

## UNDERSTANDING MODAL CHOICE: A REVIEW

I. VIERTH  
VTI



S. LINDGREN  
VTI



A. LOBIG  
DLR



P. NIÉRAT  
IFSTAR



E. BOGERS  
HAN University



I. DAVYDENKO  
TNO



A. BURGESS  
Panteia



S. van de REE  
Panteia



### Abstract

A solid understanding of the freight sector is a key input in a well-functioning and competitive transport system that is reducing its negative external effects. This study summarizes the results from a large-scale report that reviewed the factors influencing modal choice, described developments in the transport sector and the data and tools needed to analyze the impacts of trends and policy measures. The results are based on desk reviews and case studies. In this study we focus on trends in the freight and logistics sector, the main determinants of modal choice and a set of recommendations aimed at national transport authorities in Europe.

**Keywords:** Logistics, Freight Transport, Modal Choice.

## **1. Introduction**

Freight transport plays a crucial role for the functioning of economies while simultaneously being responsible for negative external effects such as congestion, noise and various forms of pollution. The need for an efficient and competitive transport system that is also reducing its negative social effects is on top of many policy-makers' lists. A key input for striving towards such a system is a solid understanding by national transport authorities of the freight transport sector in general, and the influences on the choice of transport solutions and modes in particular.

The purpose of this study is to give a comprehensive summary of the trends in the transport sector, the principles that guide firms' choice of transportation mode and recommendations of measures transport authorities should take. The content of this study is a summary of a report made on the behalf of the Conference of European Directors of Road (Vierth et al. 2017). The results are derived using several methods. For most parts, we have conducted desk reviews of existing research, grey literature and current conditions of the freight markets and public administrations in the transport sector. The results are predominantly based on experiences in European countries and focused on long-distance transportation. In the following two sections we present the results from our review of trends in freight and logistics and the influences of modal choice. We end by giving a set of recommendations to the transport authorities.

## **2. Trends in freight and logistics**

Currently, there are trends towards higher transport demand and higher logistical requirements from different types of customers. This development is expected to continue to at least 2030. The driving factors behind these trends are a growing population and international trade, solutions like e-commerce that facilitates shopping as well as higher requirements to recycle products. These trends lead to increasing requirements on the transport system, i.e. the firms that provide logistics and transport services, their personnel, the different vehicles and energies used as well as the infrastructure for information and communication technologies and transport. The main developments in the coming years are seen in: 1) changing features of demand, such as shorter order times, the need for highly flexible transportation, small shipment sizes and increasing need for reverse logistics, 2) emerging new logistic concepts and requirements like e-commerce, freight exchanges and the specialization of logistics, 3) upcoming digital solutions which foster the supply of logistic services and 4) intensified orientation of the European Transport Policy towards sustainable multimodal transport.

The transport system has large challenges in the coming years. There are currently bottlenecks in parts of the infrastructure that cause congestion and waiting time for passenger- and freight transports. The transport system also generates external costs in form of greenhouse gases, air pollution, noise and accidents. These costs are likely to rise when transport demand increases, all else equal. Different responses to these challenges are already in place in some countries (longer/heavier trucks), ready to use (alternative energies, digitalization) or under development (automation of vehicles, Internet of Things, Physical Internet). The review of the trends shows that it is necessary that several requirements are fulfilled before e.g. a new technology is implemented at a larger scale. The use of autonomous trucks requires e.g. investments in the infrastructure (sensors etc.) and digitalization to be able to develop new logistics concepts.

### 3. Understanding firms' choice of mode

Understanding what influences firms' choice of transport mode is of great importance to, given the challenges facing the transportation system. When considering firms' modal choice, it is important to note that there are various ways in which transport modes can be combined. We therefore treat the mode choice as a selection of transport solution that involves the choice between different unimodal options and various combination of modes. In the latter case, the choice entails a decision on how intensive (e.g. in tonnes, tonne-km or the number of legs) the different modes are to be used in a transport chain.

Because supply chains involve several stake holders, it is not always evident from outside who is responsible for selecting the transport solution and mode(s). The decision-makers that can be involved in the movement of goods include shippers, freight forwarders, third- and fourth party logistics providers (LSPs), carriers and receivers of the goods. Shippers are producers of the goods that need to be delivered to the receivers, who in turn use the goods for processing, final sale or consumption. Shippers may perform their transports in-house (on own account) or contract out either their transport operations or all their logistics activities to service providers. These companies include freight forwarders as well as third- and fourth party logistics providers. Carriers are contracted by shippers, freight forwarders or logistics service providers to haul cargo from an origin to a destination (e.g. from a terminal to the receiver of the goods). They include maritime shipping companies, inland waterway (IWW)-operators, rail operators and trucking companies.

The shippers and receivers set requirements to be met in the logistics process, including conditions for delivery, handling, shipment size, frequency, service quality and freight rates. Surveys show that the party determining the transport solution varies between agreements (Lammgård 2007; Lammgård et al. 2013; Andersson et al. 2016). The choice of transport solution and mode can therefore be thought of as being determined by the interactions between freight agents, and the conditions and requirements that they set. The aim of this section is to identify and describe the factors and their influence on mode choice. It is crucial to understand that the importance of these factors varies greatly across firms and depends on several aspects, including commodity class, trip distance and geographical conditions.

#### 3.1 Importance of shipment characteristics

Shipment attributes and transport distance impose restrictions on firms' ability to choose between transport solutions. The importance of these factors stems from the intrinsic qualities of each transport mode. Table 1 summarize the advantages and disadvantages of the modes, based on shipper surveys. Road is considered to have an advantage in terms of service frequency, reliability, flexibility and safety compared to rail and waterborne transports (Grønland et al. 2014; Ludvigsen 1999; Grue and Ludvigsen 2006). Rail and waterborne transports have larger vessel and vehicle capacity and are the most competitive when economies of scale are realized and transport cost is reduced. The additional advantage of waterborne transport, especially short sea shipping, is that it is typically not restricted by network capacity (as rail and road transport are in many countries). Air transport is safe and fast but usually the most expensive transport mode.

**Table 1 - Comparative advantages of transport modes**

	Road	Air	Rail	Waterborne
Speed	Medium-high	High	Medium	Low
Load capacity	Low-medium	Low	Medium-high	High
Damage risk	Low	Low	Medium-high	Medium-high
Flexibility	High	Medium	Low	Low
Reliability	High	Medium	Low	Medium

Source: Vierth et al. (2017)

The comparative advantages favor certain commodity types. Road and air transports tend to attract time-sensitive goods and products with high value-to-weight ratio (Eurostat, 2017b). These products are associated with higher cost of storage and damage and favor fast, flexible and reliable modes. Rail and waterborne transport dominate the market for heavy bulk goods such as coal, petroleum and natural gas (Dionori et al., 2015). These items make it easier to realize economies of scale and are less sensitive to time and damage.

The comparative advantages are also distance dependent. The additional transshipment and loading cost associated with waterborne and rail transport cannot be compensated for by lower transport cost if the transport distance is too short. Similarly, the speed of air transport cannot be utilized on shorter distances. This means that road transport is the dominant mode on shorter distances (below some 300 kilometers). Conversely, rail and waterborne transport are generally only competitive alternatives for longer distances, except for large and regular freight volumes (McKinnon 2015).

There are three main implications of these findings. First, for some transports, the distances class and shipment attributes are such that firms are captive to a single transport solution and have limited possibility and incentives to substitute to other solutions. Determinants of mode choice such as transport cost and time will then have limited, if any, impact on the transport decision. Second, the degree of competition between modes (including combination of modes) is different depending on the distance class and shipment characteristics. For instance, sea transport may only compete with air transport for shipments between Europe and China, but face competition from road, rail and IWW transport over intra-EU-shipments.

Third, differences in the commodity mix and transport distances explain some of the country-differences in modal split and modal competition. To the extent that international transports are taking place on longer distances compared to domestic transports, there will be more favorable conditions for rail, waterborne and air transport in exporting and/or importing countries. Countries in which shippers are transporting heavier and less time-sensitive commodities are also more likely to benefit rail and waterborne transports.

### 3.2 Case studies of mode choice

In this section, we describe the results from six case studies of with logistic and general managers and planners from shippers and logistic service providers (LSPs). We first asked the question how the choice of transport solution was made within the company. The results show that in most cases, LSPs are contracted by shippers who specify the details of their shipment (such as destination, load locations, transit time). The LSPs in turn offer a freight rate and transit

time associated with a transport solution. The shippers assess the bids from the LSPs and selects one. Cost is often the most important choice criteria, given that the transport service requirements are met. The shippers generally put little weight on which modes are being used as long as the specified conditions are fulfilled.

Road is the most commonly used mode, both when the transport is organized by the LSP and by the shippers. Trucks are chosen because they have the lowest freight rate, due to last-minute request so that the speed and flexibility of trucks can be utilized, because of limited storage capacity so that the service frequency of trucks makes them attractive, because of time pressure/habitual choices, poor rail infrastructure availability or because the LSP operates its own vehicles and wants to have control over the service level of the transport chain. Rail and waterborne services are more likely to be chosen when freight volumes are large and/or regular or when customers accept longer lead times.

We also asked whether there were any organizational strategies for sustainable mode choice and found that some companies have a sustainability strategy but in neither of the cases are there key performance indicators relating to sustainable mode choice. The sustainability measures that companies take are mainly aimed at higher efficiency (by combining flows, improving energy efficiency or increasing utilization rates). Some companies also participate in logistics platforms with similar targets.

Finally, the respondents were asked how they thought public transport authorities should influence mode choice. They called for different policies, including internalizing the environmental impact in the pricing of the modes, increase the availability of (rail) infrastructure, reduce terminal fees, pro-actively inform about public measures, include firms in the development of new plans and spread information about multimodal solutions.

### 3.3 Importance of modal characteristics

While the previous section provided an in-depth analysis of individual decision-making within organizations, in this section we review how aggregate demand for a transport mode respond on average to changes in a modal characteristic. The influence of modal attributes is summarized by elasticities, which measure the percentage change in demand for a transport mode following a one percentage change in one of the attributes explaining the demand (e.g. cost). Table 2 summarizes the elasticities from our literature review. All elasticities are for tonne-kilometre prices and tonne-kilometre demand and supported by at least 80 % of the studies.

**Table 2 – Values of price elasticity of demand**

	Road demand	Rail demand	IWW demand	SSS demand	Air demand
Road cost	0 to -1.2	0.4 to 1.7	0.3 to 0.9	0.2 to 1.1	*
Rail cost	0.1 to 0.5	0 to -1.6	0.2 to 0.8	0 to 0.3	*
IWW cost	0.1	0.2 to 0.9	-0.4 to -1.3	*	*
SSS cost	0.1 to 0.3	*	*	0 to -1.8	*
Air cost	*	*	*	*	0 to -2.0

Source: Vierth et al. (2017)

The own-price elasticities for almost all modes are bounded by zero, indicating that some decision makers do not respond at all to price changes. These are likely captive to one mode (as the only mode or a mode in the transport chain). Demand for road and inland waterway transports is insensitive to changes in cost; most estimates fall around -0.5. Demand for rail transport respond moderately to cost, with elasticities clustering around -1. Own-price elasticity for air demand and short sea shipping show a wide spread of values.

Cross-price elasticities are generally lower in magnitude than own-price elasticities. This means that the demand for a transport mode tend to respond more to a percentage change in its own cost than to the same percentage change in the cost of a competing mode. But there are notable differences in cross-price elasticities between the modes. Both rail and waterborne demand can be relatively responsive to changes in the price associated with road transports, although the estimates vary considerably. In contrast, road transport demand is insensitive to the cost of the alternative modes. One explanation for this is that trucks are considered to have a comparative advantage in service quality that is sufficiently high to off-set any price cuts of competing modes.

The literature identifies an additional set of attributes that may influence the modal choice. The importance of these variables is not summarized by elasticities, but rather in terms of how shippers value one factor relative to others. Environmental impact is attributed less importance than transport cost and service quality indicators in many studies (Laitila & Westin 2000; Björklund 2002; Björklund 2005; Grue and Ludvigsen 2006). A series of surveys of Swedish shippers carried out in 2012 and 2014 showed that a quarter of the respondents did not put any weight at all on environmental efficiency of transports and half of the sample agreed that more environmental efficient transports would increase logistics costs (Andersson et al. 2016). Wolf and Seuring (2010) conduct in-depth analyses of transport buyers and 3PL and find that decisions are still made on “traditional” performance objectives, such as cost and transport service quality.

One explanation for this is shippers’ low willingness to pay for more environmental friendly transports (Lammgård, 2007; Lundberg, 2006). But recent survey results suggest that the willingness to pay might be increasing: the share of Swedish firms paying extra for environmentally friendlier transport increased from 3 to 21 % between 2012 and 2016 (Styhre, forthcoming). This does not necessarily imply that firms will be switching between modes with different environmental impact. They may simply switch between transport solutions within the same mode. For instance, between road carriers that provide different environmental classes for trucks.

Surveys also show that shippers care about customer service, security and shipment traceability (particularly important for express freight services). These factors are more related to the service offered by the seller of transport (carrier or logistics provider) rather than the mode itself, and may induce firms to switch between carriers or logistics providers rather than change transport solution. Nevertheless, policy-makers and national transport authorities should be aware that these factors may weigh in on firms’ choice.

### **3.4 Importance of terminals**

This section addresses a range of topics related to the role of terminals in transport chains. It is important to note that the density of terminals is not the same everywhere in Europe. Terminals

are numerous in some regions, scarce and scattered in other. Not all terminals are directly connected to each other which can make it difficult or costly to get from one terminal to another. Some terminals serve as a key node for firms' transport chain and attracts large volumes. Other may be of less importance because of competing terminals in the neighboring regions. Terminals also vary in the modes they connect, the types of cargo they handle and the size.

One important factor for the modal choice is terminal accessibility, which typically refers to the time and cost required to reach a terminal or the catchment areas of the terminals. Higher availability and accessibility tend to reduce the cost of multimodal transport solutions. Although most pre- and post-haulage (PPH) is performed by road, rail or waterborne transports are also possible. Our review shows that PPH by road can account for a significant part of the cost in a multimodal transport chain. This illustrates how transport modes in some instances are complements rather than competing alternatives. Improving the conditions for one mode will increase its attractiveness but it can also benefit transport chains that include this mode. A case in point is the introduction of high capacity road vehicles, which is estimated to bring about a reduction in road transport cost – and thereby also a reduction in pre- and post-haulage costs to/from terminals.

Another important factor is transshipment cost in terminals. Estimates of transshipment cost are quite dispersed but point to €40 per twenty-foot equivalent unit (TEU) on average. The main cost drivers are terminal capacity (infrastructure and the superstructure) and the way this capacity is utilized. Capacity use is determined by some factors external to the terminal (like the development of transport demand and the mix of the load units) and by measures that the terminal operator can influence. Waiting time for drivers and vehicles also have an impact on transshipment costs. Waiting time is estimated to constitute 10-20 % of truck drivers' working time, which is a non-trivial cost component.

#### **4. Recommendations**

We conclude by providing a set of recommendations aimed primarily at national road transport authorities. The recommendations include measures within data collection, transport modelling and suggestions for public policy.

Our report concludes that there is a gap between the data transport authorities need and have access to. They all have adequate access to aggregated data that describe the level of freight activity and traffic. But there is a shortage of disaggregated data describing variables that affect firms' mode choice, including shipment characteristics (e.g., weight, value, commodity class), modal attributes (e.g., transit times, delivery reliability) and terminal structure. This makes it harder to evaluate how trends and transport policies affect the freight transport sector and modal choice. There is also a lack of data describing load factors and the cubic volume of freight moved.

We therefore recommend transport and infrastructure authorities to push the development towards the equipment of load units and vehicle/vessel with tracking and tracing devices. These devices provide data on tonnes and volume transported and movement of the load unit in time and space. Such data would make it possible to calculate load factors (tonnes and cubic meters), the extent of empty transports and kilometers travelled in different regions. We encourage the authorities to increase the scope of data collection in the freight sector. Commodity flow

surveys could be used in a larger extent, possibly including shippers' logistics structure, volumetric measures, scheduling variables and/or vehicle/vessel utilization.

We also acknowledge transport modelling as a necessary and powerful tool to estimate the potential impacts of different trends (e.g. long term economic development), infrastructure projects, policy measures as well as packages of measures. The results of impact analyses can be used directly as basis for political decisions or as inputs in social cost-benefit-analyses. We therefore call for an improvement of existing models and the possibility of sharing them between countries.

Finally, our policy recommendations cover collaboration, infrastructure and terminals. Regarding terminals, our review shows that some terminals adopt sophisticated appointment procedures to reduce idle time in terminals. Other choose to predict arrivals and inform the drivers about traffic conditions in real-time. The development of dry ports in connection to seaports can also be a way to reduce congestion in ports. These measures have potential to bring down terminal cost and make for more efficient freight transports.

Regarding collaboration, national infrastructure authorities that are not responsible for all modes should co-operate with authorities representing other transport modes than road. The modes are in many instances complements and combined together. Collaboration with other authorities could provide national road authorities with valuable insights about the interaction between the modes, e.g. in the development of intermodal services within the Trans-European Transport Networks (TEN-T). National infrastructure authorities should also make use and deepen existing collaboration with the private sector in e.g. infrastructure planning and adapting to climate change. The authorities benefit from understanding the driving forces behind firms' decision in the freight transport sector. Firms could provide valuable data. The private sector calls for better communication with and from transport authorities in order to plan ahead. Collaboration therefore has potential to bring mutual gains.

As for infrastructure measures, we recommend transport authorities to assess infrastructure requirements that come with an increased use of autonomous vehicles, electrification of vehicles and high capacity vehicles. Automation of long distance transports (especially on road) are expected to become established in the coming years. This means that requirements on infrastructure beside the vehicle-to-vehicle communication have to be checked. We also encourage increased use of e.g. Smart Infrastructure Access Policies (SIAP) and performance-based standards (PBS) for a safe and efficient use of the infrastructure and to promote the development of efficient vehicle-related technologies.

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