of funding more high-quality projects. However, as there was no ex-ante market analysis of why multimodal transport was not carried out, the effectiveness of the project in removing barriers to move freight off the road remained limited.

Administrative instruments

Important administrative policy instruments targeting modal shift are infrastructure investments and programs including improvement of capacity on rail network, road access to dry ports, and navigable waterways (modal infrastructure), as well as investments in ports and combi terminals (nodal infrastructure). These measures are usually motivated from several policy objectives, including modal shift and multimodality. The construction of the world's longest road and rail tunnel Fehrman-belt is an example of a large infrastructure project that will impact on rail transport supply. It is funded by EU grants (under Connecting Europe Facility scheme) and supported by Danish and Swedish funds.

Within the EU, the TEN-T directive together with the Transport White Paper sets the overall regulatory framework for the development of a long-distance freight transport sector shifting towards less carbon intensive modes of transport. TEN-T aims at ensuring connectivity of all regions of the EU (comprehensive network) while prioritizing parts with the highest strategic importance for the union

[13] Handbook on the external costs of transport - Publications Office of the EU (europa.eu)

(core network). The implementation of the networks is legally binding, with the core network to be implemented by 2030 and the comprehensive network by 2050. It is safe to assume that the comprehensive work carried out within the European Union during 2020 outlined in the Sustainable and smart mobility strategy (COM(2020) 789 final) in line with the European Green Deal will impact considerably on the future transport market.

The EU Combined transport directive (92/106/EEC) is an administrative policy meant to increase the competitiveness of combined transport against road-only transport. It is one of the EU measures to promote a shift from road freight transport to rail and water. In 2017, a simplification of the directive was proposed along with the introduction of economic compensation for investments in infrastructure such as international combi-terminals, etc. Amendments to the directive are still under negotiation, but they are expected to facilitate further development of multimodal transport by simplifying cross-border procedures, including the provision of additional exemptions to cabotage rules and allowing the provision of economic incentives (Pastori *et al.*, 2018). The EU mobility package ((EU) 2020/1054) including regulations on driving and rest times and cabotage for the road sector could also improve the competitiveness for sea and rail. Yet other trends, are pointing towards continued strengthening of the road sector. The so-called infrastructure directive (EU 2019/I242) will impact on future investments in charging infrastructure and hydrogen development for heavy vehicles.

Other administrative instruments indirectly affect the competitiveness of transport modes. The Sulphur Directive (2012/33/EU) came into force in EU in 2015. It demands lower Sulphur content in marine fuels within SECA (covering the North Sea, Baltic Sea and English Channel) to decrease air pollutants. As fuels with lower Sulphur content are more expensive, the directive is an example of an administrative instrument with impact on relative transport costs between modes as it affects fuel cost. It has attracted attention from the perspective of a modal backshift. There were concerns that the directive would induce a higher road transport demand at the expense of sea transports. Such effects have not been established in Sweden. Instead, the intended positive effects on air quality have been achieved and the general compliance is found to be high (Transport Analysis, 2017b). However, the long-term effects of the directive on modal shift and transport efficiency and environmental impact are yet to be determined (Raza, Woxenius and Finnsgård, 2019).

In Sweden, the infrastructure plan sets the long-term planning horizon for infrastructure maintenance, investment, and public procurement. The strategic planning document for next period (2022-2033 and 2022-2037) states that the environmental impact caused by freight transports must be reduced and that this *to a certain extent* can be achieved by modal shift. Modal shift is shown to play a minor role for the achievement of the CO_2 reduction target (Swedish Transport Administration, 2020d). In contrast, the National freight strategy from 2018 is, as previously mentioned, promoting modal shift as one of three overarching objectives.

Information instruments

Finally, information as a policy instrument, or investments in knowledge and innovation generation, are usually motivated based on the need for internalizing positive externalities (knowledge externalities, network externalities) that could improve the conditions for modal shift. For example, the Swedish Transport Administration hosts a rail sector platform “Together for on-time trains” that aims at improving punctuality in the rail sector via collaboration and availability of open data.

A similar example is the public-private enterprise Shift2Rail, formed under Horizon 2020, to coordinate research and innovation within the rail sector ((EU) nr 642/2014). The research should contribute to an increased modal shift to rail by increasing competitiveness and interoperability within the union. The national promotor for shortsea shipping and inland navigation installed in Sweden 2018 is another example.

3 Freight transport in Sweden

The Swedish freight transport market is heavily influenced by the natural resource and base industries of ore, steel, forestry, and petrochemicals producing the largest freight volumes. Production is mainly concentrated to the northern parts of Sweden, the west coast, and the northern east coast. Whereas most of the consumption is concentrated in southern Sweden, where population density is higher. Ore and mineral constitute the largest share of the total freight in tons transported by truck (34 %) and rail (46 %). About 85 % of the export volume in tons is constituted by ore, steel, forestry, and petrochemical products. Import is dominated by oil and petrochemical products (Transport Analysis, 2016). For wood and ore products, some rail infrastructure has been developed to move the goods from industry to ports (Rich, Kveiborg and Hansen, 2011). The state-owned company Green Cargo dominates the market for system trains (Gustafsson and Nyström, 2019).

Sweden's long coastline is favorable for maritime transportation and shipping is dominating the international trade. In 2011, five of Sweden's more than 100 ports were selected as part of the core infrastructure within TEN-T (Transport Analysis, 2019b). Port of Gothenburg is the largest port in Scandinavia operating around 60 % of containerized goods flows. Freight shuttle trains go between 25 railway terminals located in different part in Sweden (Bergqvist and Woxenius, 2011; Wallmark, 2015; WSP, 2019).

Freight transports are predicted to increase in Sweden by 50 % to 2040, particularly transports concentrated on larger paths and corridors (Swedish Transport Administration, 2020f). In general, the Swedish transport sector is experiencing a structural shift towards transport chains using larger vehicles operating between a few important nodes (WSP, 2019). In 2014, the Swedish commercial fleet was the smallest since 1970, in terms of ships while the total gross tonnage of the fleet has remained relatively constant. Internationally, the average gross tonnage of ships has increased by about 80 % between 2005 and 2012 (Transport Analysis, 2016). One of the reasons is the global trend towards consolidation and specialization within logistics. The share of goods transported in standardized units is increasing, which increases the possibilities for multimodality. In Sweden, growth in transportation by rail is taking place for commodities that are transported in multimodal chains (Transport Analysis, 2016). Particularly semi-trailers are gaining increasing importance. They can more easily optimize the load factor in both directions compared to container transports that more often are carried empty on the return trip. Between 2009 and 2017, the load factor on semi-trailers was 85 – 90 % on average and 60 % for containers. As reloading costs make up a large share of total transport costs in multimodal transport chains, the load factor is of major importance (Bergqvist, 2019; Transport Analysis, 2019a).

In 2018, permission for trucks of higher bearing capacity class (BK4 allowing 74 tons instead of 64 tons) was introduced on about 11 % of the public road network. The share of roads allowing for heavier trucks has successively expanded. In 2020, the share was around 20 % of the public roads and the share is expected to increase to 40 % by 2025 (Swedish Transport Administration, 2020c). Transport by longer and heavier road vehicles reduces emissions per ton-km as fewer vehicles are needed to transport the same amount of freight. However, the overall impact on the transport system is not established. The empirical question is to what extent emission reductions from road transports are offset by induced traffic and freight shifting to road from sea and rail. Allowance for even longer vehicles (from 22,25 to 34,5 meter) have been proposed on Swedish roads in 2021. The Swedish Transport Agency (2019b) argues that the reform is likely to increase transport efficiency and that this may induce some unwanted modal shift for long-distance freight transports. On the other hand, they argue that given available combi terminals, policy instruments may neutralize unwanted modal shift and instead promote a larger share of multimodal freight transport. The overall impact, it is concluded, depends on the policy mix. The difficulty of determining these effects is demonstrated in Vierth et al. (2018) who study the effect of a previous dimension reform allowing longer and heavier vehicles on part of the road network on mode distribution and environmental emissions. The authors found a high degree of incorporation of the longer and heavier vehicles in the fleet resulting in higher road freight efficiency (fewer vehicle-km needed for a given amount of ton-km). Even though road by far contribute to most emissions, the authors could not establish that the dimension reforms were associated with adverse environmental impacts for the overall freight transport sector during the period studied.

The multimodal freight transport market is dominated by a few multimodal operators and a few large forwarders/haulers (Vierth, 2012; Flodén and Woxenius, 2017). In most ports in Sweden, terminal and port activities are handled by the same company. There is however an increasing trend towards contracting the terminal activity to an external operator, which is a more common model in Europe. If the operator also owns ships and carries out transport, it has limited incentives to allow for competitors to utilize the port. Gothenburg Port, and a few other ports, have entered long-term contracts with external operators. This restricts the possibilities for operators to find enough capacity to establish new terminals or transport services. The EU has been working on ways to facilitate access to the port services market for several years (Gonzalez-Aregall, Cullinane and Vierth, 2021). The so-called Port Regulation (EU 2017/352) entered into force in 2019 with regulations about access and financial transparency and with the aim to "reduce costs for transport users and contributing to the promotion of short sea shipping and a better integration of maritime transport with rail, inland waterway and road transport". Whether this regulation will change the market conditions in Sweden remains to be determined, however Transport Analysis (2019a) points out that if the regulation actualizes the application of more correct procurement procedures it could have a positive effect.

Potential for mode shift

Several studies in recent years have concluded that there is little competitiveness between modes in Sweden (see e.g., Rich, Kveiborg and Hansen, 2011; Haram, Hovi and Caspersen, 2015). Most goods are transported with the most comparatively advantageous mode: road for shorter distance transport and transport where there is limited access (forestry), shipping for long distance and heavy cargo transportation, rail for transport of ore and steel from the base industries (Transport Analysis, 2016). Inland waterway transport is possible from Lake Vänern (via Göta canal) and Lake Mälaren (via Södertälje canal). The share of transport on inland waterways is very low. In 2021, less than one percent of the goods, in tons, with senders and receivers in Sweden was transported on inland waterways, and seven percent if counting multimodal chains including inland waterways (Transport Analysis, 2016). The types of cargo mainly transported by inland waterways are liquid fuels, forestry, and mining goods (Roso *et al.*, 2020). Since 2014, there are less strict EU regulations (EU 2016/1629) for ships trafficking inland waterways. Six new zones for inland waterway shipping in Sweden have been designated.[14]

On an aggregated level, the modal split of freight transport is relatively stable over time. Between 2011-2016, sea and rail decreased their shares with a few percentage points, whereas road transport increased a bit (Vierth *et al.*, 2020). The modal split (published in the official transport statistics) says nothing about how multimodal transport chains have developed over time. Modal shifts can be caused by different ton-km increase rates for road, rail and sea transports. The establishment of such trends is constrained by the availability of statistics. Comparing the information in the CFS from 2009 and 2016, Transport Analysis (2019a) cannot establish a trend towards increasing shares of multimodal transports. In the 2016, around 60 % of the freight transports, regardless of whether measured in value or ton, were unimodal. According to the answers in the Swedish Transport Purchasing Panel the share of unimodal road transports is a little bit higher, it lies around 75 % for the last four rounds of the survey (Styhre *et al.*, 2019).

Previous studies of modal shift potential, based on transport distances and assumed transport costs, show rather low potential in Sweden. These studies are not considering shipper specific logistics. Transport Analysis (2016) estimates that less than 10 % of the freight transport flow within Sweden in ton has potential to shift from truck to other modes, based on assumptions about suitable distances and

[14] Nya vägar för inlandssjöfarten (transportstyrelsen.se)

commodity types. The Swedish Transport Administration (2012) estimates, allegedly based on a back of the envelope calculation, that around 3-7 per cent of freight transports in ton could be shifted to waterborne transports and 2-10 per cent to rail. Their upper bound is in line with the findings in Vierth et al (2020), where around 5 – 18 percent of current road transport volumes, in ton-km, is estimated to have potential to shift to sea and rail transport. The authors stress that the real potential probably lies closer to the lower bound. Particularly some of the 7 % ton-km that has shifted from rail and shipping to road during the period 2011-2017 should have potential to shift back given the right policy mix. Based on the findings by Vierth et al (2020), the Swedish Maritime Administration (2020) estimates that a 5 % shift of ton-km from road to sea is equivalent to 82,000 transports by truck, using data from 2019. In a previous study, the Swedish Maritime Administration (2016) predicts changes in waterborne transports from hypothetical reductions in fees using the Samgods model. The results indicate that the ton-km transported by coastal and inland waterways could increase by 3 % if fairway dues were completely abolished. Transport Analysis (2019a) estimated the effect of a hypothetical decrease in transfer costs on demand for rail and shipping using Samgods (not considering capacity constraints). They found that a 10 % decrease in the transfer costs is associated with a 2 % decrease in freight transports by road, in ton-km. Freight transports on rail and shipping were estimated to increase by 2,5 % and 0,7 % respectively.

In the Transport White Paper distances above 300 km are identified as competitive for multimodal transport compared to road. Transport Analysis (2019a) estimates that transports of containerized freight on a road-rail chains can compete with unimodal road transports on distances above 350 km, considering transfer costs and time. For ship-road/rail chains, the corresponding distance increases to 550 km. On these distances reloading costs are estimated to be about 73 % of the total transportation costs for rail-road chains, and 75 % for multimodal sea transports. In 2016, more than half of the Swedish transport distances carried out by truck was shorter than 50 km and only four per cent above 300 km. However, these trips constituted 42 % of all ton-km performed by Swedish trucks during the same year (Takman, Trosvik and Vierth, 2020).

Commodity types that are transported on distances longer than 300 km and for which the modal split is not completely dominated by road can be indicative of where there may be potential to realize modal shift. In table A-1, the distribution of freight in ton-km on modes and commodity types are listed. The share of freight transported with Swedish trucks on distances shorter and longer than 300 km are also included. Of course, this simple way of categorizing goods is not considering geographical conditions such as access to rail and sea. The substitutability between modes is non-existent for some distances. This so-called structural inelasticity is particularly strong for shorter distances and certain commodity types, such as ore (Rich, Kveiborg and Hansen, 2011). However, this categorization displays the current modal split for different commodity types.

In Figure 1, commodity types are sorted in descending order based on the share of ton-km carried out on trips by road longer than 300 km. Figure 2 shows the modal split per commodity type. A large share of the commodity types consolidated goods, metal products, food, transport equipment and forestry products are longer-distance transports. These transports can be linked in multimodal transport chains.

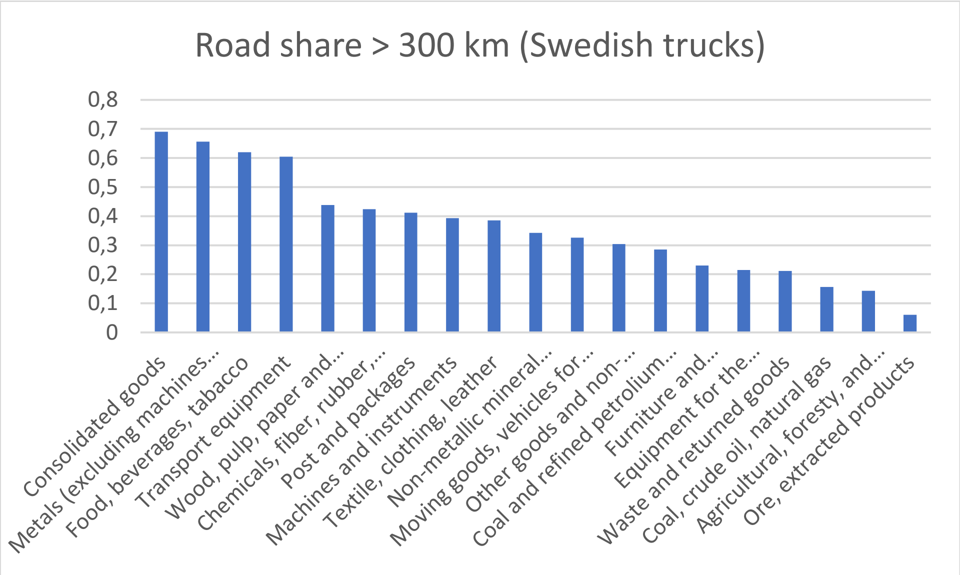

Figure 1. Share of freight transport on Swedish trucks on distances > 300 km per commodity type. The freight transported on foreign trucks is not included as the statistics do not allow to differentiate trips based on distance covered. Source: Transport Analysis (2017d)

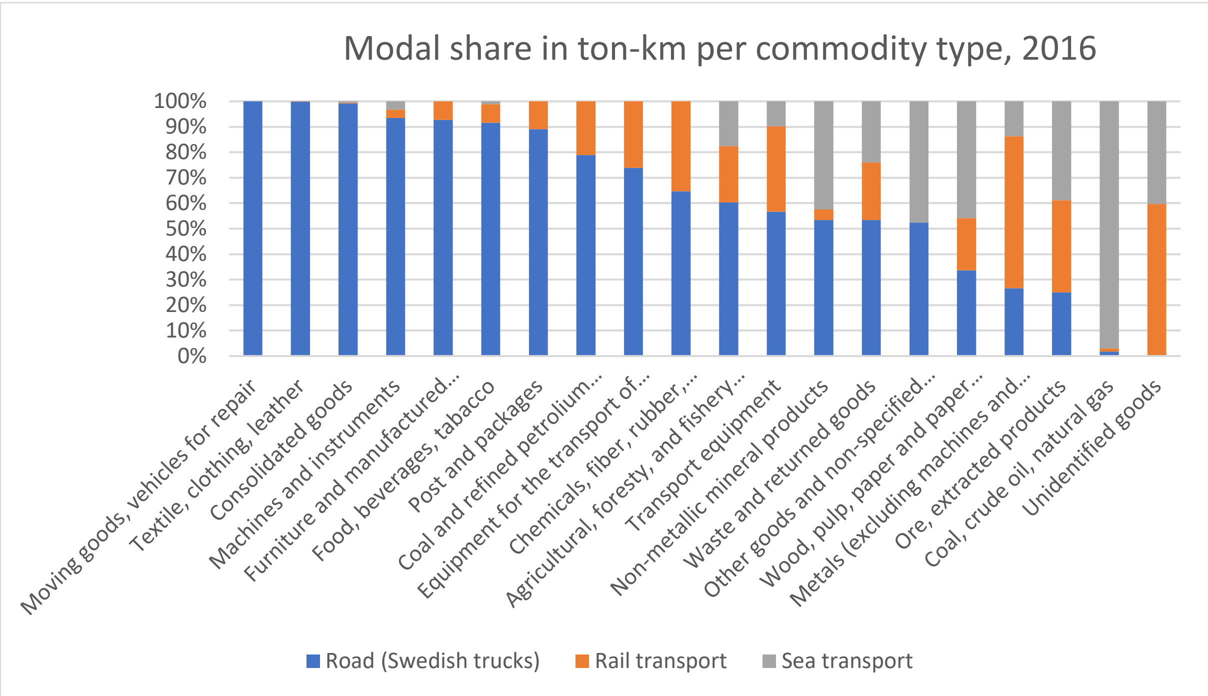

Figure 2. Modal split between road (only including Swedish trucks), rail and shipping per commodity type. Source: Transport Analysis (2017d)

Allegedly, all estimations of the theoretical potential for modal shift are only indicative of the potential that can be realized through infrastructure investments, technology development, and policies. In the short run, some freight could technically be absorbed by using existing capacity on rail and sea more efficiently. In the longer run, the potential to shift more freight to rail is constrained due to the many capacity problems associated with rail infrastructure (Swedish Transport Administration, 2019a). The quality of rail infrastructure has deteriorated over time, also in comparison to the development in other countries Many of the combi terminals are located close to larger cities or nodes, where freight transport is competing with passenger transport on several distances. The distances between the three main metropolitan areas Stockholm, Göteborg, and Malmö are particularly constrained (Transport Analysis, 2016). Policy impact depends largely on the responsiveness of shippers to changes in costs. Previous studies of mode distribution for freight transport based on revealed preferences in the Swedish CFS, show that mode choice responsiveness to cost and time is small on average (Abate, Vierth and Jong, 2014; Vierth and Merkel, 2020). However, cost responsiveness differs between different commodity types, shipment sizes, value density of goods, and level of access to rail and waterways (de Jong and Johansson, 2009; Windisch and de Jong, 2010; Rich, Kveiborg and Hansen, 2011; Jensen *et al.*, 2018; Abate *et al.*, 2019). This implies that even very ambitious economic policy instruments may have limited modal shift effects in some regions and market segments.

Demand for road transports for chemicals, metallurgic products, paper products, machines, manufactured goods, and consolidated goods are relatively responsive to changes in transport costs (Rich, Kveiborg and Hansen, 2011; Jensen *et al.*, 2018). For particularly sawmills and production of paper, transport constitutes a large share of the total production costs, and the demand for road transport is highly responsive to increases in transport costs (Hammar, 2006; Transport Analysis, 2017e). Vierth et al. (2020) categorize commodity types with potential to shift to shipping using four selection criteria: 1) trips covering distances over 300 km, 2) max 90 % of current transports in ton-km is performed by ship, 2) 10 % of the goods are currently transported on road, 3) the commodity type is responsive to changes in transport costs. The commodity types that fulfill these selection criteria include ore, food, chemicals, metallurgic products, transportation equipment, and furniture and other manufactured goods. The study is not constraining shifts to occur from road to ship, and the estimates could include a shift from rail to shipping. Abate et al., (2014) estimate that commodities within the categories paper products, cement, lime stone, building material, coal, lignite, and mineral oils have potential to shift from road to inland waterways.

Apart from commodity groups, transports in unitized cargo units have more potential to accommodate a shift. The freight with most potential is that transported in containers and trailers. A major part of the European freight is already carried part of the distances by short-sea shipping, e.g., between Denmark, Germany, and Poland. About a third of the freight flows transported on trucks in south of Sweden are transit flows between Europe and mid Sweden, Gothenburg, or Oslo. Some of these flows could continue the transport with short-sea ships. If all freight transited through south of Sweden on trucks was shifted to short-sea shipping to a port closer to start or end of its journey, 4-11 % of CO_2 emissions could be reduced (Region Skåne, 2019).[15]

In general, the stable Ro-ro freight flows from the base industries and forest sector trafficking the Baltic coast and the Bothnian Sea could have potential to be used to a higher extent for other commodity segments (Swedish Maritime Administration, 2016). For these shifts to take place, coordination between flows and consolidation of goods is necessary. The major barriers are the large transfer costs and difficulties to meet the demand for transport frequency. One recent example of a collaborative effort where these barriers have been removed, is the Swedish grocery company ICA's decision to shift some of their freight from truck to rail.[16] The solution is the result of a research project on horizontally integrated transport chains financed by the Swedish Transport Administration.[17] The project investigated the potential to coordinate load from ICA on the steel company SSAB's rail transports. The Swedish grocery company Coop and the bread company Polarbröd are precursors to shifting transports from truck to rail. Since 2012, the transportation of groceries on Swedish territory by sea, has also increased. The loading is mainly taking part around Strömstad close to Gothenburg Port and about 80 % of the freight is unloaded in three coastal zones; the south-east, Norrtälje/Nynäshamn, and Karlskrona/Trelleborg (Swedish Maritime Administration, 2016). The forest industry shows a similar potential for shifting freight by balancing flows. The forest industry has large exports of forestry products. The difficulty is to find ways to consolidate smaller import volumes or domestic transports on

[15] Based on the assumption that each ton-km freight shifted from road to sea contributes to halving the CO_2 emissions.
[16] ICA flyttar transporter från lastbil till tåg | TRANSPORTochLOGISTIK.se
[17] Horizontal collaborations for increased transport effectiveness | CLOSER (lindholmen.se)

the return trip. Collaboration between the forest industry and other industries could therefore potentially result in identifying new freight flows to shift to rail and sea (Swedish Transport Administration, 2020a). However, the (private) stakeholders do not seem to have (large enough) incentives to develop this type of solutions (improved balancing etc.) as voluntary measures.

It should be noted that a shift of freight transports to existing transport chains including greater use of shipping not necessarily contribute to lower external costs. Vierth, Sowa, and Cullinane (2019) use both Sweden's national guidelines for cost–benefit analysis (ASEK) and the European guidelines (Ricardo) to evaluate the external costs of two alternative freight transport options. They estimate that the external costs for a combined road and shipping option is lower than for a direct shipping using both ASEK and Ricardo values when internalizing taxes and fees are considered. This is the case also when the direct shipping option complies with the most stringent environmental regulations. The authors note that the CBA analysis of different transport chains is largely influenced by the guidelines and that emission factors should be regularly updated.

Stakeholder's view on potential for modal shift

To collect firsthand information from Swedish stakeholders involved in the freight transport market, focus group discussions (Parker and Tritter, 2006) were conducted during 2018 as part of this study. The aim was to identify factors that affect firms' mode choice, to discuss existing barriers to shift freight transports from road to rail and water, and to identify how mode choice determinants and barriers differ between different market segments. The focus group consisted of 16 stakeholders representing large logistics service providers in Sweden. As Sweden has a relatively high share of large firms that buy transports, it was regarded important to involve those stakeholders that are involved in large transport flows. All stakeholders were promised confidentiality.

Table 2 summarizes the segments that the participants discussed as having the greatest potential for a modal shift. These include low value commodities, commodities shipped in logistic systems (for example steel, paper, and wood), repeated or regular transportation flows, large volumes, and combination of commodities with differentiated delivery requirements. These segments are largely corresponding to the potential identified in the literature discussed above. Less suitable segments for a modal shift according to the participants were consumer products (e-commerce), temporary transportations, small volumes, high commodity value and commodities with short shelf-life.

The participants acknowledged that most segments with potential for modal shift already, to a large extent, are transported by rail or water. This is emphasized by the following comment by one of the stakeholders: "*Transportation by rail or sea is already used by those who face good conditions for it*". One stakeholder argued that the political goal of realizing modal shift is too narrowly defined. Because of the last-mile problem for most transport chains, road must be used at some point. Hence, an increase in multimodal transport might be a more realistic goal than modal shift from road to sea and railway.

Tabel 2. Segments with the greatest potential for an increased modal shift identified by stakeholders

Segments suitable for a modal shift	**Comment**
Low value commodities	Such as steel, paper, and wood
Commodities shipped in logistic systems	For example, steel paper and wood, however many of these commodities are already transported by rail or waterways
Repeated or regular flows	Commodities that are regularly transported in the same amount and for which lead time is less important

Large volumes	Commodities that are transported in large volumes
Multimodal transport	Multimodal transports are suitable for all segments and may be considered in many cases
Segments with differentiated delivery requirements	Commodities for which there is flexibility in terms of lead time
Liquid fuels	Liquid fuels are appropriate for waterways

Tabel 3. The most frequently mentioned barriers for a modal shift by stakeholders

Barriers	**Comment**
Most frequently mentioned barriers (not ranked)	
1. Prices/cost	Several factors make rail and waterborne transport expensive: taxes, multiple layers of fees (loading and unloading fees, differentiated rail fees, port charges etc.), crane, dock and staff in ports, and increased costs for European Rail Traffic Management System.
2. Economic policy instruments/fees with "incorrect" incentives	Rail charges increase every year for trains. Environmental compensation is too low.
3. Ineffective regulation	Incompatibility between ports and terminals, e.g. through opening hours, vehicle characteristics on railways, etc.
4. Poorly maintained infrastructure (interference, repairs etc.) with implications for flexibility (service frequency) and reliability (delivery security)	Infrastructure quality problems especially important for rail. Reliability and flexibility is very important as it affects the business both in terms of inventory costs and whether commodities can be sold in time.
5. Habitual choice/ Low knowledge of alternative modes	Low knowledge, experience, and competence of alternative modes. Habitual choice of logistic solution, renegotiation of transport chain not made often.

The barriers that were identified by the stakeholders concentrated on price, taxes and fees (affecting cost), ineffective regulation (affecting e.g. transit time), poorly maintained infrastructure and its impact on flexibility and reliability, and habitual mode choice/knowledge about other mode alternatives (see Table 3). Cost, transit time, and reliability were also the most influential parameter affecting mode choice discussed in section 2. According to many stakeholders, there are several factors contributing to costly rail and waterborne transports. Taxes and fees such as loading and unloading fees and rail charges, as well as the initial costs associated with the implementation of the European Rail Traffic Management System (ERTMS) contribute to making road transportation comparatively favourable. Some stakeholders argued that the subsidy "environmental compensation on rail" is too low to compensate for the planned increase of rail track charges to cover more of the non-internalized external costs (see further in section 4). Poor infrastructure connectivity and maintenance was discussed as the major factor influencing service quality, particularly for rail. For sea transports, opening hours in ports was discussed as a barrier. In general sea and rail transports were associated with problems related to lack of flexibility and service frequency (particularly rail), as well as incompatible international regulations with respect infrastructure, vehicle standards, and quay cranes.

Some actors stressed the fact that logistics decisions are not based on specific modes but rather on a logistics chain that can meet requirements of costs, transport time, frequency, etc. Once a transport solution is chosen, the choice is not reconsidered very often. *"What you are used to and know is what you will probably order again."* A modal shift within the chain is complicated, as the whole system must be reconsidered. In addition, existing transportation systems are rarely challenged or reinvented by the companies involved. One reason for this is low knowledge and experience of rail and sea transport among forwarding agents, who commonly perform the mode decision. Moreover, transport buyers are not frequently renegotiating their logistics solution. Transport buyers may ask for new prices for the service every second or third year, but much more rarely question the choice of transport modes within the chain. The real opportunity for rethinking the logistics chain is connected to major organizational changes.

The results are in line with the findings in the freight transport stakeholder survey by WSP (2016), where most actors point at lack of clarity in terms of political strategies, inadequate taxes and fees, and poor infrastructure. The results also reflect the findings in Styhre et al., (2019) that combine the Transport Buyer Purchasing Panel and a stakeholder discussion to analyse the potential for modal shift from road to shipping. The stakeholders mainly point at issues related to habitual choice and knowledge of transport alternatives as major barriers for modal shift from road. They also point at a lack of coordination and cooperation between actors and the necessity of levelling out the risks of transports by ship between stakeholders.

The barriers discussed by the stakeholders and listed as 1-5 in table 3, are affected by policy instruments to various degrees. Economic policy instruments and fees (2), regulation (3), and infrastructure (3) are most evidently affected by the current and planned policy mix. However, price (1) and knowledge/habitual choice (5) are barriers that could be solved to some extent within the private sector. For example, the potential for mode shift within segments where flows are unbalanced could be solved through coordination between private actors, and different contractual arrangements could affect the pricing of transport services. Information policy instruments used to encourage private actors to overcome some of the barriers to realize a modal shift include the EU initiative Short Sea Promotion centres. In Sweden, the Short Sea Promotion Centre[18] is a private actor, funded by the Transport Administration, with the ambition to engage shipping companies, shippers, and ports to identify low-hanging fruits for modal shift from road to sea. The Swedish national promotor for short sea shipping and inland navigation is another example which will be discussed below.

4 Effectiveness of policy instruments in Sweden

Although modal shift policy instruments at the national and EU-level (including policy framework promoting multimodal freight transport such as TEN-T and Motorways of the Sea) were implemented much earlier, the first explicit modal shift policies in Sweden were introduced in 2018. Previous infrastructure plans and roadmaps had stressed the importance of promoting intermodality, e.g. through financial support to terminals and transshipment services (Statens Offentliga Utredningar, 2004) and stimulation of research and information sharing technology (Näringsdepartementet, 2010). However, the subsidies eco-bonus for sea transport and environmental compensation for rail transport, and the national promotor for short sea shipping and inland navigation are the first instruments with a stated goal to promote modal shift. The design of both subsidies is restricted by EU state aid policy. As these explicit modal shift policies have been in place only for a short time, their effectiveness on achieving a modal shift in the medium and long term cannot be determined. Only the environmental compensation for rail transport has been evaluated at the point of writing this report (Swedish Transport Administration, 2020e).

[18] SPC – Maritimt Forum

The Swedish national freight transport strategy aims at promoting effectiveness and competitiveness for each mode *and* to promote modal shift. Competitiveness and modal shift are not necessarily compatible. Increased competitiveness for railway and sea transports could well result in a higher share of freight on these modes, but that does not necessarily imply that freight has shifted from road if it is induced traffic. Competitiveness is moreover a concept which definition is relative to the segment it is evaluated against and the classification of the market. Competitiveness could be local, regional, or international or even refer to the productivity of other industries (OECD, 2014). That the strategy is aiming at multiple objectives, and that the definitions are fuzzy, is not uncommon. Both competitiveness and modal shift are for example expressed as objectives in the Norwegian Transport Plan 2018-2029.[19] The Swedish Agency for Public Management (2018) has studied how strategies are used in Sweden as a soft policy instrument. They find that strategies often are used to indicate a desirable direction or path of development in complex policy areas. The ambition can be to legitimize planned policy instruments or accelerate coordination and cooperation between actors. However, the study finds that strategies seldom concretize objectives that could be used to measure results. In their part time evaluation of the National Freight transport strategy, Transport Analysis (2020b) recognizes this difficulty. They stress that it is hard to assess the strategy's effectiveness, specifically as there are no stipulated effect-chains or milestones to evaluate against. Overall, they find support for the strategy's role in coordinating actors, and that it is well received within the freight transport sector. At the same time, they conclude that the implementation depends on improved clarification of responsibility between actors. In their evaluation of the achievement of the modal shift target in Norway, the National Audit Office (2018) conclude that the Norwegian government has both lacked sufficient information to design effective policy instruments and implemented too few measures. Moreover, they find that when faced with political trade-offs, e.g., between effective road sector and modal shift or between freight and passenger transport, modal shift targets are not prioritized.

Environmental compensation to rail

The first round of environmental compensation for rail was directed to operators during 2018-2019 (Förordning 2018:675). The prolonging of the compensation scheme for 2021-2025 was approved in 2021.[20] This instrument is an example of a modal shift policy seeking to achieve two objectives; to strengthen the competitiveness of the rail sector *and* contribute to a modal shift to rail from road. Of the total budget of SEK 563 million, about 70 % was paid out in 2018 and the rest in 2019. For 2021-2025, SEK 400 million per year has been budgeted. The state aid rules allow compensation for external costs that can be avoided by rail transport compared to transport using other modes, for example non-internalized marginal social costs related to air pollution, climate gas emissions, traffic accidents, and infrastructure maintenance and investments. In 2015, the Swedish Transport Administration assessed that road freight transport gives rise to non-internalized social marginal costs higher than rail freight transport. Although sea transports give rise to non-internalized external costs, they were not assessed to be larger than for rail transports. Therefore, shift from sea to rail cannot be covered by the compensation scheme (Swedish Transport Administration, 2015). In 2021, this conclusion was assessed to still be valid. (Swedish Transport Administration, 2021).

The compensation amount is bound by the state aid rules. Compensation cannot be higher than 50 % of the external costs, or 30 % of the total costs, whichever is lower. In Sweden, total costs are interpreted as production costs, including personnel, capital and operating costs (estimated to SEK 0,25 per tonkm in 2021, Swedish Transport Administration, (2021)). The external costs are calculated as the difference

[19] https://www.regjeringen.no/contentassets/7c52fd2938ca42209e4286fe86bb28bd/en-gb/pdfs/stm201620170033000engpdfs.pdf

[20] 292044_2247608_5aid4_2.pdf (europa.eu)

between the total costs for road and rail transports, excluding infrastructure costs, based on the Handbook on the external costs of transport.[21] In the Swedish context, 50% of the external costs limited the compensation in the first round and the compensation was set to SEK 0,0335 per ton-km (Swedish Transport Administration, 2015). For the current compensation scheme, 30 % of the total costs limits the compensation which is set to 0,084 per ton-km (Swedish Transport Administration, 2021).

For this scheme, both an ex-ante and an ex-post evaluation has been carried out. In their ex-ante evaluation, the Swedish Transport Administration (2015) simulated the expected effect of the environmental compensation based on elasticities related to transport costs. The whole compensation was therefore assumed to be reflected in terms of lower prices for transport buyers. The results indicated a small increase in the ton-km freight carried out on rail, and that the compensation scheme had a positive net present value. However, the Swedish Transport Administration stressed that the quantitative analysis probably overestimates the effect as the inherent inertia related to transport buyer's modal choice is not captured. With respect to modal shift, the results indicated very minor, if any, effects. In their summary, the Transport Administration pointed out that the compensation scheme rather can be regarded as a tool to maintain freight traffic on rail than shifting traffic from road.

In 2020, an ex-post qualitative evaluation of the environmental compensation scheme was carried out by the Swedish Transport Administration (2020e). Again, the compensation scheme was found to rather contribute to counteracting a shift from rail to road, than vice versa. According to the interviewed operators, the most important condition for the compensation scheme to have effect, is that it is continuous, long-term, and predictable. This was not perceived to be the case as the budget for the compensation was higher in 2018 than 2019, and non-existent in 2020. Based on the interviews, the Swedish Transport Administration suggested improvements to the next scheme. Some related to the unpredictability of the payments. The compensation is calculated as the operator's relative proportion of the total rail freight ton-km of the operators that have applied for compensation. It is handed out retrospectively every 6 months to operators that have applied for it. This complicates the predictability of the amount to be received for the operators and makes it harder to adjust prices. The EU state aid rules require that transport buyers should benefit from the compensation scheme. However, there is no regulation on when or how the price adjustment should be manifested. One way to interpret the rules is that the compensation should contribute to maintaining the price levels or increasing the level of service quality without increasing the prices. In either way, the evaluation shows that the compensation scheme has led to expectations from transport buyers of lower prices that have not been met. This view was also raised by the stakeholders in the workshop for this project. The Swedish Transport Administration also suggested to reconsider the general eligibility of the compensation. All freight transported on rail was eligible in the first round of the scheme, including segments for which road competitiveness is low. During 2018 and 2019, about 22 % of the total funds were handed out to LKAB, the company dominating ore transports in system trains for which road is a very weak competitor.

One view expressed by the interviewed operators in the evaluation by the Swedish Transport Administration is that economic compensation can only be part of a short-run solution. Increased capacity on the rail network and rebates on rail fees are suggested as more long-term solutions to increase competitiveness of the rail sector that could contribute to modal shift. The interviewed operators suggest three improvements to the scheme: i) identify new freight volumes for rail transport and target compensation (preferably as an exemption from rail fees during the first 5 years), ii) use public procurement to enable more rail freight commuters and install a central freight forward agent at the Transport Administration to ensure load optimization and consolidate smaller freight volumes, iii) broaden the compensation to also include digitalization efforts for both operation and logistics planning. The eco-bonus system for sea transport was mentioned as an example of a scheme that is better designed

[21] Handbook on the external costs of transport - Publications Office of the EU (europa.eu)

to promote modal shift. In the revised compensation scheme 2021-2025, ore transports are exempted, and payments are issued every quarter instead of every six months.

The Swedish Transport Administration (2019a) has also suggested a redesign of the compensation scheme to favor new intermodal transport solutions on rail. The suggested scheme is a start-up guarantee, implying that public funds can be used to compensate for empty loads in the start-up phase of new transport solutions. The scheme is proposed to be geographically differentiated to compensate for differences in capacity constraints on the network.

In the national infrastructure plan 2018-2029 a so-called business pot of SEK 1,2 billion was set aside to accommodate rapid and targeted measures for freight transport needs on rail. The measures can for example include minor capacity improvements or the introduction of a new switch on the railway to enable a more effective flow. The idea is to work closely with the business sector to identify where these types of measures can yield large effect and benefit the competitiveness of both business and the railway sector. It is still too early to identify any effects on mode choice from these measures. However, this type of collaboration has previously resulted in a shift to rail transports. In 2005, the storm Gudrun had a large impact on the demand for timber transport. The demand increased for all transport modes, but timber (roundwood) transports on rail remained at a higher level, about 10 percentage points, even in the long run. In a study by Vierth (*forthcoming*) shows that the shift was enabled through a combination of factors. Previous political decisions, such as the deregulation of the railway sector and permission of longer and heavier vehicles on road implied that there were several companies that could mobilize to meet demand. In addition, the quick policy response in terms of exemptions from driving and rest times and cabotage enabled a larger supply of chauffeurs. One of the deciding factors for the long-lasting shift to rail transports, however, was that the forest industry already was mobilizing to enable new transport chains involving larger terminals. Within this work they had already identified necessary improvements to railway infrastructure to streamline transport flows. The storm implied that the railway infrastructure could be adjusted relatively quickly to these types of identified constraints. Moreover, new logistics solutions could be tested in large-scale and some of the these remained viable even in the longer term.

Eco-bonus

The subsidy eco-bonus directed to sea transport has been in place in Sweden for two periods: 2018-2020 and 2021-2022 with a budget of SEK 50 million annually. Shipping companies can apply for the bonus to improve existing or new maritime transportation routes that can be shown to generate a shift of freight from road to sea transport. The instrument is aimed at directly affecting the relative competitiveness of sea transport by reducing cost during the program period. One of the eligible criteria for eco-bonus is that the estimated (or reported) total environmental cost associated with the new/improved sea transport route is lower than for the alternative by road.[22] In the second application period, there is also a requirement to document how the estimated flows will be secured for example through a contract with commodity owners. In their proposal for how an eco-bonus scheme could be designed, Trafikanalys (2017a) discuss the trade-off between an administrative simple system and the possibilities to favor the most environmentally beneficial projects. They suggested prioritizing a simple administrative model, which was the one implemented (Förordning 2018:1867). The current environmental performance is calculated using the NTM Calculation Tool administered by a Swedish NGO, using ASEK values.[23]

The compensation can be used to cover operating costs and equipment for reloading services. After three years the project should be commercially viable. The amount of compensation is based on the difference in non-internalized marginal costs related to greenhouse gas emissions and air pollution between road and sea. This amount is estimated to be SEK 0,12 multiplied by every ton-km shifted freight (Transport

[22] Riktlinjer för ekobonus 2021. See also: Ekobonus – miljökompensation för överflyttning av gods till sjöfart - Trafikverket

[23] About NTM - Network for Transport Measures

Analysis, 2017e). The design implies that there are little incentives to further reduce environmental impact once the eligibility criteria is reached. Moreover, only the amount of goods that has been shifted and the financial statements are followed-up. The environmental outcome of the route is not re-evaluated. Another design feature is that all projects face an equally sized cut of budget if the applied amounts are larger than the total budget for the period. This implies that the companies face uncertainty with respect to the actual amount of subsidy to be paid out.

Due to issues with legal clearance, the application period for the first project phase was rushed. Of the five applications received, only two met the eligibility criteria. Of these two, one project was implemented but was discontinued. The second application period was started at the end of 2020 and was opened for almost two months. Five applications were received and four were approved. As the total eco-bonus budget was overshot, each of the four projects were assigned a budget corresponding to 75 % of their applied amounts. The projects include the routes Nynäshamn-Rostock and Norrköping-Kapellskär as well as transport within the Mälar region and within the regions of Kalmar/Copenhagen.[24] The Mälar shuttle[25] for example, is a co-operation between the ports in Lake Mälaren (Mälarhamnar), the Ports of Stockholm (Stockholms Hamnar), Hutchison Ports Stockholm, and the shipping company Wallenius Marine. The Mälar shuttle is assumed to relieve the land infrastructure and to contribute to a sustainable development in the greater Stockholm area by moving freight on inland waterways.

In a report on competitiveness of short-sea shipping based on interviews with a sample of Swedish ports, the stakeholders' experience of and views on eco-bonus are summarized (Region Skåne, 2019). Regarding the effectiveness of eco-bonus in realizing modal shift, the interviewed ports have different opinions. One issue raised is that the design more explicitly should favor transport buyers in terms of lower transport prices. Another issue raised is that the eco-bonus should be broadened to include a larger share of reloading services and costs. It is argued that a larger share of freight is unaccompanied (semi-trailers and containers without drivers) and that this is requiring new solutions in port. The eco-bonus scheme has not yet been evaluated and it has hence not been calculated if the scheme has a positive net present value.

Transport Analysis (2019a) has suggested that a general and extended eco-bonus directed to any actor working to shift transports to more energy-efficient modes should be introduced. The general eco-bonus is suggested to include unimodal sea and rail transports and services, as well as multimodal transport and services, offered by a single or a combination of companies. Moreover, investments in terminals and other infrastructure necessary to enable reloading are suggested to be eligible for the bonus. It is also suggested that the environmental incentives for projects should be increased to also include technical innovations and energy use. Estimated environmental improvements are suggested as one of the main parameters for prioritizing between projects. In a recent study by Pinchasik et al. (2020), the effects of combining eco-bonuses for sea and rail transports on modal shift and environmental outcomes (in terms of CO_2, NO_x, and PM emissions) are simulated compared to a reference scenario for 2030. The authors use the National Freight Model for Norway to simulate different scenarios based on four policies that could stimulate modal shift: eco-bonus for sea, eco-bonus for rail, increased eurovignette, and accommodation of longer and heavier freight trains. The authors also model the effect of combining these policies as well as harmonizing policies across Norway, Denmark, and Sweden. The eco-bonus scenarios are modeled as a subsidy with an annual budget set to NOK 150 million for both rail and sea transport, respectively. The entire budget is assumed to be paid out in both scenarios. For sea transport, the subsidy is operationalized in the model as a per ton reduction in terminal costs for loading and

[24] Ekobonus – miljökompensation för överflyttning av gods till sjöfart - Trafikverket

[25] https://www.stockholmshamnar.se/om-oss/nyheter/2020/malarpendeln--ett-unikt-samarbete-for-hallbara-transporter/

unloading which differs between ship segments (bulk and comparable transports are not eligible). Similarly, for rail transport the eco-bonus is implemented as a reduction in terminal costs per ton combi-freight handled (bulk and timber transports are not eligible). The authors find that the eco-bonus scheme for rail induces a modal shift from road in ton-km about four times larger than in the scenario with eco-bonus for sea transports. Moreover, the rail eco-bonus implies small environmental effects whereas the sea eco-bonus results in small increases in CO_2, NO_x, and PM. In both scenarios, it is mostly the long-distance freight that shift from road. The difference in environmental outcomes is explained by the high degree of electrification of rail transports and that relative to most ships, trucks contribute to lower NO_x, and PM emissions.

The authors also simulate the effect from combining different policies. For example, a combination of Norwegian sea and rail eco-bonuses combined with increased eurovignette rates in Denmark and Sweden result in strong modal shifts from road to rail, and smaller shifts to sea transports. Harmonizing both sea and rail eco-bonuses across all three countries, is found to strengthen the competitiveness of rail at the expense of sea transports. Adding increased euro vignettes in all three countries to the scenario (a scenario in which Norway is assumed to have a eurovignette rate in line with those in Sweden and Denmark even though such an instrument is not currently in place in Norway), only results in minor additional modal shifts. Combination of policies and harmonization across countries is found to strengthen effects on modal shift in some scenarios, but the magnitude depends on transit traffic and effects on border-crossing. In general, because of the truck transports required in both ends of the transport chain in many cases, the increased ton-km performed by rail and sea transports are larger than the reductions in road transports. The environmental effects depend on the mode distribution where rail contributes to lower energy use and sea to higher air pollutants. Most scenarios imply reduced CO_2 emissions, particularly those scenarios where modal shift to train is strong, However, the authors stress that even with strong policy instruments in place, CO_2 reductions are never larger than 3.6 % compared to the reference scenario for 2030. In some scenarios, NO_x and PM emissions increase, of course this is an effect of the assumptions made about the technological development particularly within the shipping sector. The authors conclude that modal shift policies may not be counted on as large contributors to achievement of the climate objective. On the other hand, modal shift policies may be desirable for the achievement of other policy objectives. These insights are important. Maximizing modal shift is not necessarily the same as maximizing environmental benefits (Bouchery and Fransoo, 2015)

National promotor for short sea shipping and inland navigation

In the context of modal shift information policies, the Swedish assignment of a national promotor (seated at the Traffic Administration) for short sea shipping and inland navigation, 2019-2024, is an interesting example. The purpose is to establish a dialogue with the principal owners of ports about competitive port fees, as well as analysing availability and development of dry ports and reloading on inland waterways, to increase competitiveness for shipping and increase port capacity.[26] The EU encourages coastal member states to install Shortsea Promotion Centers to promote short-sea shipping. The Swedish centre is recognized as an important partner to facilitate outreach for the national promotor. In Sweden, national promotors have been used previously to create mandate for change (Swedish Agency for Public Management, 2014). The national promotor for the initiative Fossil-free Sweden[27], mobilizing different sector within the industry towards climate action, is an example. When the initiative was evaluated, the promotor himself was highlighted as the key for driving industries forward by “being the right person at the right place at the right time”. His role made it possible to focus on opportunities instead of challenges and enable to find common grounds in situations with conflicting interests. At the same time, it is acknowledged that the work has mostly led to development of different strategies and roadmaps and

[26] andring-av-uppdraget-att-inratta-en-nationell-samordnare-for-inrikes-sjofart-och-narsjofart.pdf (regeringen.se)

[27] Start - English - Fossilfritt Sverige

that additional measures may be necessary to make sure that implementation efforts are carried out (Governo, 2019).

Besides appointing a national coordinator for short sea shipping and inland navigation, the Swedish Transport Administration has been commissioned to intensify the work of promoting intermodal rail transports, and to work towards improving the conditions for rail and sea transports. The insights and proposed actions from this work are summarized in a road map to promote a modal shift of freight from road to rail and sea (Swedish Transport Administration, 2020a). The aim of the roadmap is both to facilitate prioritization of actions and clarify the roles of responsibility for implementation, and to serve as a communication tool. Each proposed action point is either regarded as prioritized (to be implemented within two years) or to be implemented in the longer term (within 5 years). Actions include collecting information on the status and location of multimodal terminals, installing regional freight councils, analyzing freight flows with modal shift potential, identifying infrastructure needs in collaboration with stakeholders, making sure that public infrastructure connected to terminals and ports is maintained according to freight flow needs, and to reviewing possibilities to condition large infrastructure investments to favor modal shift.

In addition, there is a specific roadmap for shipping by the National promotor for short sea shipping and inland navigation (Swedish Transport Administration, 2020b). That roadmap includes 62 action points grouped under the categories Objectives, Collaboration, Information and Knowledge, Infrastructure and Planning, Governmental actions, Regulatory development, and Energy efficient shipping. The actions are listed together with the Governmental Agency that thereby declare itself responsible for their implementation. The Swedish Transport Administration is for example committing to propose modal shift objectives as well as to specify key performance indices to allow for follow ups. They also commit to collect information on the environmental and climate impact of sea transports.

The action plan proposes several actions to initiate dialogue fora on short sea shipping potential for example including ports, transport buyers, and regional freight transport councils. Another action includes dissemination of research knowledge and innovations. The Swedish Maritime Administration for example, responsible for safety, accessibility, and sustainability at sea, run projects related to more efficient navigation and multimodal information exchange. In this projects' stakeholder workshop, limited knowledge among freight forwarders about short-sea shipping opportunities was mentioned as one of the barriers to realizing modal shift. The need for increased knowledge about short-sea shipping as a transport alternative has also been raised by transport buyers and freight forwarders in dialogue fora carried out by the Swedish Shortsea Promotion Centre (Styhre et al., 2019). Continued financing of the Swedish Shortsea Promotion Centre, organizing freight forwarders and transport buyers, is proposed as another action in the roadmap.

Another action proposed in the road map is to promote that large infrastructure investments are conditioned to favor modal shift. Such a condition was incorporated in the financing of the fairway into port of Gothenburg 2020. The Swedish state funds 50 % of the extension (SEK 2.5 billion) and requires that the port promotes short-sea shipping. However, these requirements are not specified further and will be hard to follow-up.[28] The Swedish Transport Administration also commit to review possibilities to use sea transport as an alternative transport mode choice for freight of building material in public procurement, and to develop a guide that can be used by other actors and agencies.

[28] Göteborgs hamn satsar på närsjöfart – Dagens Logistik

One important action is that the Swedish Transport Administration together with the Swedish Transport Agency and the Swedish Maritime Administration will revise the method for impact analysis to better consider how regulatory changes and fees affect freight transport modal shifts.

The collection of 62 action points in a road map could be an effective means to broadly collect the current situation for inland shipping and short-sea navigation, and to point out directions for future development. Several action points contain commitments to work more purposefully, *within* the existing regulatory framework, to promote inland navigation and short-sea shipping. However, this road map has moreover identified the need for, and committed to, both specifying modal shift objectives and developing the method to carry out impact analysis that consider modal shift effects. If these two actions are implemented, they will improve the possibilities to evaluate policy instruments' impact on freight modal shifts and the related environmental and climate impacts.

5 Discussion

In Sweden, there are three policy instruments explicitly promoting modal shift; two economic schemes to favor modal shift to rail and sea transports, and the appointment of a national promotor for shortsea and inland navigation. Modal shifts from road are also expressed as one of three overarching goals in the National Freight Transport Strategy. However, in the proposal for the next infrastructure planning period in Sweden (2022-2037), freight transport modal shifts are dismissed in terms of relevance for achieving the national climate target. Instead, modal shifts are described as potentially politically desirable based on other societal objectives. That there are trade-offs between political goals is not unique for the freight transport sector. However, that modal shifts sometimes are interpreted as a means and sometimes as an objective further complicates the ability to assess the impact of different political strategies. It is important to recognize that modal shift targets rests on assumptions of relative environmental performance between transport modes. For example, today every ton-km freight shifted from road to sea transport in Sweden, is estimated to halving the CO_2 emissions (Transport Analysis, 2017c).

There is little evidence that economic policy instruments could realize large freight modal shifts on their own. The responsiveness to transport costs has been shown to be low on average, implying that price signals from general economic policies need to be, perhaps prohibitively, substantial. Considering modal shifts as a means to realizing climate and environmental objectives, there is even less evidence of the effectiveness on mitigating negative externalities.

Ultimately, regional and local political decisions on infrastructure and promotion of technology development will largely affect future freight transport traffic and modal split. The comprehensive work with the Sustainable and smart mobility strategy (COM(2020) 789 final) carried out within the European Union will for example have large impacts. Differences between modes in terms of competitiveness and environmental impact depend on the advances in battery technology, alternative fuels, automatization, and digitalized transport solutions. The way information is shared between different actors to optimize the load factor within the transport network will impact both mode distribution and influence market power between shippers and carriers. Some of these developments are pointing in the direction of increased opportunities for shifting freight from road on full or parts of distances. For example, the EU mobility package (EU 2020/1054) including regulations on driving and rest times and cabotage for the road sector could improve the competitiveness for sea and rail. Yet other trends, are pointing towards continued strengthening of the road sector. The so-called infrastructure directive (EU 2019/I242) will impact on future investments in charging infrastructure and hydrogen development for heavy vehicles. In Sweden, comprehensive work is undertaken to study the possibilities for and impacts of a 3000 km electrified road network and fast charging infrastructure by 2035.[29] Even though development towards

[29] Planering för elvägar och snabbladdning - Regeringen.se

energy- and environmental efficiency is carried out within all sectors, the efforts to improve environmental performance in the road sector is facilitated by the much faster turn-around of the vehicle fleet compared to sea and rail. The current political and technological development could improve conditions for complementarity between modes and multimodal transport solutions through organizational innovations and business models taking advantage of load standardization, digitalization, data-sharing, and innovations. As technology develops, the assumptions about the relative environmental performance and costs of different modes will determine the political ambitions with respect to realizing modal shift.

This paper is not making the case that freight modal shifts are not desirable from a societal point of view. What we are trying to problematize is the interpretation of modal shift as an objective in itself. Overarching societal objectives, such as safety, environmental pollution, health concerns, congestions, etc. may all justify a shift from road transports to other transport modes – as one of several means towards goal achievement. By interpreting modal shifts as an own objective, we risk suboptimizing the investments and financial transfers. A successful transition within the transport system towards less climate and environmental impact requires political flexibility based on evaluation of different strategies with respect to goal achievement and cost efficiency.

References

Abate, M. *et al.* (2019) ‘A disaggregate stochastic freight transport model for Sweden’, *Transportation*, 46(3), pp. 671–696. doi: 10.1007/s11116-018-9856-9.

Abate, M., Vierth, I. and de Jong, G. (2014) ‘Joint econometric models of freight transport chain and shipment size choice’, *CTS working paper 2014:9*.

Ambra, T., Caris, A. and Macharis, C. (2019) ‘Towards freight transport system unification: reviewing and combining the advancements in the physical internet and synchromodal transport research’, *International Journal of Production Research*, 57, pp. 1606–1623. doi: 10.1080/00207543.2018.1494392.

Ben-Akiva, M. and de Jong, G. (2013) ‘The Aggregate-Disaggregate-Aggregate (ADA) Freight Model System’, *Freight Transport Modelling*, pp. 69–90. doi: 10.1108/9781781902868-004.

Bergqvist, R. (2019) ‘HCT Intermodalt - en genomförbarhetsstudie’, *Handelshögskolan vid Göteborgs Universitet, Triple F*.

Bergqvist, R. and Woxenius, J. (2011) ‘The Development of Hinterland Transport by Rail – The Story of Scandinavia and the Port of Gothenburg’, *Journal of Interdisciplinary Economics*, 23(2), pp. 161–175. doi: 10.1177/02601079X11002300204.

Bernhardsson, V. (VTI) and Rosklint, E. (Trafikverket) (2016) ‘Representation of the Swedish transport and logistics system in Samgods v. 1.1’, *Vti*, 17A-2009, pp. 1–93. Available at: http://www.vti.se/en/publications/pdf/representation-of-the-swedish-transport-and-logistics-system-logistics-model-version-200.pdf.

Bouchery, Y. and Fransoo, J. (2015) ‘Cost, carbon emissions and modal shift in intermodal network design decisions’, *International Journal of Production Economics*, 164, pp. 388–399. doi: https://doi.org/10.1016/j.ijpe.2014.11.017.

Brogan, J. J. *et al.* (2013) ‘Freight Transportation Modal Shares: Scenarios for a Low-Carbon Future.’, in *Transportation Energy Futures Series. Prepared by Cambridge Systematics, Inc. (Cambridge, MA), and the National Renewable Energy Laboratory (Golden, CO) for the U.S. Department of Ene*.

Dahlman, J. (2019) ‘STM Validation, scientific review’, *VTI on request from Swedish Maritime Administration*.

EU (1987) ‘COUNCIL DIRECTIVE of 3 December 1987 on the approximation of the laws of the Member States relating to the measures to be taken against the emission of gaseous pollutants from diesel engines for use in vehicles eous pollutants from diesel engines for use’.

European Commission (2017a) *Motorways of the Sea: An ex-post evaluation on the development of the concept from 2001 and possible ways forward*. Available at: https://ec.europa.eu/transport/themes/infrastructure/motorways-sea_en.

European Commission (2017b) ‘Support study for the Impact Assessment for the Revision of EETS Legislation’, (May), p. 126.

European Court Of Auditors (2013) *Have the Marco Polo Programmes Been Effective in Shifting Traffic Off the Road?*

Feo, M., Espino, R. and García, L. (2011) ‘An stated preference analysis of Spanish freight forwarders modal choice on the south-west Europe Motorway of the Sea’, *Transport Policy*, 18(1), pp. 60–67. doi: https://doi.org/10.1016/j.tranpol.2010.05.009.

Flodén, J. and Woxenius, J. (2017) 'Agility in the Swedish intermodal freight market – The effects of the withdrawal of the main provider', *Research in Transportation Business & Management*, 23, pp. 21–34. doi: https://doi.org/10.1016/j.rtbm.2017.02.010.

Fowkes, A. S. *et al.* (2004) 'How highly does the freight transport industry value journey time reliability—and for what reasons?', *International Journal of Logistics Research and Applications*, 7(1), pp. 33–43. doi: 10.1080/13675560310001619259.

Gonzalez-Aregall, M., Cullinane, K. and Vierth, I. (2021) 'The relationship between port governance and port initiatives to promote freight modal shift in Europe', *Logistics and Transport Research Group, University of Gothenburg, Working Paper*.

Governo (2019) 'Utvärdering av Fossilfritt Sveriges arbete. Utredning på uppdrag av Fossilfritt Sverige'.

Gustafsson, C. and Nyström, J. (2019) 'Den svenska marknaden för godstransporter på järnväg En analys av dominerande ställning', *VTI-notat 5*. Available at: http://www.diva-portal.org/smash/get/diva2:1317387/FULLTEXT02.pdf.

Hammar, H. (2006) 'Konsekvenser för skogsindustrin vid ett eventuellt införande av en svensk kilometerskatt', *Konjunkturinstitutet, Specialstudie Nr 10, december 2006*, (10).

Haram, H. K., Hovi, I. B. and Caspersen, E. (2015) 'Potensiale og virkemidler for overføring av gods fra veg- til sjøtransport', *TØI rapport 1424/2015*.

Hensher, D. A. and Puckett, S. M. (2005) 'Refocusing the Modelling of Freight Distribution: Development of an Economic-Based Framework to Evaluate Supply Chain Behaviour in Response to Congestion Charging', *Transportation*, 32(6), pp. 573–602. doi: 10.1007/s11116-004-7615-6.

Hensher, D. A. and Puckett, S. M. (2007) 'THEORETICAL AND CONCEPTUAL FRAMEWORKS FOR STUDYING AGENT INTERACTION AND CHOICE REVELATION IN TRANSPORTATION STUDIES', *International Journal of Transport Economics / Rivista internazionale di economia dei trasporti*, 34(1), pp. 17–47. Available at: http://www.jstor.org/stable/42747786.

Hensher, D. A., Puckett, S. M. and Rose, J. M. (2007) 'Agency decision making in freight distribution chains: Establishing a parsimonious empirical framework from alternative behavioural structures', *Transportation Research Part B: Methodological*, 41(9), pp. 924–949. doi: https://doi.org/10.1016/j.trb.2007.04.003.

Holguín-Veras, J. (2002) 'Revealed Preference Analysis of Commercial Vehicle Choice Process', *Journal of Transportation Engineering*, 128(4), pp. 336–346. doi: 10.1061/(ASCE)0733-947X(2002)128:4(336).

Holguín-Veras, J. *et al.* (2021) 'Freight mode choice: Results from a nationwide qualitative and quantitative research effort', *Transportation Research Part A: Policy and Practice*, 143, pp. 78–120. doi: https://doi.org/10.1016/j.tra.2020.11.016.

Islam, D. M. Z. *et al.* (2015) 'Assessing the impact of the 2011 EU Transport White Paper - a rail freight demand forecast up to 2050 for the EU27', *European Transport Research Review*, 7(3), p. 22. doi: 10.1007/s12544-015-0171-7.

Jensen, A. *et al.* (2018) 'A disaggregate freight transport chain choice model for Europe', *Transportation Research Part E: Logistics and Transportation Review*, 121. doi: 10.1016/j.tre.2018.10.004.

Johansson, M., Vierth, I. and Bondemark, A. (2020) ‘Utvärdering av Sjöfartsverkets nya avgiftsmodell 2018: en modelljämförelse för perioden 2017 till 2019’, *VTI rapport 1034*.

Johansson, M., Vierth, I. and Holmgren, K. (2021) ‘Klimat- och miljöeffekter av att flytta godstransporter från väg - Beräkningar för år 2017, 2030 och 2040’, *VTI rapport 1091*.

de Jong, G., Ben-Akiva, M. and Baak, J. (2010) ‘Method Report - Logistics Model in the Swedish National Freight Model System’, (January), p. 58.

de Jong, G. and Johansson, D. (2009) ‘Discrete mode and discrete or continuous shipment size choice in freight transport in Sweden’, *Association for European Transport and contributors 2009.*

Kaack, L. H. *et al.* (2018) ‘Decarbonizing intraregional freight systems with a focus on modal shift’, *Environmental Research Letters*, 13(8). doi: 10.1088/1748-9326/aad56c.

Lammgård, C. and Andersson, D. (2014) ‘Environmental considerations and trade-offs in purchasing of transportation services’, *Research in Transportation Business and Management*, 10, pp. 45–52. doi: 10.1016/j.rtbm.2014.04.003.

Liedtke, G. (2009) ‘Principles of micro-behavior commodity transport modeling’, *Transportation Research Part E: Logistics and Transportation Review*, 45(5), pp. 795–809. doi: https://doi.org/10.1016/j.tre.2008.07.002.

Lindé, T., Vierth, I. and Cullinane, K. (2019) ‘Evaluating the effects of Sweden’s environmentally differentiated fairway dues’, *Transportation Research Part D: Transport and Environment*, 70, pp. 77–93. doi: https://doi.org/10.1016/j.trd.2019.04.003.

Lindgren, S. and Vierth, I. (2017) ‘Vad styr valet av trafikslag för godstransporter? En kunskapsöversikt’.

Mandell, S., Nilsson, J.-E. and Vierth, I. (2014) *Freight transport, policy instruments and climate, Working papers in transport economics NV - 2014:5*. Transport economics Stockholm, Society, environment and transport, Swedish National Road and Transport Research Institute: CTS. Available at: http://vti.diva-portal.org/smash/get/diva2:707689/FULLTEXT01.pdf.

Näringsdepartementet (2010) ‘Handlingsplan för logistik och godstransporter -rapport från en arbetsgrupp inom Logistikforum’, *Regeringskansliet*.

Nealer, R., Matthews, H. S. and Hendrickson, C. (2012) ‘Assessing the energy and greenhouse gas emissions mitigation effectiveness of potential US modal freight policies’, *Transportation Research Part A: Policy and Practice*, 46(3), pp. 588–601. doi: https://doi.org/10.1016/j.tra.2011.11.010.

Ng, A. K. Y. *et al.* (2018) ‘Transport Networks and Impacts on Transport Nodes’, *Transport Nodal System*. 2018/01/29, pp. 9–28. doi: 10.1016/B978-0-12-811067-6.00002-X.

Nikolakaki, G. (2012) ‘Economic incentives for maritime shipping relating to climate protection’, *WMU Journal of Maritime Affairs*, 12. doi: 10.1007/s13437-012-0036-z.

Nocera, S., Cavallaro, F. and Galati, O. (2018) ‘Options for reducing external costs from freight transport along the Brenner corridor’, *European Transport Research Review*, 10, p. 53. doi: 10.1186/s12544-018-0323-7.

OECD (2014) ‘Experiences with Competition Assessment: Report on the Implementation of the 2009 OECD Recommendation’, pp. 1–73.

Parker, A. and Tritter, J. (2006) ‘Focus group method and methodology: Current practice and recent debate', *International Journal of Research & Method in Education*, 29, pp. 23–37. doi: 10.1080/01406720500537304.

Parry, I. *et al.* (2018) 'Carbon Taxation for International Maritime Fuels: Assessing the Options', *IMF Working Papers*, 18(203), p. 1. doi: 10.5089/9781484374559.001.

Pastori, E. *et al.* (2018) 'Research for TRAN Committee – Modal shift in European transport: a way forward', *European Parliament, Policy Department for Structural and Cohesion Policies, Brussels*.

Pinchasik, D. R. *et al.* (2020) 'Crossing Borders and Expanding Modal Shift Measures: Effects on Mode Choice and Emissions from Freight Transport in the Nordics', *Sustainability*, 12(894). doi: 10.3390/su12030894.

Le Pira, M. *et al.* (2017) 'Towards a decision-support procedure to foster stakeholder involvement and acceptability of urban freight transport policies', *European Transport Research Review*, 9. doi: 10.1007/s12544-017-0268-2.

Raza, Z., Woxenius, J. and Finnsgård, C. (2019) 'Slow Steaming as Part of SECA Compliance Strategies among RoRo and RoPax Shipping Companies', *Sustainability*, 11, p. 1435. doi: 10.3390/su11051435.

Region Skåne (2019) 'Förlängda sjöben: när- och kustsjöfartens potential', *Projektet är utfört inom ramen för Triple F*.

Rich, J., Kveiborg, O. and Hansen, C. O. (2011) 'On structural inelasticity of modal substitution in freight transport', *Journal of Transport Geography*, 19(1), pp. 134–146. doi: https://doi.org/10.1016/j.jtrangeo.2009.09.012.

Riksrevisjonen (2018) 'Riksrevisjonens undersøkelse av overføring av godstransport fra vei til sjø og bane', *Dokument 3:7 (2017–2018)*.

Rodrik, D. (2014) 'Green industrial policy', *Oxford Review of Economic Policy*, 30(3), pp. 469–491. doi: 10.1093/oxrep/gru025.

Roso, V. *et al.* (2020) 'Drivers and Barriers for Inland Waterway Transportation', *Operations and Supply Chain Management: An International Journal*, 13(4), pp. 406–417.

SOU (2017) 'Vägskatt', *Statens Offentliga Utredningar 2017:11*.

Statens Offentliga Utredningar (2004) 'Godstransporter - noder och länkar i samspel.', *SOU 2004:76*.

Steer Davis, G. (2015) 'Freight on Road: Why EU Shippers Prefer Truck to Train.', *Directorate general for internal policies policy department B: Structural and cohesion policies transport and tourism, Brussels*.

Styhre, L. *et al.* (2019) 'Transportköparens roll för ökad och hållbar sjöfart', *IVL, SSPA och Maritimt Forum*, Rapportnum.

Swedish Agency for Public Management (2014) 'Nationella samordnare - Statlig styrning i otraditionella former?', *Om offentlig sektor*.

Swedish Agency for Public Management (2018) 'Strategier och handlingsplaner - Ett sätt för regeringen att styra?', *Om offentlig sektor*.

Swedish Maritime Administration (2016) 'Analys av utvecklingspotentialen för inlands- och kustsjöfart i Sverige', Dnr 16-007.

Swedish Transport Administration (2012) ‘Godstransporter Underlagsrapport’, *2012:119*.

Swedish Transport Administration (2015) ‘Förutsättningarna för att miljökompensera transporter på järnväg’, *Trafikverkets publikationer ; 2015:158,* (November). Available at: http://www.diva-portal.org/smash/get/diva2:1364611/FULLTEXT01.pdf.

Swedish Transport Administration (2018) *Trender i transportsystemet - Trafikverkets omvärldsanalys 2018, Rapport 2018:180*. Available at: https://www.trafikverket.se/contentassets/384aceff303140ea99296b35f71b0445/trender_i_transportsystemet_2014_2014-115_final.pdf.

Swedish Transport Administration (2019a) ‘Hinder för ökad omlastning till intermodala järnvägstransporter. Delredovisning av regeringsuppdrag.’, *TRV 2018/93255. 2019:212*.

Swedish Transport Administration (2019b) ‘Längre lastbilar på det svenska vägnätet – för mer hållbara transporter’, 2019:076.

Swedish Transport Administration (2020a) ‘Färdplan för över flyttning av godstransporter från väg till järnväg och sjöfart’, *Trafikverket 2020/7472*. Available at: https://trafikverket.ineko.se/Files/sv-SE/76735/Ineko.Product.RelatedFiles/2020_054_fardplan_overflyttning_av_godstransporter_fran_vag_och_jarnvag_till_sjofart.pdf.

Swedish Transport Administration (2020b) ‘Handlingsplan för svensk sjöfart. Sjöfartssektorn kraftsamlar med 62 förslag för stärkt sjöfart’, *TRV 2018/93261*.

Swedish Transport Administration (2020c) ‘Implementering av bärighetsklass 4.’, *TRV 2020/44448*.

Swedish Transport Administration (2020d) ‘Inriktningsunderlag inför transportinfrastrukturplaneringen för perioden 2022−2033 och 2022−2037’, *TRV 2020/73376*.

Swedish Transport Administration (2020e) ‘Miljökompensation till järnvägsföretag. Uppföljning enligt 15 § förordning (2018:675) om miljökompensation för godstransporter på järnväg’, *TRV 2020/20665*.

Swedish Transport Administration (2020f) *Prognos för godstransporter 2040 – Trafikverkets Basprognoser 2020*.

Swedish Transport Administration (2021) ‘Angående utformning av miljökompensation till järnvägsföretag 2021-2025’, *PM TRV2020/99069*.

Takman, J., Trosvik, L. and Vierth, I. (2020) ‘Omvärldsanalys Policy’, *Triple F etableringsprojekt,* (2020.2.13).

Tao, X., Wu, Q. and Zhu, L. (2017) ‘Mitigation potential of CO2 emissions from modal shift induced by subsidy in hinterland container transport’, *Energy Policy*, 101, pp. 265–273. doi: 10.1016/j.enpol.2016.11.049.

Transport Analysis (2016) ‘Godstransporter i Sverige - en nulägesanalys’, 2016:7, p. 195. Available at: http://www.trafa.se/globalassets/rapporter/rapport-2016_7_godstransporter-i-sverige---en-nulagesanalys.pdf.

Transport Analysis (2017a) ‘Eco-bonus för sjöfart - slutredovisning’, *2017:11*.

Transport Analysis (2017b) ‘Effekter av SECA på sjöfartens Rapport bränsleanvändning, efterlevnad 2017:14 och kustnära luftkvalitet’, 14.

Transport Analysis (2017c) ‘Kunskapsunderlag om skatter och avgifter på transportområdet – delredovisning’, *Rapport 2017:19*.

Transport Analysis (2017d) ‘Lastbilstrafik 2016. Swedish national and international road goods transport 2016’, *Statistik 2017:14*.

Transport Analysis (2017e) ‘Skogsindustrin och kostnader för lastbilstransporter – en faktorefterfrågeanalys’, *PM 2017:11*.

Transport Analysis (2019a) ‘En breddad ekobonus Rapport 2019:1’, *Trafikanalys*.

Transport Analysis (2019b) ‘Hamnar i fokus PM 2019:7’.

Transport Analysis (2020a) ‘Transportsektorns samhällsekonomiska kostnader 2020:4’, 4.

Transport Analysis (2020b) ‘Uppföljning av den nationella godstransportstrategin’, *Rapport 2020:3*.

Tsamboulas, D. *et al.* (2015) ‘Could Subsidies for Maritime Freight Transportation Achieve Social and Environmental Benefits?: The Case of Ecobonus’, *Transportation Research Record*, 2479(1), pp. 78–85. doi: 10.3141/2479-10.

Vierth, I. (2012) ‘Uppföljning av avregleringen av godstrafiken på järnväg’, *VTI rapport 741*.

Vierth, I. *et al.* (2020) *Konkurrensyta land - sjö : Vilken potential finns för överflyttning till sjöfart?*

Vierth, I. (forthcoming) ‘Virkestransporter på järnväg efter stormen Gudrun - vad kan vi lära oss av erfarenheterna?’, *VTI rapport 1072*.

Vierth, I., Lindgren, S. and Lindgren, H. (2018) ‘Vehicle Weight, Modal Split, and Emissions—An Ex-Post Analysis for Sweden’, *Sustainability* . doi: 10.3390/su10061731.

Vierth, I. and Merkel, A. (2020) ‘Internalization of external and infrastructure costs related to maritime transport in Sweden’, *Research in Transportation Business and Management*, p. 100580. doi: 10.1016/j.rtbm.2020.100580.

Vierth, I., Sowa, V. and Cullinane, K. (2019) ‘Evaluating the external costs of trailer transport: a comparison of sea and road’, *Maritime Economics and Logistics*, 21, pp. 61–78.

Wallmark, W. (2015) ‘Intermodala transportsystem i Sverige. En fallstudie äver Göteborgs hamns logistiklösning’, *Kungliga Tekniska Högskolan. Institutionen för Transportvetenskap*.

Windisch, E. and de Jong, G. (2010) ‘A disaggregate freight transport model of transport chain and shipment size choice’.

WSP (2016) ‘Förutsättningar för godstransporter – en intressentundersökning’, *Trafikanalys Underlagsrapport till regeringsuppdrag N2015/5047/TS*.

WSP (2019) ‘Styrmedel och åtgärder för att öka andelen intermodala transporter. Del 1 - den svenska marknaden för intermodala transporter’, *Underlagsrapport till Trafikanalys regeringsuppdrag N2018/0458/TS*.

Appendix

Table A- 1 Transportation in ton-km for different commodity groups per mode

Commodity group	Road > 300 km within Sweden (Swedish trucks)	Road < 300 km within Sweden (Swedish trucks)	Total road within Sweden (Swedish trucks)	Road outside Sweden (Swedish trucks)	Total road outside Sweden (Swedish and foreign trucks)	Road (total)	Rail (total)	Sea within Sweden	Sea outside Sweden	Sea (total)	Total
Coal, crude oil, natural gas	14	75	89	0	0	89	67	56	4941	4997	5153
Moving goods, vehicles for repair	36	75	111	0	32	143			0	0	143
Textile, clothing, leather	19	31	50	2	136	188	0	0	0	0	188
Unidentified goods	0	0	0	0	427	427	4 384	197	2764	2961	7772
Furniture and manufactured goods	52	174	226	34	639	898	21			0	919
Other goods and non-specified goods	159	364	523	36	459	1018		37	471	508	1526
Post and packages	451	646	1097	30	179	1305	139			0	1444
Equipment for the transport of goods	215	783	998	54	369	1422	372		0	0	1795
Coal and refined petrolium products	363	911	1274	65	163	1502	357			0	1860
Transport equipment	346	227	573	254	959	1787	490	9	135	144	2421
Machines and instruments	300	463	763	101	1232	2096	30	0	30	30	2156
Waste and returned goods	315	1170	1484	249	758	2492	737	133	647	780	4010
Non-metallic mineral products	610	1170	1780	101	1069	2950	142	755	742	1497	4590
Chemicals, fiber, rubber, plastic, nuclear fuel	520	706	1226	346	1525	3096	857			0	3954
Ore, extracted products	200	3113	3313	63	163	3539	4 866	1461	3771	5232	13 637
Metals (excluding machines and equipment)	841	441	1283	164	2294	3742	3 247	30	719	749	7738
Agricultural, foresty, and fishery products	867	5165	6032	195	1842	8069	2 286	190	1620	1810	12 165
Food, beverages, tabacco	3519	2161	5680	180	2753	8614	465	14	61	75	9153
Wood, pulp, paper and paper products	1921	2463	4384	420	3948	8751	2 913	206	6333	6539	18 204
Consolidated goods	5788	2598	8386	869	3227	12 481	32	6	48	54	12 567
Totalt	16 537	22 736	39 273	3164	22 174	64 611	21 406	6610	28 912	35 522	121 538

Source: Transport Analysis (2017d)