DRIVERS OF FREIGHT TRANSPORT DEMAND WORLDWIDE

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1. INTRODUCTION

Freight transport, the ability to move goods from origins to destinations, is a basic component of the worldwide economy. In the past decades, freight transport has increased rapidly and it is predicted that the high growth rates will continue in the coming decades (IEA, 2002). The growth in freight transport cannot be explained completely by increases in the number of freight shipments. The distances over which freight is transported have increased as well. Furthermore, there has been a trend towards smaller and more frequent deliveries of goods.

There is growing concern about the external effects of the projected future growth. Policymakers are looking for ways to decouple the growth in the economy from the growth in freight transport and shape freight transport growth in a more sustainable direction. If one wants to affect the future demand for transport, one needs to know what drives the demand.

Recently, RAND Europe carried out an investigation to gain insights into what drives the demand for freight transport around the world and how these drivers can be influenced. In support of this goal, the study sought to provide answers to the following two questions:

1. What are the key drivers of freight transport demand and how do they affect the demand?
2. Which of the key drivers can be influenced and how?

In order to answer these questions, we were faced with a problem that does not exist for passenger transport – the data for freight analysis are limited and scattered. There are many reasons for this:

- Freight transport is the outcome of a series of choices made by various decisionmakers (forwarders, carriers, intermediaries, drivers, and receivers -- often several of these are involved in the same shipment);
- There are many different types of commodities that make up freight transport, each of which has its own characteristics;
- Freight movements are measured in a variety of units, including dollar value, quantity, weight, volume, number of containers, and truckloads;

[1] The authors wish to thank Maarten van de Voort of RAND Europe for his useful input to this paper.

- The cost of moving freight is hard to determine because a variety of specialized services are required for freight transport;
- Data that relate to commercial operators are often confidential.

Our solution to the data problem was to combine data and information from a variety of sources and synthesise a large body of work that had already been carried out at RAND Europe. In addition, a three-fold approach was taken, which consisted of a literature study, data analysis, and case studies of urban areas. The three parts of the approach complement each other. The outcomes of the literature study formed the foundation for the rest. The data analysis and the case studies were used to fill in missing pieces.

In the next section, we identify each of the drivers of freight transport demand. For each of these drivers we discuss how it affects not just the composite demand, but whether and how it affects the abovementioned choices that determine transport volumes, mode shares, load factors, and the traffic distribution over time and over the networks. Next, we give an overview of possible policy options to decouple the growth in GDP from the growth in freight transport and shape demand in directions leading toward more sustainable development. We then draw some overall conclusions about the key drivers and policy options.

2. DRIVERS OF FREIGHT TRANSPORT DEMAND

We used a systems approach, focusing on the choices made by the various actors in the system, to identify the key drivers of freight transport demand. The amount and composition of freight transport demand is determined by a set of choices made by a variety of decisionmakers (see the demand choices in the middle of Figure 1). These choices include:

- *Shipment choices* (shipment size, frequency, etc.), which result in shipments of commodities with certain weights, sizes, and values between or origins and destinations. The flow in tons times the trip length is the transport volume. The transport volume is measured in ton-kilometres (ton-kms). The size and value of the shipment are important characteristics because they affect the mode choice and the load factor.
- *Mode choices*, which result in a modal split and, together with logistic decisions, determine the vehicle load factor. Together with the transport volumes, the mode shares and the load factor determine the number of vehicle-kilometres by mode.
- *Time-of-day choices* and other issues on timing (e.g. day of the week), which produce a distribution of traffic over time periods.
- *Route choices*, which yield the distribution of traffic over the network.

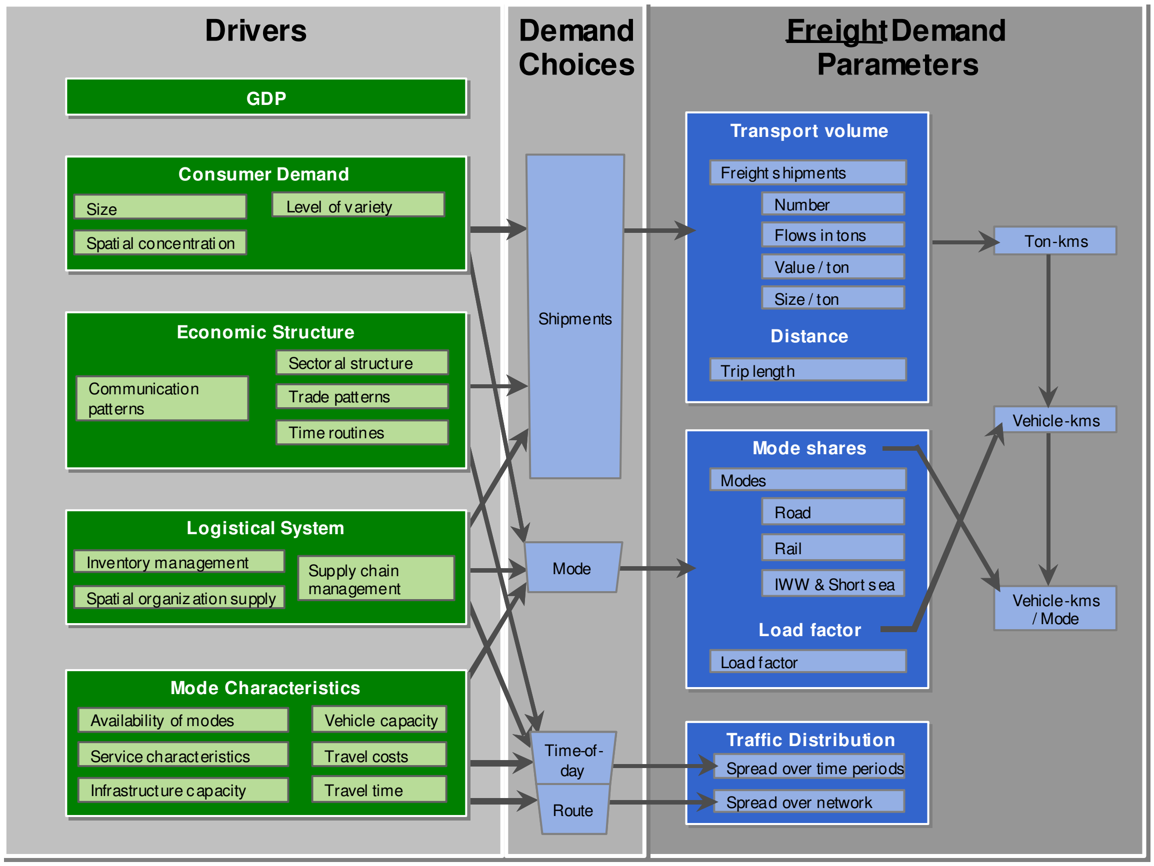


Figure 1: Drivers of freight transport demand

As shown on the left side of Figure 1, the drivers can be clustered into five groups – GDP, consumer demand, economic structure, logistical system, and mode characteristics. With the exception of GDP, each driver is divided into several elements. Below, the drivers are discussed in the order depicted in Figure 1.

2.1. GDP

The Importance of GDP

GDP has traditionally been seen as one of the key indicators for changes in freight transport demand, which is reflected in a strong relationship between freight transport in ton-kms and GDP. A study by the World Bank (Bennathan et al., 1992) based on data from the 1980s and covering 17 developed, 11 developing, and 5 transition countries, found that the variation in GDP measured in purchasing power parity (PPP) alone explained 81% of the variation in ton-kms (total by road, rail, and water). A similar result was obtained after including area size as an additional regressor. RAND Europe performed a similar analysis based on data for 49 countries and found that the variation in GDP (in PPP) explained 92% of the variation of ton-km by road, rail, and water. Figure 2 illustrates the close relationship between freight transport volume (measured in ton-kms) and GDP for the EU-15.

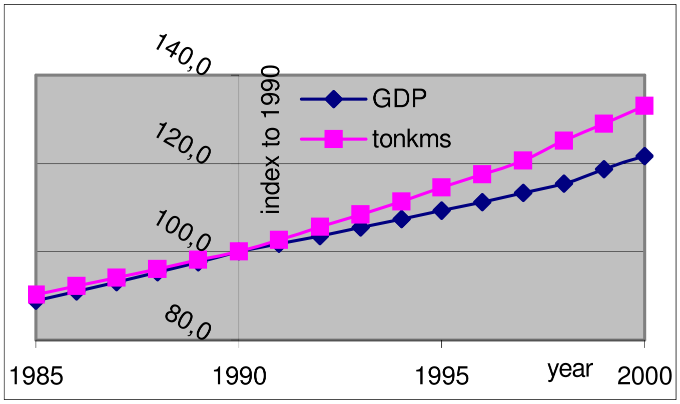


Figure 2: Relative growth of GDP and freight transport (ton-kms) EU-15, 1985-2000 (1990=100)

GDP Elasticities

The relationship between freight transport demand and GDP is often expressed as the GDP-elasticity. The GDP-elasticity is the ratio between a percentage change in freight transport demand, measured in ton-kms or tons, and a percentage change in GDP. A GDP-elasticity greater than 1 indicates that for each 1 percent of growth in GDP, there is more than a 1 percent growth in freight transport demand.

Empirical data show that GDP-elasticity rises as GDP declines. In developed countries, the GDP elasticity of ton-kms is less than 1 in every major OECD region except Western Europe. The OECD average elasticity is 0.83 (IEA, 2002). In developing countries, the GDP-elasticity of ton-kms is greater than 1. RAND Europe has estimated it to be 1.30.

In developed countries, the GDP-elasticity of truck-kms tends to be appreciably higher than that of ton-kms. For example, RAND Europe analysis showed that, in the United States, the GDP-elasticity of truck-kms to GDP was 1.01 for the period 1985-1997, while the GDP-elasticity of ton-kms to GDP was 0.77. The difference between the two elasticities reflects a shift in modal share from rail to trucking, a shift from bulk goods toward components and finished consumer goods, and a growing tendency toward more frequent deliveries and smaller consignments.

Although freight transport by all modes is closely related to GDP, airfreight transport is more sensitive to GDP than other modes. Since 1970, air cargo traffic (measured in revenue ton-kms) has expanded by about 7.1% annually (i.e., more than 2.4 times faster than the rate of GDP growth), leading to an almost eightfold increase in total traffic volumes. The impact of economic downturns or political crises on airfreight development is more severe than on freight transport by other modes. Total world airfreight growth and world GDP growth show a clear correlation. The peaks and troughs in freight traffic and GDP growth often coincide. During periods of strong economic growth, airfreight growth has topped 10% per year. In economic downturns however airfreight has shown negative growth.

2.2. Consumer Demand

Although GDP is the primary driver of freight transport demand, it is only an indirect driver. GDP drives demand for freight transport through its influence on the size of consumer demand and on the sectoral structure of the economy. Consumer demand has three elements. The size and the variety of consumer demand are major drivers of the number of freight shipments and also have an impact on modal split and load factors. The spatial concentration of demand is an important driver of trip lengths and influences mode choice. We discuss these three elements of consumer demand in this section.

Size

As societies become wealthier, consumer demand increases, which leads to an increase in transport volumes. In addition, the demand structure changes as well, with a lower share of demand for basic goods (food, clothing) and an increasing demand for luxury goods with higher value-to-weight ratios. This shift has an important effect on the value placed on transport time and, therefore, the choice of mode. Air and truck transport are favoured for goods with higher value-to-weight ratios, while rail and barge transport are preferred for lower-value bulk goods. This is because transport costs are a smaller part of the total costs as the value-to-weight ratio of the products increases. The share of transport costs as a percentage of production costs drops from between 3 and 7% for low-value goods to between 0.7% and 1.3% for high-value goods (see Table 1). High-value goods have high inventory cost and therefore a higher value of time than low-value goods. Therefore, for high-value goods it is more important to use fast modes.

Table 2 shows that in the U.S. in 1997, the five top value sectors (with about 40% of the total value all goods) are for the most part moved by road. The lower part of the table shows the five top sectors according to ton-miles. These categories comprise only about 10% of the total value of all goods, but more than 40% of the total ton-miles. Comparing the average distances of each sector, and considering the share of ton-miles of the two groups, the table indicates that high-value goods are moved over long distances in relatively small tonnage volumes per vehicle, while low-value goods are moved over shorter distances, but in high volumes per shipment. Obviously, rail and water are the most appropriate modes for low-value products (road accounts for no more than 30% of four of the top five sectors by ton-miles), while road is the most appropriate mode for high value products (road accounts for more than 80% of the ton-miles for three out of the top five sectors by value).

Table 1: Share of transport costs in total production costs for selected commodities[2]

Commodity	Share of transport costs in production costs (%)
Ores	6 - 7
Building materials	6.5 - 7.2
Iron, Steel	4.5 - 5.0
Foodstuff	3.6 - 3.9
Petroleum products	3.3 - 3.6
Chemicals	2.1 - 2.5
Office equipment, electronic products	1.3
Retail products	0.7

Source: Aberle G. (2001)

Table 2: Value per ton, mode choice, and transport distance (1997)

Top 5 sectors by value	Value/Ton (U.S.$)	% Share of ton-miles Road	Rail	Water	Air	Multiple modes	Avg. distance (miles)
Electronic & other electrical equipment, components, office equipment	21,955	80.2	2.2		3.2	11.1	640
Motorized and other vehicles	5,821	55.5	25.3			11.9	278
Textiles, leather, etc.	11,591	83.1	2.2		0.8	11.7	912
Machinery	9,926	80.5	3.9		1.8	10.1	356
Other prepared foods, fats & oil	1,008	63.5	27.0	1.8		6.2	127
% of total value of top 5 sectors	38.3						
% of total ton-miles	6.5						
Top 5 sectors by ton-miles	**Value/Ton (U.S.$)**	**% Share on ton-miles Road**	**Rail**	**Water**	**Air**	**Multiple modes**	**Avg. distance (miles)**
Coal	22	1.7	81.0	4.2		12.0	81
Cereals, grains	110	9.1	58.0	29.0		1.5	125
Other prepared foods, fats & oil	1,008	63.5	27.0	1.8		6.2	127
Coal & petroleum products	158	28.5	35.6	18.2		n.a.	85
Basic chemicals	446	24.7	50.8	19.3		2.2	332
% of total value of top 5 sectors	10.6						
% of total ton-miles	42.7						

Source: U.S.DOT/U.S.DOC (1999)

[2] Shares are based on a German case study and are most likely lower for the U.S. and Japan.

Variety

In highly developed economies, socio-economic trends are leading towards an older, wealthier, and more individualized society with more leisure time. The consumers in such societies express their tastes and product preferences in strong demands, often for individualized goods. In response to these tastes, producers offer more diverse and more tailor-made products. This has an effect on the structure of the producer-to-consumer chain, and therefore influences which goods in that chain are transported when and in what form (from raw materials to finished products). Consumers in these economies change their tastes and product preferences quickly and expect to be offered the products they prefer. The diversification and short lead times lead to higher numbers of trips and smaller loads, together making the most flexible mode (practically always road transport) more attractive.

Spatial Distribution

In freight distribution, trip lengths in freight transport are affected by the spatial dispersion of the population. Furthermore, each mode shows a characteristic distance range where it is most appropriate (of course modal choice is also dependent on other attributes, such as time and cost). Figure 3 shows the modal shares of alternative transport modes in relation to different transport distances in the EU. It shows that the share of commodities moved by truck falls as the trip distance increases, while at the same time the percentage moved by other modes, such as ship and rail, increases. Of particular note in Europe is the sharp increase in the share of short sea shipping for distances of around 1,000 kilometres. This is obviously a consequence of Europe's geography; it is the dominant mode for transporting from Scandinavia and the United Kingdom to Europe's mainland as well as among the Mediterranean littoral states. It is regarded as a reliable and efficient mode of transport, which enhances its value and increases its usage even when other modes might serve as a substitute.

Each country or region is characterized by a unique distribution over modes and distances, which is often influenced by the local geography. In addition to the macro-level effects of spatial distribution on freight transport demand patterns, at the micro level, increasing suburbanisation leads to a dispersion of demand, which leads to an increase in road transport to serve the decentralised shop locations.

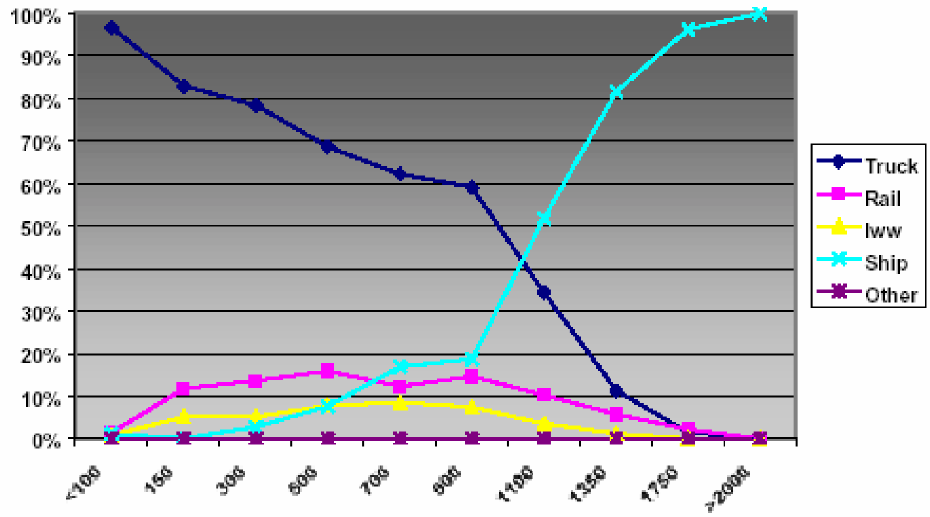


Figure 3: Mode shares by distance (% tons lifted, all commodity groups, EU-15) (Source: ME&P, 2001)

2.3. Economic Structure

In this section we discuss the impact of the economic structure on freight transport demand. We divide economic structure into four elements: communication patterns, sectoral structure, trade patterns, and time routines, each of which is discussed separately. Apart from its direct effect on freight demand, economic structure also affects freight demand in an indirect way -- through other drivers. In fact, the impacts of new communication technologies on freight transport are mostly realized either through changes in the logistics system (discussed in the next section) or changes in trade patterns. Furthermore, there is a mutual dependency between the sectoral structure and the trade patterns.

Sectoral Structure

Sectoral value-added shares provide a good perspective on the structure of an economy. Some economies are heavily oriented towards services or tourism (e.g., the United States, Greece), while others have a significant manufacturing sector (e.g., Ireland) or a large agricultural sector (e.g., Turkey). In general, developing countries have a high share of primary (agriculture) and secondary (extractive) industry, while developed countries have a high share of tertiary (services) industry. Countries with dominant primary and secondary sectors generate more freight transport demand in tons per unit of GDP than countries with a large tertiary sector. Hence, the transport of heavy bulk goods has been growing much faster in terms of ton-kms and tons in developing countries than in developed countries.

Within the industrial sector, the share of output from heavy industry, which by definition involves the production of heavier bulk goods, has fallen relative to sectors such as electronics and electrical equipment. Also, in order to reduce inventory and transport costs, companies are redesigning their products and packaging to make them smaller and lighter. This trend is accompanied by postponement manufacturing, since many products can be shipped more space-efficiently in the form of components rather than as final products. An example of this kind of postponement manufacturing that reduces freight transport can be seen in the restaurant business, where soda manufacturers deliver solid extracts to which water is added at the point of sale. This application of postponement manufacturing reduces freight transport by over 90 percent and also relieves transport of some of its quality demands, since the extract is not as sensitive to rough handling as the final product would be. These trends towards service economies and lighter/smaller products and packaging are leading to smaller increases in the number of tons, ton-kms, and vehicle-kms to be transported, as well as decreasing the costs of transport and inventory.

As mentioned above (in the Consumer Demand section) there is a trend toward an increase in the value to ton ratio of the goods being transported. For example, within the industrial sector, the share of output from heavy industry (which, by definition, involves the production of heavier bulk goods) has fallen relative to sectors such as electronics and electrical equipment. These developments lead to an increased use of road transport.

Trade Patterns

Trade patterns are changing rapidly under the increasing globalisation resulting from liberalization, deregulation, and e-society developments. Globalisation implies a process of ongoing and often rapid increase in worldwide flows of traded goods and services of all types. It includes the concentration of activities on a global scale. Several interrelated factors have contributed to the globalisation process of the 1990's. Examples include: growing liberalization of trade and financial flows, advanced information and communication technology, lower transport costs, firms' strategies regarding location and the need to exploit worldwide technological and organizational advantages, etc. As the world market becomes more globalised, businesses tend to seek comparative advantage by arranging their facilities differently to benefit from low labour costs, tax regimes, site costs, accessibility to markets, and flexible, non-restrictive legislation, leading to shifts in trade patterns. In particular globalisation can be observed in sectors where price differences in resources are considerable and in cases where location factors such as tax climate and environmental regulations play a major role. As a result, labour-intensive facilities are increasingly located in low labour cost countries, such as in Southeast Asia, Eastern Europe, and South America, while the demand remains for a large part in the former regions, leading to the transport of goods over longer distances.

Communication Patterns

New communication patterns are an increasingly important driver for freight transport because of their impact on the logistics system and business relations. E-commerce has been increasingly adopted for business-to-business (B2B) and business-to-customer (B2C) communications, and its share is expected to continue to grow. E-commerce includes shopping, negotiation, contracting, purchasing, payment, fulfilment, etc. Recent studies have shown that B2B accounts for 85-90% of all e-commerce, while B2C covers the remaining 10-15%. B2B dominates e-commerce because inter-company trade is larger than trade between companies and consumers, and inter-company trade has traditionally been structured in a more straightforward way; large volumes are shipped, frequently by third-parties, and the process is supported by a variety of documents describing the characteristics of the cargo and its transport. B2B is in fact just a way of substituting this traditional paper trail with a more reliable, faster, interactive, verifiable, less costly digital one.

B2B e-commerce is facilitated by Internet portals – password-protected Websites through which supply chain partners can trade goods, trace shipments, and inquire into the availability and prices of goods and services. These portals have a dual effect on transport. On the one hand, physical or “bricks and mortar” points of sale disappear, eliminating “middlemen” and resulting in a reduction in transportation. On the other hand, transport distances increase, since market areas are enlarged (customers are now able to purchase goods through a global network) and manufacturers centralize their production and storage within this global network. In some cases, besides the communication on the cargo, the cargo itself can also be digitised, causing the physical transport to be substituted by digital transport, which leads to reductions in transport volume. B2B telecommunication can also be used to increase load factors, which would lead to fewer vehicle trips to transport the same amount of cargo.

As for B2C e-commerce, it is not yet clear how it will develop and what effect its development will have on freight transport demand. The substitution of e-commerce for traditional sales may lead to a reduction in the number of local points of sale. Small traditional single-owner shops may disappear and be taken over by large retail chains. Also, retail chains may offer different shopping formulas for different consumers, which will change in response to market demand. For instance, there may be larger shops with a full range of products (possibly at new locations) and small convenience stores in inner-city regions with large flows of shoppers. In any case, e-commerce is unlikely to replace most physical shops, but some changes in the number, size, and location of the physical shops is likely.

Replacement of conventional shopping with e-commerce (including home delivery) is likely to have the following effects on freight transport:

1. Increased delivery vehicle-kms, due to the substitution of large trucks by smaller vehicles, leading to an increase in the number of commercial trips.
2. Increased transport distances, since people are now able to order goods through the Internet from anywhere on earth; prices may be lower elsewhere, and people may be able to locate a product they want that is not sold locally.
3. Multiple delivery trips, since recipients are often not at home when the deliveries arrive. Some couriers use lockers, pick-up points, and unattended home delivery, but there has not yet been a breakthrough for solving this problem.
4. A possible decrease in total vehicle kilometres and trips. Although it is unlikely that the growth in home delivery trips will be compensated by a reduction in shopping trips, the home deliveries should have a more efficient routing than the separate shopping trips (one multiple stop commercial vehicle tour can serve several homes). However, it has been shown that people have a constant propensity to travel (OECD/ECMT, 2001), which could offset the decrease in travel for shopping purposes.

Time Routines

The manner in which societies are organised temporally affects both the distribution of traffic over time periods (times of the day, days of the week, seasons of the year) and the number of vehicle kilometres. For example, many cities have delivery time windows (specified times when deliveries can be made to the city centre). These have some advantages in terms of working hours at the destination locations and possibly congestion reduction. However, these restrictions force truck operators to use their equipment and personnel in a sub-optimal way. The number of stops that can be combined during a time window is limited; therefore, time windows can increase the number of vehicle trips and reduce load factors. A similar argument goes for night bans and weekend bans for freight traffic for specific areas and roads.

One way of alleviating the loss of efficiency due to delivery time windows is to increase nominated day and time deliveries – delivering on fixed days and times. By concentrating deliveries in particular areas on particular days, companies can achieve higher levels of transport efficiency and achieve higher levels of load consolidation and vehicle utilization, resulting in fewer vehicle kilometres. Recent ICT developments enable tighter scheduling of transportation means, which are leading to an increase in nominated delivery schedules.

2.4. The Logistics System

In this section, the fourth driver, the impact of the logistics system on freight transport demand, is described. The logistics system includes three elements: spatial organization of supply, inventory management, and supply chain management. The logistics system affects the number of freight shipments, trip lengths, mode choice, load factors, and the spread over time periods.

Spatial Organization of Supply

Although population densities account for many of the differences in average freight transport distance, differences in facility location may also be a factor. The locations of sources of raw materials tend to be fixed spatially, as well as – to a somewhat lesser degree – the location of the users. However, the locations of other activities in the production and supply chain (e.g., processing and distribution facilities) are responsive to economic incentives. With regard to sustainability, changes in the spatial structure can help to shorten transport distances, e.g., with industrial clusters and concentration of freight transport on few corridors with large volumes. On the other hand, greater dispersion of manufacturing and retail locations leads to more and longer trips.

Inventory Management

Unit transport costs have decreased over the last decades while unit inventory costs have increased. This change in the relationship between storage and transport costs has led to the use of the Just-In-Time (JIT) concept, which has led to a decrease in inventory levels and an increase in delivery frequency. Trucks are increasingly used as a means of “mobile inventory”. This has led to an increase in vehicle kilometres and an increased demand for van transport (using vehicles with a maximum load of 2,5 tons) instead of truck transport. Over the past two decades the number of van-kilometres has increased by an average of 7% per year, and the share of van transport in total transport (in vehicle kilometres) has more than doubled (to 11%). The growth of JIT transport increases the service requirements of the transport modes, especially with regard to reliability of the transport time (delivery at the agreed time or within the agreed time window) and flexibility (short reaction time between order and delivery). Road transport modes are considered by the industry to perform considerably better than other modes on these factors, and so the growth of JIT transport has improved the competitive position of road transport.

Supply Chain Management

Technological developments in production facilities and supply chains are facilitating demand-driven production. This has two components. The first component is lean production – the flexible production of (semi-)manufactured goods, whereby the production facility can be reconfigured within hours (instead of days) to switch between products. This enables manufacturers to produce a wide range of products and a wide diversity of a given product at a single facility. The second component is postponement manufacturing. Semi-manufactured goods are produced according to a demand forecast (BTS: Built To Store) at a central production facility and are shipped to assembly facilities near the market. At the moment a final product is ordered, it can be assembled at the assembly facility, resulting in very short lead times and quick fulfilment. Due to the manufacture of a variety of components, orders can be customized to match the demands of the customer. This influences what needs to be shipped and where it is shipped.

These developments put specific demands on the supply chain. The supply chain must be flexible enough to enable short lead times (time between order and delivery) and reliable delivery of products. ICT tracing and planning systems enable the control of material flows, providing real-time information on the status of the products. This has resulted in a restructuring in the management of the supply chain. The various transport modes differ in the way they can meet the demands for shorter lead times and JIT delivery. The dominant view among shippers is that road transport is the mode that can provide the highest flexibility and reliability (Hague Consulting Group, 1992).

Another development in supply chain management is the increased use of distribution centres and hub-and-spoke systems. This helps to reduce the costs of distribution facilities, transportation, warehousing, and inventory. Economies of scale can also be achieved by concentrating production facilities in fewer locations and centralizing inventory by reducing the number of stockholding points. Inventory centralization occurs on a larger geographical scale, which results in longer routes in general, but also to a consolidation of traffic flows. Consolidating freight flows leads to higher load factors, use of larger vehicles, and opportunities for alternative modes on the long haul. Larger vehicles are more economical in terms of cost per ton than smaller ones, provided they are fully loaded. By consolidating freight flows, it is possible to collect sufficiently large volumes for transport over longer distances by vehicles of a larger size. Furthermore, consolidating freight flows makes non-road transport on the long-haul more attractive.

It needs to be mentioned, however, that for the short-distance movements at both ends of the long-haul transport, road transport remains necessary. In fact, final deliveries to retail establishments generate the largest numbers of commercial vehicle trips within regions. According to one estimate (Roberts, 2000), relatively small shipment sizes combined with high distribution frequencies generate 71% of total commercial vehicle movements (see Figure 4). These movements are the primary cause of urban congestion, since they frequently take place at the same time as local personal trips. This leads to additional transport costs due to longer trip times. In areas that suffer from heavy congestion, shippers and carriers attempt to maintain the reliability of the supply chain by setting up denser depot networks, or by purchasing more delivery vehicles.

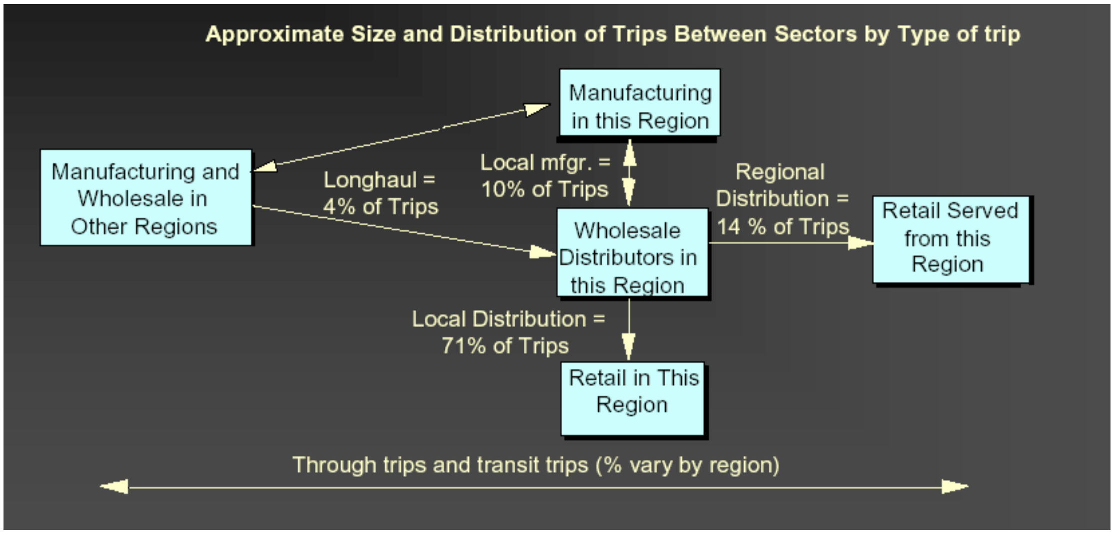


Figure 4: Truck movements as a percentage of different types of journeys (Source: Roberts, P.O., 2000)

2.5. Mode Characteristics

In this section, we discuss the impact of mode characteristics on freight transport demand. In doing that, the following six mode characteristics are distinguished: infrastructure capacity, availability of modes, service characteristics (excluding shipment size, cost, and time), vehicle capacity, travel costs, and travel time. These characteristics primarily affect the choice of mode; but they also affect the traffic distribution (spread over time periods and over the transport network).

Infrastructure Capacity

Infrastructure capacity is affected by its physical and operational characteristics. The physical characteristics of the infrastructure usually restrict the size, weight, and speed of vehicles that use the infrastructures, due to such aspects as the width of lanes, design of curves, road or track, and underground use. The operational characteristics are related to the regulations. Examples of regulations are speed limits (high speed for some vehicles results in large speed differences that reduce the capacity), rules for overtaking (U.S. motorways exhibit higher capacities than German motorways, since passing cars/trucks in the U.S. is possible on all lanes), or networks dedicated exclusively to freight or passenger traffic. The physical and operational characteristics affect transport time and the time reliability of a mode, which affects mode choice. Traffic management systems, information systems, and other intelligent transport systems (e.g., harmonizing speeds through signalling or active road signs) enable efficient management of road traffic flows, resulting in increased road capacity.

Availability of Modes

Availability of a freight transport mode refers to both the mobile (e.g. trucks, wagons) and immobile (e.g. road and rail networks) infrastructure. As in most countries, the road network shows a higher density than rail or waterway networks (see Table 3). Because of availability, road transport is often the preferred mode for final distribution and for shipping from factories or distribution centres.

Table 3: Modal network densities for selected countries (year 2000, in km per square km)

	Road	Rail	Inland Waterways
Brazil	0.011	0.003	0.006
China	0.034	0.006	0.012
Egypt	0.050	0.005	0.004
EU-15	1.147	0.015	0.015
India	0.510	0.021	0.005
Japan	1.466	0.055	0.005
Russia	0.021	0.005	0.006
United States	0.405	0.028	0.004

Sources: Road: World Bank (2002); Rail: World Bank (2001); Inland waterways: CIA (2002)

Service Characteristics

In a recent study for the European Commission, RAND Europe identified eleven service characteristics that were most important in the choice of mode for freight transport – in particular, the choice of road transport over intermodal transport (INTERMODA, 2003). These characteristics and their descriptions are given in Table 4.

Table 4: Intermodal service characteristics compared to road transport

	Characteristic	Description
1	Cost	is transport cheaper or more expensive than by road?
2	Travel time	does it take longer or is it quicker than road transport?
3	Reliability	is it more or less reliable than road transport (in terms of the length and frequency of delays)?
4	Flexibility	can it quickly adjust to changes in demand and in customer requirements?
5	Tracing of freight	can the location and status of load units and cargo be checked easily?
6	Use of infrastructure	is the quality and capacity of the infrastructure (including terminals) sufficient?
7	Scale/volume	Is it better or less able to handle large volumes of goods than road transport?
8	Service of terminals	do the services provided at terminals give the mode that uses these terminals an advantage over road transport or do they make it more cumbersome?
9	Legislation	does the mode have legal advantages or are there legal bottlenecks that road transport can circumvent?
10	Safety	do load units and cargo incur more or less damage than in road transport?
11	Security	are goods better or less well protected in intermodal transport?

This section deals primarily with the characteristics besides scale/volume, travel cost, and travel time, which are dealt with in the three sections that follow. We provide overall conclusions about mode choice from INTERMODA and other studies in which RAND Europe has been involved:

1. *High service quality requirements imply reliable transport, but not necessarily rapid transport.* For freight with high service quality requirements, reliable transport is more important than short transport time. Long transport times are often accepted as long as the delivery is reliable and on time. Reliability is often associated with flexibility -- in terms of the time between the booking and the departure of the haulage, for example, and the possibility to monitor the status of the shipment. Delays are even accepted, as long as information on problems is available in time to allow counter actions. For high-quality services, higher transport prices are also accepted.

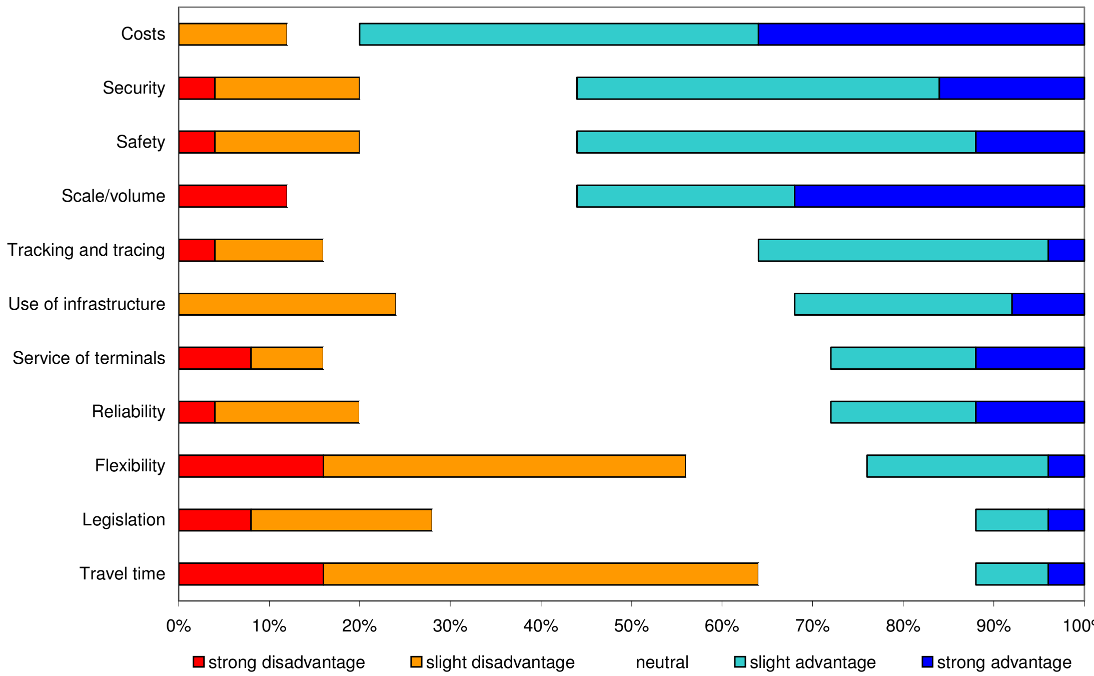
2. *For most of the service quality characteristics, road is regarded as the better option, with specific strengths in flexibility and availability.* The dense road network, coupled in many countries with a highly developed and competitive road transport sector, results in a level of availability and flexibility for road transport that is unrivalled, in particular on short and medium distances (final distribution). If the product flows can be bundled to sufficient volumes, rail, barge and short sea shipping are often the most efficient choice for long haul transport. However, if these alternatives cannot offer required service characteristics (e.g. competitive and reliable transport time, status information, safety, and security), road transport will most likely be chosen.

3. *Intermodal transport currently has a relatively small market share, but it is a promising mode for long-distance haulages.* Intermodal transport is aimed at combining the advantages of road and rail/water transport, i.e. the flexibility of road transport for collection and delivery services over short distances, and the low costs and more environmentally friendly energy and emission characteristics of rail/water over long-distance connections.

4. *Some of the service characteristics of intermodal transport are competitive with road transport.* According to freight forwarders surveyed during the INTERMODA project, the service quality of intermodal transport is closest to road in terms of costs, scale/volume, and safety/security. Flexibility, reliability, transport time, and availability are seen as the weakest quality characteristics of intermodal transport compared to road transport. This is partly due to low demand volumes. For example, due to low demand volumes, most intermodal train connections are only served once a day; if

customers cannot provide their goods on time, there is a delay of one day. The results of the INTERMODA survey are summarised in Table 5. The complete results are presented in (INTERMODA, 2003).

Table 5: The advantages and disadvantages of intermodal transport relative to road transport



Vehicle Capacity

For surface transport, there is a strong correlation between shipment size and trip distance: the longer the distance, the larger the shipment size. Larger shipment sizes usually correlate with lower delivery frequencies. Large shipment sizes make rail and barge more attractive compared to road. Figure 3 shows that with increasing distances, vehicles that permit higher average loads become more competitive.

Freight transport is most cost-effective if vehicle capacities are fully used. This means that the vehicle capacity must be harmonized with shipment sizes. Small consignments like parcels or final distribution of goods are conveyed with small trucks and vans, while large shipments over long distances use heavy trucks or alternative modes of transport.

While larger vehicles can potentially increase the transport efficiency of large shipments over long distances, they cannot always be used, due to regulations, physical infrastructure characteristics, or safety considerations. For example, the design of roads and bridges allows only limited vehicle weights, rail tunnel profiles are not designed for two-story container loading, and train lengths are restricted due to operational and safety characteristics of the network. There are large variations among countries. For instance, in Australia many areas cannot be accessed, which has led to the use of large truck trains, i.e. trucks with three or four trailers, which provide high transport capacities. In Sweden road freight transport capacity is increased by the admission of 44-ton heavy trucks, while in all other European countries heavy trucks are limited to a maximum weight (truck and loading) of 40 tons. Even greater variations in loading capacities can be found on the railways: mountainous areas show train loads of 300 to 400 tons (e.g. Switzerland, Austria) while in flat areas, train loads in Europe can reach 1000 and more tons. Significantly higher loading rates can be found in flat areas in the U.S. and China, with loading capacities of 3000 to 4000 tons.

Because of increased cargo security and the ease of handling and tracking, containerisation has led to extraordinary improvements in the efficiency of medium- to long-haul freight transport. These improvements tend to be a precondition for the development of intermodal systems. For intermodal transport, forwarders and haulers have expressed a demand for a larger container to increase efficiency, but there are conflicts regarding weight and size regulations for road transport in Europe. These conflicts may prevent the wider introduction of larger containers. A further barrier to the wider introduction of larger containers could be the problem of handling a third standard container size (besides the traditional 20- and 40-foot containers that are currently used). Container ships, handling, storage, and maintenance facilities would have to be adjusted to the new container size, which would be likely to bring about additional costs.

Travel Cost

Price elasticities of demand for various transport modes are rather elastic in Europe (see Table 6). Increases in road transport costs for general cargo and especially for bulk goods on transport distances over 500 kilometres have a substantial effect on modal choice, although cost differences among modes are of less importance for high-value goods than for low-value bulk goods. As shown in Table 6, raising truck transport costs will lead to a modal shift in bulk transport away from trucks mainly to rail and inland waterway transport, while for higher-value general cargo the shift will mainly take place from truck to rail and intermodal combined transport. For trips up to 500 km, the elasticities are considerably smaller (between 0 and –0.3 for the truck price elasticity of truck transport of bulk products, and between 0 and –0.5 for general cargo).

Table 6: Truck price direct and cross elasticities for bulk and general cargo at different transport distances for the EU-15[3]

Mode	Distance range 500 to 1,000 km		More than 1,000 km	
	Bulk	General cargo	Bulk	General cargo
Truck	-0.5	-0.7	-1	-0.8
Inland waterway	1	0.5	0.6	0.2
Rail	1.5	1.1	1.7	1.2
Combined transport	0	1.1	0	1.2
Short sea	0.3	0.2	0.3	0.1

Source: RAND Europe (2002)

If several routes are available with different cost levels, road freight vehicles will use the cheapest, if the detour is not too long. Most freight transports have high values of time and therefore the detours can only be small. Shifts to cheaper time periods (e.g., because of peak-period pricing) are not very likely in freight transport. The higher peak-period tolls for instance on the Tappan Zee Bridge in New York did not have large impacts on time-of-day choice for trucks (Resource Systems Group et al., 1999).

Travel Time

Travel time is one of the most important drivers of mode choice for high-value and time-sensitive goods. The transport costs of high-value goods are of less importance than timely, reliable delivery. Interestingly, general cargo deliveries show substantial shifts from road to other modes at distances over 1000 km. This sharp increase in the elasticity may be explained by a critical distance at around a 1000 km. At an assumed average truck speed of 70 to 80 km/h, a distance of about 1000 km is an upper limit that can no longer assure timely overnight delivery. At distances below 500 km, the time elasticities of truck ton-km are lower.

If several routes are available with different travel times, road freight vehicles will use the fastest, if there are no extra costs. Most freight transports have high values of time, and therefore the cost difference needs to be substantial to outweigh the time difference. In the evaluation study of the effects of the opening of the Amsterdam Orbital Motorway (Bovy et al., 1992) it was found that, after the opening of a major new motorway route that offered substantial time gains for many origin-combinations, truck traffic changed route as least as much as passenger traffic. Shifts to time periods with shorter travel times (less congestion) also occur in freight transport (e.g. some shifts towards night-time transport), but only on a small scale so far. Most freight transport is already avoiding the rush hours.

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[3] E.g. a one percent increase in truck costs would decrease truck demand in ton-kilometres by –0.5% (case: bulk between 500 and 100 km) and increase demand on alternative modes by 1% (inland waterways), 1.5% (rail), 0% (combined transport), 0.3% (short sea).

3. POLICY OPTIONS

In the previous sections, we have identified the most important drivers of transport demand for freight transport. Some of these (e.g., the size of consumer demand) are not reasonable targets for transport policies. However, many of the drivers can be influenced by policy in order to shape demand in directions leading toward more sustainable development. These policies include changes in prices, regulations, infrastructure, traffic management, information provision, and subsidies adopted by governments or other institutions, all of which affect one or more of the transport demand drivers or directly affect demand.

Driver by driver, this section identifies policies that can affect the demand for transport. The drivers are associated with policy categories. Within each policy category we describe one or more specific policy options and how they affect the drivers of transport demand. Most of the policy options have never been implemented. They have been mentioned as good ideas in the transport policy literature, based largely on insights from modelling exercises and expert judgments.

We have grouped the policy into four categories:
1. Spatial planning
2. Policies affecting the economic structure
3. Policies affecting the logistical system
4. Changing mode characteristics

3.1. Spatial Planning

While the economic and socio-demographic structure strongly influences what is to be transported, the spatial structure is important because it determines the points from and to which freight needs to be transported (its origins and destinations). Changing the nature of production in an economy takes a long time, and government has only limited possibilities for influencing this. Spatial planning, however, can help to reduce the need for freight transport and facilitate the bundling and integration of freight flows in transport chains. The spatial structure is easier to influence and attempts by the government to do so are more appropriate than attempts to influence the economic structure. Examples of spatial planning policies that can affect freight transport demand are:

- *Stimulating the vertical spatial clustering among firms* (encouraging firms that are part of the same logistics chain to locate close to each other).
- *Stimulating the horizontal spatial clustering of firms* (encouraging different companies in the same industry – e.g., chemicals – to locate close to each other).

- *Stimulating firms to locate near railways and waterways or along transport corridors*.
- *Stimulating the decentralization of production facilities*; the more locations producing the same product, the shorter will be the average distance to where the product is needed.

There are a number of instruments that can be used to stimulate these changes in the freight transport system. These include: zoning, providing incentives (e.g. subsidies), using building permits, and enacting regulations similar to the Netherlands' ABC location policy to match company types with types of accessibility. The ABC location policy was introduced in the Netherlands in 1989. The core element of the policy is a classification of types of locations and types of companies. Companies are graded according to access needs and modal shift potential (mobility profile), while locations are graded according to their accessibility by public and private transport (accessibility profile). The accessibility profiles are graded A, B or C. A-locations are highly accessible by public transport. Examples of A-locations are major public transport nodes, such as central stations in the larger urban areas. B-locations are reasonably accessible both by public transport and by car, while C-locations are exclusively accessible by car. C-locations are found near motorway exits in fringe areas having poor public transport access. To enhance the effectiveness of the ABC location policy on mobility, limits are placed on the number of parking places allowed at A- and B-locations. It is assumed that the good public transport accessibility of these locations provide commuters with an alternative to the use of cars, and therefore legitimises the restriction on parking facilities.

A "hub-and-spoke" spatial structure for urban freight distribution is one way to reduce the number of large trucks entering cities. Movement toward this structure can be facilitated by stimulating the use of city distribution centres on the borders of cities.

3.2. Policies Affecting the Economic Structure

Time Routines

Freight traffic can be spread over the day by changing the temporal structure of the freight distribution system. Transporters can be stimulated to make use of off-peak hours through a range of policy instruments. For example, if there are tolls for using roads, these can be varied by time of day. Also, trucks can be denied access to particularly crowded roads during peak hours.

3.3. Policies Affecting the Logistics System

The freight flows that result from the spatial and economic structure are shaped by the supply chain configuration, which can be split into inventory management, cooperation with other companies of the same type, and supply chain management. The most important driver of logistic management is information and communication, both within businesses and among businesses (B2B). The government can facilitate these processes by stimulating the use of information brokers and information exchange facilities, stimulating the use of regional dispatching systems, and/or directly stimulating B2B communication for logistic management.

The government can also improve logistics management by supporting scans for improving logistics efficiency. For example, the Dutch government has adopted a program called ‘Transactie Modal Shift’, which provides government funds to shippers to conduct logistics scans and to develop long-term plans for more efficient goods movement. The program’s stated aim is “to promote efficiency in transport by supporting business activities that lead to modal shift, fuel economy, and reduction of kilometres per trip, and with that the reduction of CO2 and NOx”. Between 1997 and 2000, the government conducted 200 logistics efficiency scans, which resulted in a reduction of 72 million vehicle-kms due to more efficient logistics strategies (Huiskamp and Walker, 2001). The improvements included changes in distribution structures and reductions in delivery frequencies.

3.4. Changing Mode Characteristics

Until recently, policymaking in the field of transportation has focused almost exclusively on individual modes. The needs of each mode are examined, and policies are designed to make these modes operate more efficiently with fewer negative externalities. Primarily, this has meant building sufficient infrastructure to accommodate the modal needs. This is still largely the case. But, there has been increasing recognition that, for a variety of reasons, it is neither feasible nor desirable to significantly expand the existing physical infrastructure. This had led to an integrated systems approach to transport policymaking. This approach offers policymakers the ability to focus on optimising the performance of the total freight transport system instead of optimising pieces of the larger system, and has led to the examination of policies to increase intermodal transport. In this subsection, we first discuss policies to improve the performance of individual modes. We then discuss policies related to encouraging and improving intermodal transport. Finally, because of the importance of transport costs both within modes and between modes, we conclude this section with a discussion of transport costs.

Improving Individual Modes

One purpose of changing mode characteristics is to make freight transport within a mode more efficient. Efficiency refers to using the existing transport fleet and transport infrastructure more efficiently. Efficiency policies tend to be not only beneficial for the sustainability of society, but also reduce transport costs. There are several ways that policies can increase efficiency.

The first way is to focus on the choice of shipment size. Examples are policies that stimulate the use of larger trucks, and policies that stimulate the use of telematics to fill the trucks fuller.

The second way is to affect the choice of route. This can be done by giving information about alternative routes or by preventing trucks from using certain roads (in general or at certain times of day).

The third way is to make more efficient use of the infrastructure. There are many mechanisms that can help attain a more efficient use of infrastructure. Some of these apply specifically to passenger transport or freight transport, but most apply to both. For example:

- Build dedicated truck lanes to reduce the problem of trucks travelling at different speeds from cars -- to avoid congestion and safety problems. There are scattered examples of dedicated truck lanes throughout the world, in both developed and developing countries.
- Prohibit overtaking by trucks during peak hours to avoid trucks blocking the highway lanes.
- Build additional lanes for slow traffic going uphill to avoid backups behind slow-moving trucks.
- Change delivery time windows, and enact night bans, weekend bans, and Sunday bans for trucking, in order to obtain a better distribution of traffic over times-of-day and days-of-week.
- Enact parking and loading/unloading regulations to ease the competition between cars and trucks for space within urban areas.

Some other policies, not directly related to passenger-freight interactions, which can make a given amount of traffic move more smoothly through the network are:

- The application of new technologies to infrastructures (e.g., automated vehicle guidance systems that would control vehicle speeds and spacing; “road trains”, which would place vehicles on conveyers; information systems to provide information on traffic conditions or alternative routes).
- Traffic management measures (e.g., speed control, road access, ramp metering, tidal flow lanes that can change flow directions depending on traffic conditions).
- Market functioning and other uses of pricing policy (e.g., make the user pay full costs for the infrastructure plus external costs).

There are many other innovative infrastructure policies that can be considered. Two examples are:

- New infrastructure for underground transport to get freight off the roads. The Netherlands has proposed an underground logistics system for moving flowers between the flower auction centre and both the railroad and airport.
- Dedicated railway lines for freight to avoid problems caused by giving priority to passenger trains. A dedicated freight line (the Betuwe line) is currently under construction that will carry goods from the Port of Rotterdam to the Ruhr area of Germany.

Governments can also improve modal transport by influencing market access and the availability and attractiveness of different transport means and services at different locations. For example, there are government requirements that have to be met before a trucking company or rail company can offer transport services.

Improving Intermodal Transport

Another purpose of changing the individual mode characteristics is to change the mode choice. Mode shift policies are specifically designed to stimulate the shift of freight from roads onto other modes of transport. In Europe, one of the European Commission's major transport policy objectives is to "turn intermodality into reality" (EC, 2001). It proposes to improve the integration of the modes through technical harmonization and interoperability between modes, particularly for container transport. The United States sees a similar need to improve intermodal freight transport. Since the Intermodal Transportation Efficiency Act of 1991 (ISTEA), it has focused on policy options for increasing intermodal freight transportation (see: TRB, 1998).

The primary rationale behind the promotion of intermodal traffic is the desire for more sustainable transport. A truly intermodal freight transport system optimises the use of different transport modes over the various legs of a given route. Thus, an intermodal freight transport system will, in theory, reduce the adverse side effects of freight transport more than any other system. Policymakers should, therefore, try to improve the competitive position of all the transport modes. If their policies have the intended effects, they will result in users making choices about which transport mode to use based on real attributes of the transport mode and the route that has to be travelled rather than artificial or perceived differences in quality and price of different transport modes. (For example, it has been shown in "modal shift scans" that many producers perceive inland shipping to be more costly than road transport. However, after a thorough scan, this difference does not appear to actually exist).

An intermodal transport route is a sequence of legs. Mode changes from one leg to another are made at transfer terminals. Thus, one of the critical factors for an intermodal freight transport system to work efficiently is that there are frequent and efficient connections between the different modes at the transfer terminals (high interconnectivity and interoperability). This means that one of the most important needs in intermodal transport is for efficient, cost-effective transfer terminals. Governments can help provide support for their construction.

In Europe, there is another barrier to the use of rail in intermodal transport: rail standards among countries are not harmonized (thus limiting interoperability). Differences in voltages and track gauges in different countries currently lead to long times spent at border crossings, which result in long travel times and low use of trains for freight transport.

Most waterway and rail improvements (including the construction of transfer terminals) are relatively expensive, so few are viewed as cost-effective. However, there are policies for improving the service characteristics of rail and waterway transport to make mode shift more attractive to freight forwarders that cost relatively little (e.g., reducing times at border crossings, increasing service frequencies, increasing competition, changing terminal opening time regulations, and increasing night-time operation of locks and bridges).

At the present time, in most countries, most points in the freight transport network lack real choice among transport modes (especially in many newly-developed industry and business parks). The lack of access to multiple transport modes means that businesses in these locations have no choice but to meet their freight transport needs by using trucks. Even when water and rail connections exist, they are often not used as much as they could be simply because these sectors are not as well organized as the road transport sector. Governments can play a large role in helping to improve the organization of the rail and waterway sectors, helping to improve the quality of the services they provide, and increasing awareness about the quality and costs of these modes.

Changing Travel Costs

Non-road modes can be made more attractive by changing their relative costs. This can be done by increasing the variable costs of truck use or decreasing the variable costs of non-road modes.

There are currently many pricing policies affecting the transport of freight. However, most of these are not aimed at affecting the demand for freight transport – in particular, the mode choice. They are primarily designed to cover the costs of building and maintaining the infrastructure. Just as for automobiles, there are taxes on truck purchase and annual fees for truck ownership. Most of these are based on truck characteristics, such as weight and number of axles. Aside from taxes on fuel, there are few prices that vary with truck use. One of these in Europe is the vignette, which applies to foreign heavy goods vehicles (HGV) using toll roads in some European countries (Sweden, Belgium, Denmark, Luxemburg, the Netherlands, and Germany). The vignette applies to all trucks and truck/trailer combinations with a total weight of 12 tons or more that are used for the transport of goods. The cost can depend on the distance driven on a toll road, the emission category of the vehicle, and the number of axles of the truck or truck/trailer combination (although yearly vignettes are fixed costs, not linked to the distance covered by a vehicle during the year). The cost is designed to reflect the damage the truck causes to the environment and roads. The vignette is a receipt for payment, and is paid in advance.

Germany and France are planning additional charges for HGV for the use of all infrastructures based on their emissions, weight, and distances travelled (Switzerland already has such charges) (METTLE, 2003). Their objective is to raise money to fund new infrastructure (mainly rail and inland waterways) and to partially cover the external costs of freight transport (accidents, air pollution, noise and congestion). In the proposed French system, the shippers would be charged instead of the transport companies.

In Europe, it is expected that railway liberalization will stimulate competition and lead to significant cost reductions. As a result, it is hoped that rail will begin to increase its share of the freight transport market.

There are many instruments that can be used to increase the costs of road transport. We discuss three of these instruments below: fuel taxes, road pricing, and carbon tax. All three can be applied to both freight and passenger transport.

Fuel Taxes

Fuel taxes are almost universal. The revenues generated from fuel taxes play an important role in the financing of national budgets (especially in developed countries). They represent a reliable, high-volume source of revenues to cover expenditure for transport investment, but also for other sectors as well. (In Germany, fuel taxes are the third-largest source of income for the federal budget, following personal income taxes and VAT). As a policy instrument, they have not been traditionally viewed as a way of reducing the attractiveness of road transport or promoting modal shift. In fact, while effective at reducing energy consumption, carbon dioxide, and some tailpipe emissions, fuel price increases have only a minor effect on vehicle travel. This is because drivers respond primarily by shifting to more fuel-efficient vehicles. Thus, increased fuel prices would provide a much lower reduction in demand than would the same total revenue raised through mileage-based fees or parking charges.

Fuel taxes are usually levied as a fixed amount per litre or gallon. Consequently, when oil prices rise, the share of fuel tax in the total price of fuel falls; when oil prices fall, the tax share rises.

Fuel policies throughout the world vary considerably. According to a GTZ (2001) survey of fuel prices on November 2, 2000, the lowest fuel prices are found in oil producing countries and other countries that subsidize their fuel prices. In these countries, fuel is sold at prices below the world market reference price (e.g., $0.02/liter in Turkmenistan). High price countries include Hong Kong, Japan and all members of the European Union. For example the average price in Hong Kong in 2000 was $1.46/liter.

The taxes on diesel fuel are usually lower than those on gasoline (e.g., the EU's minimum tax rate on unleaded gasoline is €0.287/liter and on diesel fuel is €0.245/liter). Average consumer prices for diesel fuel in November 2000 ranged from $0.02/liter in Turkmenistan to $1.22/liter in the United Kingdom.

Road Pricing

Road pricing is a generic term for different methods of directly charging fees for the use of roads. The methods include road and bridge tolls, congestion fees, and entry (cordon) fees. The prices often vary by vehicle type, and sometimes by time of day. Pricing mechanisms are already being used in most areas of the world (for an overview of the possibilities, see ESCAP/GTZ, 2002). Two innovative policies are described below:

- Rush hour tolls.
- Congestion fees.

Rush hour tolls. Variable rush hour tolls can easily be implemented at existing toll facilities. For example, variable bridge tolls, like long-distance telephone rates, would charge more for using bridges during peak periods and less during off-peak. Compared to a flat toll, variable tolls would save travellers time and reduce emissions. They would encourage peak-hour bridge users to shift to higher occupancy modes and reschedule some trips to less congested hours. The fee could be varied by time of day, or based on the real-time congestion situation. An electronic fee collection system could be used, such as the E-ZPass electronic toll collection system that is used in the Northeast United States. Under this system, cars do not need to stop. The fees are automatically calculated and deducted from a prepaid account as customers pass specific points in the road network. Other electronic systems include invoicing on the basis of number plate recognition or using electronic permits.

Congestion fees. In both rush hour tolling and congestion charging, the main rationale is to spread traffic more evenly over the day. In practice, this means that the peak charges exceed the off-peak charges. On 17 February 2003, London introduced a congestion charge for central London. A fee of 5 pounds per day is now charged for entering the cordon around the centre between 7:00 a.m. and 6:30 p.m. According to The Economist (2003) the first results were to reduce traffic within the cordon by 20%, reduce delays in this area by 30%, and more than double the speeds from 9.5 miles per hour to 20 miles per hour. These results were better than the advocates of the scheme had expected.

Even more sophisticated (and potentially more effective) forms of congestion charging would base the charge on the observed level of congestion: if congestion is higher, the price for avoiding it would become higher.

Carbon Tax

Carbon taxes are direct payments to government based on the carbon content of the fuel being consumed. The tax would be highest per unit of energy for coal, less for gasoline, lower for diesel, and least for natural gas. The tax can be placed on both mobile sources of fuel use (such as cars and trucks) and fixed sources (such as electricity generating facilities). Many governments are currently considering imposing a carbon tax as a way to meet the Kyoto targets. The European Community has been debating such a tax, but has yet to agree upon its need or how it might be implemented.

4. CONCLUSIONS

Freight transport, the ability to move goods from origins to destinations, is a basic component of the worldwide economy. In the past decades, freight transport has increased rapidly and it is predicted that the high growth rates will continue in the coming decades. The growth in freight transport cannot be explained completely by increases in the number of freight shipments. The distances over which freight is transported have increased as well. Furthermore, there has been a trend towards smaller and more frequent deliveries of goods.

In this paper, we have identified the key drivers of freight transport. The structure of consumer demand and the trade patterns are the most important drivers of total freight transport. Logistic developments and attributes of the modes (especially costs, time, reliability, flexibility), on the other hand, are more important drivers of modal split and shipment size. The following developments are taking place with respect to these drivers:

- Consumer demand is likely to continue to rise all over the world, which in turn would lead to an increase in the number of freight shipments. Furthermore, consumer demand is also likely to become more dispersed spatially due to suburbanisation, which would lead to increases in transport distances.
- Increasing trade among countries (due to globalisation) is likely to lead to further increases in transport distances.
- Changes in the logistics systems being used, in particular changes in inventory and supply chain management concepts (e.g. increasing

application of the Just-in-Time concept), have led to smaller and more frequent deliveries. This has increased the amount of road vehicle-kms. Moreover, these developments lead to an increased demand for reliable and flexible transport, which can best be met by road transport.

After the discussion of the drivers of demand, we presented an overview of policy options that could be used to decouple the growth in GDP from the growth in freight transport and shape demand in directions leading toward more sustainable development.

Although, as we have shown above, increases in freight transport have been closely linked with increases in GDP, it might be possible for policymakers to decouple a growth in freight transport from a growth in GDP by paying attention to some of the drivers of freight transport demand that have been described above. Consideration of the drivers should also make it possible to improve the balance of freight transport between road and other modes. Some possibilities for policymakers' attention are the following:

- To some degree, policies can affect choices made by people concerning where to live and choices made by firms about where to locate. For example, regulations or financial incentives can stimulate mixed land use or the spatial clustering of firms.
- Governments can promote certain logistic developments. For example, they can assist in encouraging the emergence of information brokers and promote other means of sharing data on consignments.
- Transport policy can influence some of the service characteristics of the modes, especially travel time (by making investments in network links and terminals) and cost (through taxes, tolls, and subsidies). In some segments of the freight transport market (e.g., low value goods, long distance shipments) the modal choice is highly responsive to time and cost changes by mode. However, transport policies usually have a greater impact on time-of-day and route choices than on modal choices, and therefore have a greater potential for reducing congestion than improving the balance of freight transport across modes.
- Introducing more competition into the rail sector and encouraging interoperability through government policies should improve the service characteristics (innovativeness, reliability, interoperability, flexibility) of the rail sector (and intermodal road-rail transport) and lead to shifts of freight from road to rail.

In summary, the most effective policies for affecting freight transport demand would appear to be policies focused on changing transport mode characteristics and spatial planning policies. Such policies have the potential for producing significant changes in freight transport demand. In particular, they can shorten transport distances and improve the way the transport system is used (by affecting the choice of mode, time-of-day, and route).

Some of these policies will take a long time to implement and for their results to be realized (such as land use planning and infrastructure expansion), while others can be implemented more quickly and will produce their desired effects in the short term (such as road pricing). Because large shifts in demand will be needed to produce a sustainable freight transport system and time is of the essence, both short-term and long-term actions should be considered.

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