CHAPTER I

THE INTERMODAL TRANSPORT

As start of the present thesis, chapter I will introduce the reader to the concept of intermodal transport, to its characteristics and technicalities.

The reason of starting the dissertation with such detailed information is related to the necessity of clarifying some aspects before entering in the development of the work. It is fundamental to have clear in mind what intermodal transport is and which are its technical aspects, its pitfalls, some statistics and so on.

The first paragraph will give an overview about the concept of intermodal transport, the different definitions in use will be presented and a list of the operators involved in it will be introduced to the reader. Further, the different types of transport modes present in intermodal transport will be illustrated, these modes will be described in detail considering as well technical and operational aspects. In addition, the available statistics resembling the situation in Europe will follow, to conclude some European projects and policies for the promotion of intermodal transport will be summarized. The last aspect considered in this chapter is the concerns about liability in intermodal transport.

1.1 Terminology and concepts related to intermodal transport

The concept of intermodal freight transport is relatively young and rather complex, presumably for these reasons a clear and unanimous definition has not yet been recognized.

An unambiguous and common definition could improve and simplify the interactions among transport operators, prevent misunderstandings or problems related to the organization of the transport.

The organizational and technical difficulties, the large number of operators involved and the lack of a common consensus on the intrinsic characteristics of this mode of transport makes difficult to narrow down the research to one precise definition. Nonetheless, the definitions of intermodal transport given on European level can be considered a landmark when dealing with this topic.

The need to clarify the concept of intermodality, multimodal transport, combined transport and other terminologies related to combined transport rose from the European Conference of Ministers of Transport (ECMT), the European Commission (EC) and the United Nations (UN) in 2001.

The conjoined document, “Terminology on combined transport” is the result of a processing work on previous definitions given by different institutions. In the editing of the text, it is firmly stated that the purpose of the document is to determine the meaning of the terms and make them understandable to the community that has to deal with these topics. Nevertheless, it is specified that the definitions given cannot be applied strictly to any legal or statistical document, since in these fields other relevant references already exist.

According to the mentioned document:

Intermodal transport *is the movement of goods in one and the same loading unit or vehicle, which uses successfully several modes of transport without handling of the goods themselves in transhipment between the modes.*

Through a perusal of the definition, two main elements are pointed out: the same loading unit that allows avoiding a break of the cargo and the employment of different modes of transport, one next to the other.

It is important to underline that the goods are transhipped between modes, without any handling activity.

Combined transport *is a transport in which the major part of the European journey is carried out by rail, inland waterways or sea and in which any initial and/or final leg carried out by road are as short as possible.*

This definition shows a higher level of detail in specifying a hierarchic order of use of the modes of transport. Rail, inland waterways or sea have to be the longest part of the journey, while road constitutes the initial and final leg of the trip. Combined transport implies a precise selection of transport modes with a reduction of road use.

Multi-modal transport *is a carriage of goods by at least two different transport modes.*

Among the definitions given, this is the most general, and takes in consideration just the need to have at least two modes of transport, without any particular specification, not even for the loading unit. (UN/ECE, ECMT, EC, UN, 2001)

Previous to the above mentioned definitions are the description of intermodal transport given by the European Commission and the United Nations.

According to the European Commission, COM (97) 243 Final of 29/5/1997:

Intermodality *is characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a 'door-to-door' transport chain... Intermodality clearly is not about forcing a specific modal split. However, by improving the connections between all modes of transport and integrating them into a single system, intermodality allows a better use to be made of rail, inland waterborne transport and short sea shipping which, by themselves, in many cases do not allow a door to door delivery.*

The focus of the European Commission is on the different modes of transport that can be combined together with the aim of obtaining a better interaction among them in the whole picture of a door-to-door transport chain; regardless of loading unit or prevalence of one mode on the others.

The definition given by the United Nations in 1980, in the document "Convention on Multimodal Transport of Goods" is the following:

International multi-modal transport *is the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place of designated for a delivery in a different country.*

With this concept of multi-modal transport the United Nations focus mainly on two aspects: the use of at least two modes of transport and, for the first time in this list of definitions, the role of the multimodal transport operator and his responsibility for the entire transport chain.

Tab. 1.1: Concepts' definitions

Source	**Definition**	**Prevalent modes**	**Combination of modes**	**Loading Unity**	**Operators**
ECMT, EC, UN, 2001	Intermodal transport		One after the other	Same LU	
ECMT, EC, UN, 2001	Combined transport	Rail, inland waterways, short sea			
ECMT, EC, UN, 2001	Multi-modal transport		At least two modes of transport		
EC, COM (97) 243 Final, 29/5/1997	Intermodal transport		Different modes of transport that can be combined together		
UN, 1980	Multi-modal transport		At least two modes of transport		Multimodal transport operator

Source: own elaboration based on different sources

The main aspects that emerge from the different definitions and that can be seen as the distinctive elements that characterize intermodal transport are:

- The use of several modes of transport that are identified under a unique transport contract. There is the tendency to use rail, inland waterways or short sea shipping transport as alternative to road only transport. Road transport tends to remain the initial and final part of the transport chain.
- The use of a loading unit, from the initial point of departure until the final place of consignment. Such loading unit can be an ISO-container, a swap body, a trailer, a semi-trailer.
- The loading unit is shipped from one mode to another without any handling of the goods, for the entire door-to-door transport chain.

1.2 Economic concepts related to intermodal transport

According to Marchese (2001), transport cycles can be divided in simple and complex. The former definition can be given to transport freight cycles that have one operation for loading/unloading of the cargo, while the latter implies the presence of more than one mode of transport, thus more handling operations.

Intermodal transport is considered a complex transport's cycle, since more than one mode of transport is used and more handling activities are needed.

The definition of complex is especially appropriate for intermodal transport, not only for the involvement of different transport's modes, but also for the complexity in the organization of the administrative and operational activities.

Due to the complexity that this mode of transport implies, it is important to understand which the benefits that it can provide are and that can justify its use by the operators. The benefits that relate to intermodal transport could necessarily be connected to economic aspects, as well as social and welfare characteristics.

It is worth to clarify that intermodal transport can be distinguished in two categories: enforced intermodal transport and economical intermodal transport (Musso, 1990 and Bacelli, 2001).

While in the first case the use of intermodal transport is forced from geographical, infrastructural or political reasons, in such manner that the operators can not choose an alternative, in the case of economical intermodal transport the operators decide to use it regardless of any geographical or infrastructural constraints.

In this thesis, just the second category will be analyzed.

Intermodal transport is used when demand requirements and supply dimension match each other in a way that there could be economies of scale, reduction of the costs, improvement in the speed of the transports, such as the diseconomies due to the transhipment of the freight are downsized.

When considering intermodal transport it is necessary to bear in mind that the costs related to it are various and, the ones related to handling activities can have a crucial weight on the overall cost function. Therefore, the competitiveness of intermodal transport is more evident for long distances. The additional costs that have to be paid for the movement of the goods from one mode of transport to another can be compensated by the economies of scale given by long distances and the adoption of the most efficient mode of transport.

The transport cost is divided into different parts: a fixed component, not related to the distance, and another part related to the distance. The fixed component is obviously different for road, rail or maritime navigation. In road transport, the infrastructural and capital costs are definitely lower than in the other two cases, as can be seen in figure 1.1.

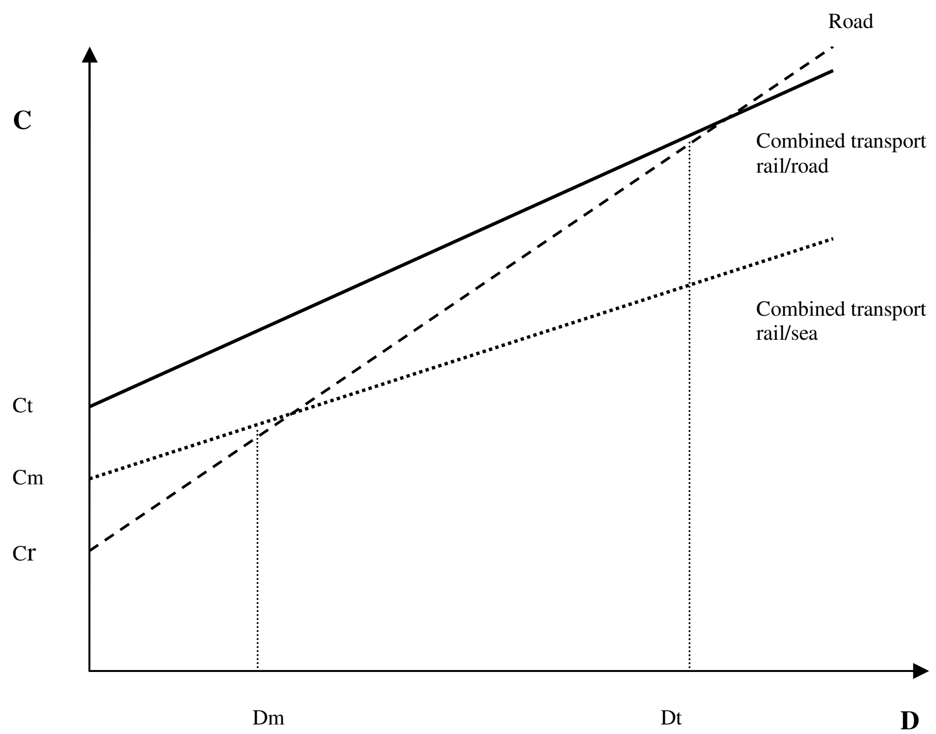


Fig. 1.1: Minimum distances for multimodal transport efficiency

Source: Bacelli, 2001

Figure 1.1 shows that fixed costs of road transport (*Cr*) are lower than fixed costs of the road/rail option and the rail/sea path. There are two break-even points in *Dm* and *Dt,* where intermodal transport is more convenient than road transport.

It is clear that the bigger the volume and the longer the distance, the higher the advantages of intermodal transport. The advantages that users can achieve in this way can be related to an increase of efficiency, due to the reduction of the costs. The different modes are better organized in relation to the volume and to the distance, so that a reduction of average cost for tonkm can be achieved.

A reduction of diseconomies can be expected if the different mode of transport are used efficiently, for big volumes and long distances. The investments costs can be reduced and there could be an optimization of the travel time.

A number of other elements support the use of intermodal transport such as a reduction of energy needed for tonkm, a reduction in externalities, better working conditions, improvement in safety conditions for dangerous freight, and a better utilization of the territory.

As already mentioned earlier some of the disadvantages of intermodal transport are related to the increase in operational costs, namely transhipment costs occurring during loading and unloading operations.

The complexity of this mode of transport makes also the management of its entire door-to-door chain more expensive, increasing the cost for the administrative, legal and bureaucratic organization.

If intermodal transport is not well organized and structured, it is likely that the time spent for the entire service can increase, and some qualitative aspects can worsen, such as the reliability, the flexibility or the safety of the cargo.

These last mentioned aspects are not residual and, on the contrary, can play a fundamental role when a mode choice has to be taken. The loss of reliability, flexibility or safety entails an increase in total cost function, due to the higher cost of insurance, the loss of credibility with clients, and delays in the production system.

As always in economics theory, also intermodal transport will be chosen, according to economic principle of benefits' increase and costs' decrease, both quantitative and qualitative, considering therefore the generalized cost.

1.3 Intermodal loading units

According to the definitions given in the previous pages, one of the main aspects that characterized intermodal transport is the use of a single loading unit that contains the different commodities. The reasons that support such a choice are related to the handiness of moving a single unit rather than individual packages of goods, with a lower risk of damage or loss of the freight and with fewer costs due to precautions that need to be taken.

The use of standardized loading units is already a common procedure in all single modes of transport: maritime containers, semi-trailers in road or rail transport, swap bodies in road transport. It is clear that the use of specific loading units in each single mode of transport promotes and simplifies the employment of such loading units in intermodal transport.

The main un-accompanied loading units used in intermodal transport are: containers, swap bodies, semi-trailers and in the case of accompanied units: trucks, articulated trucks and semi-trailer trucks. The distinction between accompanied and un-accompanied is quite evident and derives from the presence or absence of a driver.

For a better understanding of the typologies of loading units that are currently employed and their technical characteristics, an overview is provided in the following sub-paragraphs.

1.3.1 Container

The use of the container became common practise in the sixties. The most popular nowadays is the ISO container (International Organization for Standardisation).

It is a metal box, with standard length of 20, 30 or 40 feet, the technical characteristics of which are summarized in table 1.2.

Tab. 1.2: Container Technical Characteristics

Length	Width	Height	Gross Weight	Tare
610-1120 cm	244 cm	259 cm	24.000-30.480 kg	2.000-4.000 kg

Source: own elaboration based on different sources

ISO containers are mainly used in maritime transport and given the relevance that this loading unit has achieved in the maritime business, containers ships capacity is now measured in TEU, acronym of Twenty-feet equivalent unit. In Europe, the main land use of the ISO container is related to pre-post maritime transport, and it can be loaded on trucks, trains and barges. Some of the advantages of ISO container are: airtight, safety against damages or thefts and stack ability. There are also several typologies of containers used for particular transports or commodities, as refrigerated, open-top, tanker containers or with lateral sides that can be opened.

Some drawbacks remain, such as the need of appropriate handling facilities and the different measures that do not allow Euro pallets to fit properly inside the containers.

Figure 1.2 shows an ISO container of 20 feet

Fig. 1.2: ISO Container 20 feet

Source: Internet sources

1.3.2 Swap body

Swap body is the most used loading unit for road/rail intermodal transport; curtains, tarpaulins or more hard surface materials supported by backing legs constitute it. The operational activities of loading/unloading are carried out in a vertical way from trucks or rail wagons and there is the possibility to load them on the side or from the back. The dimension of a swap body is bigger than an ISO container and that allows for a complete loading exploitation in the case of Euro pallets.

Tab. 1.3: Swap Body Technical Characteristics

Length	Width	Height	Gross Weight	Tare
715-1360 cm	255 cm	267 cm	16.000-34.000 kg	1.900-5.000 kg

Source: own elaboration based on different sources

The disadvantages of swap bodies are related to the fact that it is not possible to stack them, that they are less resistant to external or wheatear events.

A typical example of swap body is presented in figure 1.3.

Fig. 1.3: Swap body

Source: Internet sources

1.3.3 Semi-trailer

The definition of semi-trailer is related to vehicles without engine that are fostered by a trailer or a truck. The name itself explains the utilization of this vehicle that is supported by itself just for part of its weight and for the rest by a trailer. These characteristics allow the vehicle to be hooked up by different trailers and to be moved easily. Semi trailers can be used in road, rail and maritime intermodal services.

As can be seen from table 1.3, the dimensions of length and width are the same of a swap body. This implies efficiency in loading Euro pallets, nonetheless this loading unit is heavier and more difficult to lift vertically and semi-trailers are not stackable.

Tab. 1.4: Semi-trailer Technical Characteristics

Length	Width	Height	Gross Weight	Tare
1250-1360 cm	255 cm	352 cm	Max 37.000 kg	5.000-8.000 kg

Source: own elaboration based on different sources

Fig. 1.4: Semi-trailer

Source: Internet sources

In figure 1.4 a semi-trailer is represented, which can be identified by its own number plate as well as from the number plate of the trailer vehicle.

1.3.4 *Truck, articulated truck and semi-trailer truck*

What has been presented up until now was related to un-accompanied loading units, truck, articulated and semi trailer trucks are accompanied loading units.

The main characteristic of a truck is its own motive power and the possibility to load cargo on itself without the need of any other loading unit.

Fig. 1.5: Truck

Source: Internet sources

An articulated truck is a vehicle that consists of a towing engine or a truck and a trailer. The trailer does not have an engine, as shown in figure 1.6.

Fig. 1.6: Articulated Truck

Source: Internet sources

The last accompanied loading unit is the semi-trailer truck that has a truck or a towing engine, plus a semi-trailer.

Fig. 1.7: Semi-trailer Truck

Source: Internet sources

In the case of accompanied transport, the vehicle will be loaded horizontally on the train or on the ship; the driver will travel in specific wagons or passenger cabins and will take back the vehicle at the end of the rail or maritime voyage.

Accompanied transport is often used in geographical areas, with very severe and restrictive norms for heavy road transport, such as Switzerland or Austria, or where incentives for modal split changes are sought.

1.4 Intermodal transport modes

Intermodal transport is, by its own nature and definition, a transport mode where different means of transport are used. Within the general concept, different combinations of transport can be seen: intermodal rail transport, intermodal inland waterways transport and intermodal maritime transport.

Road transport still functions as a backbone in the door to door transport chain, mainly used in the initial and final leg of the voyage. The reasons of its fundamental role are related to the impossibility, for the other modes of transport, to reach the very final destinations, where, in most of the cases, the volume is low and the consignee is just one company. Another characteristic that makes road transport rather appealing is its flexibility in the management of the organizational structure of the service. Bearing in mind that road transport will never disappear from the transport chain, the pressure coming from government policy on a European scale is to diminish the impact that road transport has on environment, on transport safety and on congestion.

Notwithstanding it is necessary to consider the entire intermodal transport service, it can be useful to classify each single mode of transport to provide a general overview.

In the present sub-paragraphs, the peculiar characteristics of each mode will be presented.

1.4.1 Intermodal rail transport

The use of rail transport in the intermodal transport chain is mainly due to the fact that, for long distances, it is less expensive than road transport, if considering out of pocket costs, and it is possible to tranship higher volumes.

When looking at the cost structure of rail transport, what appears clear is that it is characterized by high fixed costs, namely terminal and infrastructure costs, and a relatively low variable costs component.

These two aspects are decisive when having a modal choice problem; it is stated, according to experiences and common practice in transport, that the minimum rail distance that allows a shift from road to rail is around 500-600 km. Such distance can be lowered to 250-300 km for routes from/to ports, where the high volume of the traffic allows for shorter distances (Bacelli, 2001). The two cases above refer to economical convenience, not considering service quality nor welfare costs.

The advantage of using rail transport can be perceived when the amount of freight is big enough to use a train or several wagons on it; the aspects related to the transhipment of the freight has to be taken into account as well, in the intermodal rail transport a series of operations of loading and unloading of the cargo occur. The costs related to a more complex organization are justified if the volume and the distance are big enough to reach economies of scale and the transport costs are eventually reduced.

For what concerns the operational technicalities of intermodal rail transport two main typologies of services are provided: rail shuttles and block trains.

Rail shuttle trains are trains with a fixed number and fixed typology of wagons that have scheduled stops during the route. These trains provide liner services and this implies that during the year the demand for this service should be quite constant.

Block trains, on the other side, are trains leaving from point A and reaching point B without any intermediate stop; normally the number or the typology of wagons is not fixed and is very often used for connecting the hinterland’s ports.

The inconveniences that intermodal rail transport has to face in Europe are related to the lack of interoperability in the European rail network, as for the gauge dimension, for the electrifications systems, or for the signalling frame. Together with the mentioned aspect, other types of differentiations hamper the development of rail intermodal transport: different labour regulations among the European countries, different languages requirements, numerous documentation processes.

1.4.2 Inland waterways intermodal transport

The use of inland waterways is indissolubly related to geographical aspects, namely the presence of a navigable river or canal that could allow a barge to ship the freight.

Also in this case, as in rail transport, but even more strongly, it is important that the freight volume reaches considerable dimensions.

Intermodal inland waterway can be seen as an international transport mode, since the distance that is considered sufficient for shifting from road to inland waterways is around 700-800 km, (Bacelli, 2001) distance that a river can usually cover in more than one country. As mentioned earlier for rail transport, also in this case the volume and the distance between origin and destinations are the main elements when considering the economics behind a modal choice. In particular in Europe the main rivers that allow for freight inland navigation are Rhine, Danube, Main, Seine, and Rhone and consequently the countries involved are Belgium, The Netherlands, Germany, Switzerland, France and Austria.

It can be noticed that most likely, but not necessarily, the voyage will start in a maritime port, with waterways connections and will end at the final point of destination of the freight.

Inland waterway transport is characterized by its reliability, it is particularly effective, and energy efficient since its consumption of energy per tonkm corresponds to one-sixth of the consumption for road transport. Also in relation to other external costs, as accidents, noise or air pollution inland waterways seem to perform very well compared to the other modes of transport (Lowe, 2005).

The drawbacks that inland waterways faces are related to some aspects, as such as the impossibility to stack the containers and some organizational issues related to the interconnection with the maritime side of the transport chain.

1.4.3 Intermodal maritime transport

The meaning of intermodal maritime transport has to be strictly related to the concept of short sea shipping and feeder service. In this context it is important to stress that maritime transport route could be alternatively performed by road transport.

The choice of using maritime transport is thus not mandatory, but is preferred to road transport for economic reasons, for environmental reasons or for helping relieve road congestion.

Short sea shipping, for being efficient, needs to have big volumes and a sufficient distance between the two transhipment points that in the case of a comparison with road transport need to be at least of 1000 km (Bacelli, 2001).

In the case of intermodal maritime-rail transport the costs could be lower since the transhipment operations are just related to the transfer of the freight from the vessel to the train and the road leg will be used just in the very final part of the voyage to the consignee. Another reason that can explain the higher use of rail transport in relation to maritime traffic is the big volume that is handled by deep sea vessels.

It is important to take in consideration some intrinsic aspects of this mode of transport, such as the extra hours for performing the entire maritime transport, the higher costs due to transhipment operations and the smaller degree of flexibility compared to road transport.

Some advantages associated to short sea shipping are the minor environmental and noise impact and the support to roads decongestion and accidents.

On a European level, the main areas where short sea shipping is currently in use are the Mediterranean Sea, the North Sea and the Baltic Sea. The traffic flows can be either international or national, according to commercial reasons and geographic morphology of the countries in these areas.

The main short sea shipping services are the following:

- Lo-Lo, (Lift on-Lift off) transport is a service that uses mainly containers loading units, on a national or international level.

  It can be either a short sea service or a feeder service from hub ports to the neighbouring smaller ports. Container vessel ships can be employed, for the transhipment from the mother vessel in the hub port.
- In the case of Ro-Ro, (Roll on-Roll off) the transport is developed through an accompanied service, in which the freight is loaded/unloaded in a horizontal way. Ro-Ro transport can be carried out with dedicated ships or with mixed Ro-Pax ships.

1.5 Stakeholders involved in intermodal transport

The transport sector is rather complex and the stakeholders involved in the management of the entire door-to-door chain are numerous and of different nature.

In the case of intermodal transport, the high number of links among the stakeholders and its organizational complexity emphasizes the situation.

It is crucial to have a good level of internal organization so that the final client could perceive the transport service as complete and functional. The intermodal transport market is characterized by a big variety of players that differ in the services that they provide, in their dimension and in their business origins.

In this paragraph, a short description of the stakeholders and their roles in intermodal transport is provided, facing the problem from a demand-supply point of view.

The demand side consists of potential users of intermodal transport, these could be:

- *Shippers*. They are the owners of the cargo and their demand is to ship the freight from an origin to a specific destination. In some cases, the shippers organize the transport procedures directly; in other cases, other operators act on their behalf. The role of the shippers can vary a lot according to the quantity of cargo that has to be shipped and according to the power that they have, manly related to company dimension.
- *Forwarders*. The forwarders act on behalf of the shippers and take the responsibility for the management of the entire transport chain. The forwarders try to find the best solution for each particular shipment case and interact with all the supply actors. Presumably the forwarders will not have any transport asset and will just manage the operational phases as organizers of the service.
- *Ocean Shipping lines*. On the maritime side, the shipping lines ask for the extension of the voyage in the hinterland of the ports. Most frequently maritime companies enter in the intermodal business, not anymore in the demand side, but in the supply side providing complete services that include both maritime transport and inland transport, as a result of integration in the supply chain.

On a supply side level the main operators involved in intermodal transport operations are:

- *Terminal operators*. The role of terminal operators is to provide handling services in sea ports or inland ports. Their main assets are related to the transhipment facilities that they run. Also in this case it is more and more common that they will develop forms of integration with shipping lines.
- *Rail, road, inland waterways, short sea shipping operators*. These operators constitute the central part of the transport business, since they run the main physical transport operations. In most cases they are simply the providers of intermodal transport that are managed and co-ordinated by forwarders or intermodal transport operators.

- *Intermodal transport operators*. These operators are the ones running the entire door-to-door transport chain, they take charge of any commercial or physical risk that may occur to the freight during the transport process (Vrenken, et al. 2005).

After providing a general overview of the players that take part in the entire intermodal transport chain, it is necessary to go deeply in the description of the supply side of the service. This is due to the complexity of the intermodal sector, in which each stakeholders plays a crucial role.

The analysis will be provided, according to the different modes of transport.

1.5.1 Intermodal rail operators

Intermodal rail operations consist of different levels and, in order to obtain a good level of effectiveness a good coordination on a functional level is needed.

The functional components are mainly:

- Functional organization of the entire transport chain;
- Functional organization of each single link of the service;
- Technical-operational functions.

The original function of rail operators is providing rail haulage between transhipment terminals, complemented by logistics activities and added values service so that their business goes further than the mere rail operations.

On a European level a classification among rail intermodal stakeholders can be identified:

- *UIRR companies*. *(International Union of Combined Road Rail Transport Companies)* These companies are constituted by multimodal terminal operators (MTO), they provide mainly combined road/rail transport, both accompanied and un-accompanied. The operators are private companies and very often there could be a participation of national rail companies. The companies coordinate, integrate and manage the international operations through the organization on a European scale.

The common practise in UIRR is to provide a terminal-to-terminal service and leaving the organization of the initial/final road part of the voyage to the forwarder. In 2009, the UIRR members were 18 over Europe.

- *Intercontainer Interfrigo (ICF).* This company is an intermodal European operator run by national rail companies. ICF offers services for the maritime market with express trains from/to ports, and at the same time continental services for swap body transport. This company provides also road connections with own or rented means of transport.

Table 1.5 gives an overview of the companies belonging to UIRR and to ICF.

Tab. 1.5: ICF and UIRR members (2009)

Country	**ICF Members**	**UIRR Members**
Germany	Container-Terminal Herne	Kombiverkehr
Romania	ICA Romania srl	Rocombi
Austria		Intercontainer Austria, Okombi
Scandinavia	Intercontainer Scandinavia AB	
Norway	Intercontainer Scandinavia AB	
Sweden		
Italy		Alpe Adria, Cemat
Switzerland	Frigosuisse Immobilien AG	RAlpin, Hupac
France		Naviland Cargo, Novatrans
Spain	Intercontainer Iberica	Combiiberia
Belgium	Interferry Boats	Interferry Boats
Hungary	Intercontainer Hungary	Hungarkombi
Croatia		Crokombi
Poland	Polcont Spolka zoo	Polzug Intermodal
Check Republic		Bohemiakombi
Slovenia		Adria-Kombi
The Netherlands		Hupac NV

Source: UIRR and ICF websites and own elaborations

- *Rail intermodal operators.* These companies provide rail transport from maritime terminals in ports to inland terminals mainly on a national level, both for container transport and for swap bodies. Very often, these companies cooperate with ICF.
- *Other minor companies or new entrants.* The intermodal rail sector, despite the obstacles for the entrance, the high initial investment costs and the complexity of the business, attracts new entrants from different transport business sectors. Some examples can be given from the maritime segment, where container shipping lines started to operate intermodal shuttles trains according to their traffic flows inside continental Europe. Also big shippers, started to develop their own rail connections among their terminals, factories and warehouses, in case the big volumes could allow for a convenient in-house transport.

  Pure private operators and small national or regional rail companies started to enter in the intermodal rail transport business, with shares in bigger companies or providing intermodal services for specifics clients or geographical areas.

1.5.2 *Intermodal Inland waterways operators*

Intermodal inland waterway transport is diffused mainly in North and East Europe, where it is possible to find navigable rivers, and where the maritime traffic coming from the big ports, as such as Antwerp or Rotterdam, can offer enough volume. The main river in Centre Europe is the river Rhine that, with his 1326 km goes through Switzerland, France, Germany and The Netherlands, and can be considered the highway for inland navigation in Europe.

The central role of the river Rhine is also due to its numerous connections to several destinations in central Europe thanks to its effluents and the vast number of channels.

The other main river in Europe is the Danube that has a length of 2888 km and passes through 10 countries, from Germany to Ukraine. Nonetheless its incontrovertible relevance on a geographical level, the river Danube suffers from bottleneck during its way, limits for drought and height. Moreover, the low population density and the low degree of industrialisation prevent from an effective development of inland waterway transport. It can be expected that the trend could change, considering the relevance that eastern European countries are witnessing in terms of economic development and commercial flows.

In Europe, inland waterway transport is almost fully liberalized, so that any operator can decide to start up a service on these rivers. The level of sophistication that has been reached from the barge operators is very high and comparable with the maritime services.

The inland waterways market structure is heterogeneous, there are big companies operating along the entire river Rhine and there are smaller companies that provide services in narrow areas. It is quite common to develop strategic co-operation among the operators. The inland waterways operators usually organize the intermodal transport, while the shipping companies own and operate the vessels.

Nowadays the main inland waterways companies operating on the Rhine are Rhinecontainer and CCS- Combined Container Service.

1.5.3 Intermodal maritime operators

As mentioned earlier the main areas where intermodal maritime transport is developed are the Mediterranean Sea, the North Sea and the Baltic Sea. The countries that overlook these seas are the ones mainly involved in the use of intermodal sea transport, both feeder and short sea shipping.

In the last years, and mainly after the liberalization of the liner maritime business, in 1999, the share of intermodal sea transport grew.

The application of this rule allowed operators in Europe to provide liner services among third nations, even when the national coasts were not involved in the maritime transport. Despite the fact that intermodal maritime transport is an interesting business, it is still not always true that short sea shipping or Motorways of the Sea are preferred to road transport by freight forwarders or shippers.

In order to promote intermodal sea transport for the demand side of the transport, and on the other side to provide incentives for the supply of new services, more and more promotional policies have been developed on a European level.

As mentioned before, intermodal sea transport is divided in Lo-Lo and Ro-Ro services. The differences on a technical and structural level result in specific commercial aspects and market structure.

An additional sub-division exists in the category of Lo-Lo services: feeder services and short sea shipping services, the latter mainly developed on a national or intra-community scale.

The feeder service uses small vessels to connect the hub port with the near local ports where the freight will be unloaded and will reach the final destination. This service is the prosecution of a deep-sea service, where mother vessels are employed. Usually the mother vessel has bigger dimensions and goes just to the hub ports in which feeder ships operate.

Short sea shipping operators provide national or continental connections between ports or for a door-to-door chain. In most cases short sea shipping is trying to subtract market share to road transport on routes where they are competitors.

The use of intermodal sea transport is encouraged from the fact that it is more environmentally friendly, and in a large number of cases cheaper than road transport.

In this framework many European measures have been developed, such as the Motorways of the Sea (European Commission Programme).

In the case of feeder service the feeder vessel is dependent from the mother vessel, both for operational activities and for the time schedule.

On the other side, short sea shipping is a complete independent service that has fixed liner services and its own departures/arrivals timing. In several cases short sea shipping operators are also integrated in the land service provision for road or rail transport.

Concerning Ro-Ro transport it is important to focus the attention on its market that is mainly national or continental and has no connections with deep-sea trades. In most of the cases Ro-Ro transport is characterized by accompanied transport, and very often Ro-Pax vessels are employed for combined freight-passengers transport.

The intermodal sea transport market is rather heterogeneous, since a big variety of operators is involved; which differ by the geographical coverage, by the company dimension or by the typology of services provided.

Some big international maritime companies that provide deep-sea transport can decide to provide both feeder and short sea shipping services.

In Europe, short sea shipping operators are mainly national or European companies that in some cases provide also road or rail services.

In recent years new services have been launched in the market from new entrants, possible explanations for this phenomenon could be the financial incentives that some nations are providing, or a stronger awareness of the capabilities of this mode of transport.

1.6 Intermodal transport in Europe: statistics and policy

The presence of intermodal statistics, both national and international is scarce and the reliability of the reports is not always un-doubtful. The reason behind this lack of information and certainty is the low harmonisation among the institutions that deal with intermodal transport.

Nonetheless, more and more attempts are carried out in order to obtain a consistent database that could allow for a better use of the collected information.

Still some gaps exist in the available statistics and documentations, most of them due to the fact that intermodal transport is not considered as an independent mode of transport. The statistics are related to each single mode of transport included in the intermodal chain and in this case, the unit of measurement is tons or tonkm, instead of TEU. Another problematic issue is related to the double counting of the freight during the transhipment operations, and also the lack of systematic collection of data on a national level that prevent from a complete international data base creation.

In respect to what mentioned above, an overview of intermodal statistics will be presented according to European data, collected by official European institutes, such as Eurostat or by international intermodal associations. First, a short analysis of the European freight market structure will be provided, followed by an overview of the available European statistics on intermodal transport and to conclude a detailed review of the current statistics for each of the modes that can take part in an intermodal chain.

The Panorama of Transport 2009 (Eurostat Publication, 2009) shows the changes in freight modal split from 1995 to 2006, pointing out that during this period several political and administrative changes occurred as, for instance, the enlargement to 27 EU States.

During these 11 years, the average annual growth rate in good transport was 2.8%, and all the modes of transports contribute positively to this increase, but with different influences. The mode of transport that reported the highest growth was road, which contributes for more than 55%, followed by sea transport with 37% of the total.

Rail transport, inland waterways, oil pipelines and air transport follow in order as it can be seen from figure 1.8.

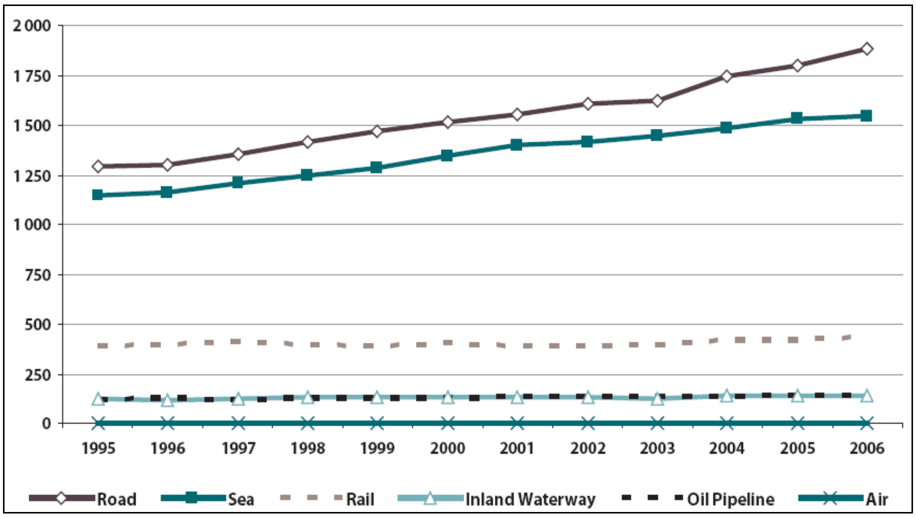


Fig. 1.8: Good transport performance by mode, EU-27, 1995-2006 (billion tonkm)

Source: DG Energy and Transport

If looking at the rate of growth for each individual mode, it is possible to have a better understanding of the relative importance of the total evolution during the years.

Road had an average yearly growth of 3.5%, during the period 1995-2006, an evident support to road transport statistics was given by the entrance of new EU Members. Sea transport had an increase, on average, of 2.7%, followed by air transport, 3.8%, the strong raise in air transport was due to an increase of passengers traffic, to conclude oil pipelines, 1.5%, inland waterways, 1.2% and rail transport, 1.1%.

The variation in the composition of the modal split between 1995 and 2006 can be seen clearly in figure 1.9.

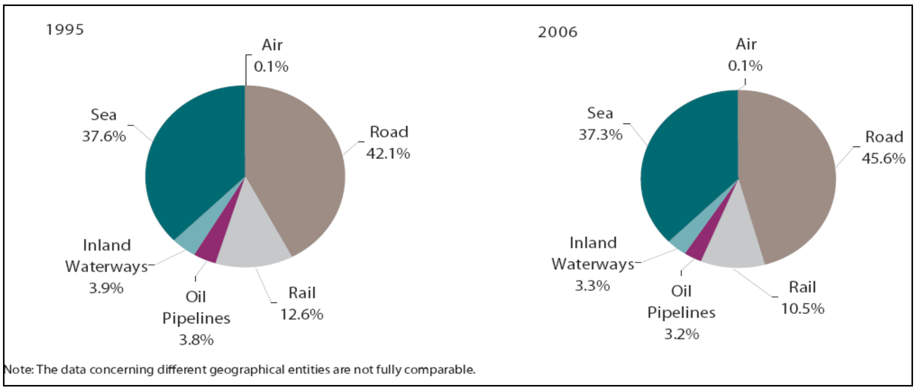


Fig. 1.9: Modal distribution of goods transport performance, EU-27, 1995-2006 (%tonkm)

Source: DG Energy and Transport, Eurostat, US Bureau of Transportation Statistics, Japan Statistics Bureau, National Bureau of Statistics of China, Goskom STAT (Russia), International Transport Forum

The data of 2006, allows to compare the three inland modes of transport and to understand the single share of the modes in relation to tons and tonkm. Road was the mode that transported most goods in 2006, being both the mode that carried most in terms of tons loaded (89 %) and the one that performed most tonkm (77 %). Greater loads of goods that are carried by road over relatively shorter distances explain the different proportions in the two measures.

The percentage of rail per tonkm was 17%, while the tons carried were lower, 8%, the same happened to inland waterways that had 6% of tonkm and 3% of tons; this can be explained by the fact that both rail and inland waterways transport goods for longer distances than road.

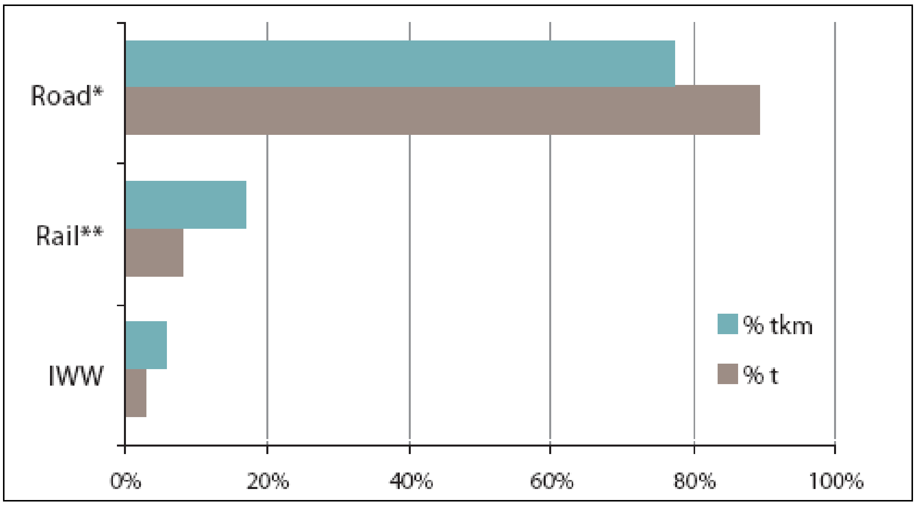


Fig. 1.10: Modal share in inland goods transport, EU-27, 2006 (%tons and %tonkm)

Source: Eurostat (Transport)

In 2011 the official sources about intermodal statistics are poor and out of date; EU Intermodal Freight Transport, is the only document that the European Commission produced and it dates back to 2002, with an analysis of the sector from 1992 to 1999 (Eurostat, 2002). Because this document is quite dated, it is not meaningful to report data from it; however, one remarkable consideration needs to be pointed out: it was considered that 8% of the internal trade, in tonkm, in European Union was developed through intermodal transport. Considering the lack of official data, it could be interesting to analyse the road, rail, sea and inland waterways intermodal structure through updated information from other sources, such as transport institutes or associations.

As already mentioned earlier, road transport remains fundamental in intermodal transport, for this reason some statistical information about the share of road transport in EU-27 in 2006 will be provided. The amount of international road transport was 32.6% of the total road transport. The nations that had greater share of international traffic were the ones in Centre and East of Europe, Benelux, Austria and Portugal.

It is noticeable that the countries having the bigger share of road transport, in tonkm, are large economies such as Germany, Spain, France, United Kingdom and Italy.

In order to analyse road transport in the intermodal transport chain, it is important to consider the average length that is covered with this mode of transport. Eurostat elaborated an analysis of road freight transport according to kilometric distances, as shown in figure 1.11.

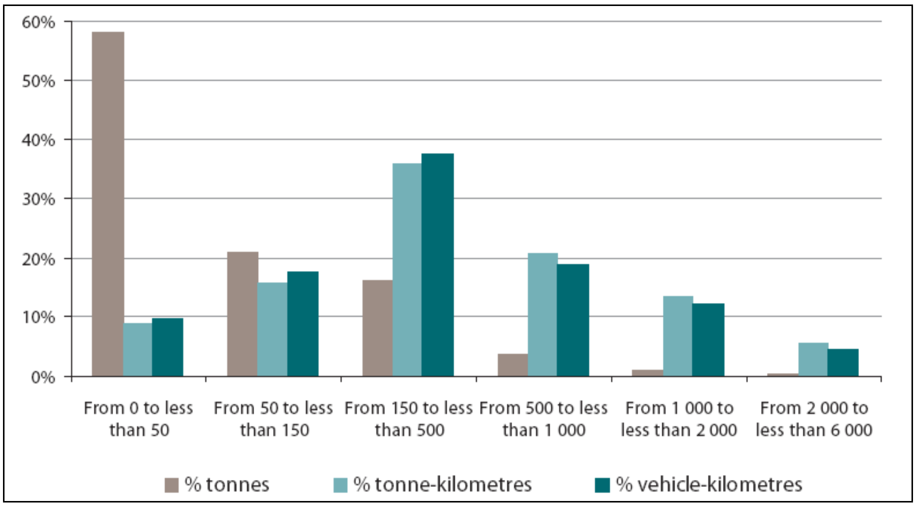


Fig. 1.11: Road goods transport, distribution by kilometre distance class, EU-27, 2006 (%tons, %tonkm, % v/km)

Source: Eurostat (Transport)

Both the share of tonkm and v/km are bigger in the distance class comprised between 150 and 500 km. This information is quite crucial when considering the role of road transport in the entire door-to-door intermodal journey. Short distances for pre/post haulage can be covered in many cases by road transport; it is also true that for such distances the competitiveness of intermodal transport compared to road only transport is doubtful.

In order to present reliable information about intermodal rail transport it is advisable to refer to UIRR that draw up statistics on their traffic.

In this thesis, the main sources will be the annual statistics presented by UIRR in 2008, the UIRR members are the bigger international intermodal rail operators in Europe. The UIRR statistics consider accompanied and unaccompanied traffic and for the entire rail traffic the main flows in Europe are the ones from North Italy to Benelux and Germany, followed by the flows between Italy and France, Italy and The Netherlands, Italy and Austria, Switzerland and Germany, Germany and Austria and Germany and Poland.

From the above mentioned list of traffic flows it results that most of the flows pass through the Alps, hence through Switzerland and Austria, countries where the morphological configuration do not allow for easy transport solutions, and where the intermodal rail solution seems to be the preferred one.

Between 2007 and 2008 an increase of 2% in the use of intermodal rail transport was registered, when zooming in on the composition of the traffic it appears that most of the traffic is unaccompanied but the evolution in the last year was higher for intermodal accompanied rail transport, that increased of 10% versus 1% of the former. The main 5 operators were: Kombiverkehr, Hupac, Cemat, ICA and Kombi.

The table below shows the variations in the international traffic during the years for the operators belonging to UIRR.

Tab. 1.6: International traffic per UIRR Member Company 2004-2008

Company	Number of consignments					
	2004	2005	2006	2007	2008	% 08-07
UNACCOMPANIED + ACCOMPANIED						
Adria Kombi	40 245	41 131	53 044	64 944	**62 463**	**-4%**
Alpe Adria	21 548	22 170	26 989	34 173	**32 731**	**-4%**
Bohemiakombi	14 413	1 424	3 643	5 309	**6 302**	**19%**
Cemat	227 491	236 824	266 493	270 822	**259 464**	**-4%**
Combiberia	16 851	24 406	29 499	29 167	**27 244**	**-7%**
Conliner	56 028	45 337				
Crokombi	3 520	1 796	1 719	2 841	**2 723**	**-4%**
Hungarokombi	50 568	37 076	27 275	16 831	**18 278**	**9%**
Hupac	248 692	291 157	346 060	396 641	**390 862**	**-1%**
Hupac NV	47 899	57 085	69 554	71 567	**72 533**	**1%**
ICA		123 753	154 797	167 946	**166 115**	**-1%**
Kombi Dan	5 568	7 205	6 822	7 940	**6 972**	**-12%**
Kombiverkehr	372 290	351 371	375 836	402 148	**401 443**	**0%**
Naviland Cargo[2]	27 832	12 804	15 629	18 791	**35 355**	**88%**
Novatrans[3]	41 733	37 848	43 714	46 538	**35 647**	**-23%**
Ökombi	127 541	90 677	117 456	113 412	**120 835**	**7%**
Polzug[4]			76 513	88 569	**90 329**	**2%**
RAlpin	64 715	79 248	80 864	80 342	**85 106**	**6%**
Rocombi	0	38	15	41	**10**	**-76%**
T.R.W.	59 762	85 889	98 516	98 786	**82 946**	**-16%**
SUM	1 426 693	1 547 238	1 794 434	1 916 808	**1 897 358**	**-1%**

Source: UIRR Statistics, 2008

As a preliminary remark, it is necessary to draw the attention on the fact that intermodal maritime transport, meant as short sea shipping and feeder services, is not so easy to capture in terms of statistics and data availability. In many cases, there is a double counting of the TEU's or tons, which can be calculated both at the transhipment port and at the final port of destination.

Referring to the Eurostat study of 2002 about statistics in intermodal transport, the rate of maritime transport on the overall intermodal transport was 5.3% in tonkm for intra EU flows.

As an indication of the relevance of maritime transport in Europe, an overview of the main container ports in Europe is provided in table 1.7. For the purpose of this research only container ports are considered, the reason is mainly that containers are the maritime loading unit for intermodal maritime transport.

Tab. 1.7: Top 20 European Container Ports

TOP 20 EUROPEAN CONTAINER PORTS

Port	Country	2010	2009	2008	2007	2006	2005
Rotterdam	**Nederland**	**11,146**	**9,743**	**10,784**	**10,791**	**9,654**	**9,288**
Antwerp	Belgium	8,468	7,310	8,663	8,176	7,018	6,488
Hamburg	Germany	7,896	7,008	9,737	9,890	8,862	8,088
Bremen	Germany	4,888	4,579	5,448	4,892	4,444	3,744
Valencia	Spain	4,207	3,654	3,602	3,043	2,612	2,410
Felixstowe	United Kingdom	3,400	3,100	3,200	3,300	3,000	2,700
Gioia Tauro	Italy	2,851	2,857	3,468	3,445	2,938	3,209
Algeciras	Spain	2,810	3,043	3,324	3,414	3,257	3,179
Zeebrugge	Belgium	2,500	2,328	2,210	2,020	1,653	1,408
Marsaxlokk	Malta	2,371	2,330	2,300	1,887	1,485	1,321
Le Havre	France	2,356	2,241	2,450	2,638	2,137	2,058
St. Petersburg	Russia	1,930	1,340	1,983	1,970	1,450	1,121
Southampton	United Kingdom	1,600	1,400	1,710	1,900	1,500	1,374
Barcelona	Spain	1,422	1,800	2,569	2,610	2,318	2,071
Ambarli	Turkey	1,312	1,836	2,262	1,940	1,446	1,186
La Spezia	Italy	1,285	1,046	1,246	1,187	1,137	1,024
London	United Kingdom	869	846	1,167	844	743	735
Genoa	Italy	860	1,534	1,767	1,855	1,657	1,625
Constantza	Romania	557	584	1,359	1,411	1,018	771
Bilbao	Spain	531	443	557	555	523	504

Source: Port of Rotterdam web site

Table 1.7 shows a continuous growth in all the twenty ports. Naturally, not all of these ports are involved in intermodal maritime transport at the same level. As a matter of fact the bigger hub ports, as Hamburg, Rotterdam, Antwerp for the North range and Valencia, Gioia

Tauro and Algeciras for the Mediterranean range are the ones with higher degree of transhipment, thus feeder transport.

Concerning short sea shipping, it is mostly developed in Italy, Spain, France, Germany, United Kingdom, Belgium and The Netherlands.

The share of intermodal inland waterways transport was, in 1996, 0.2%, in tonkm, of the total intra EU traffic flows. Nowadays the situation has not really changed, also because the main traffic flows are limited to the Northern ports as Antwerp or Rotterdam and the inland ports are in Benelux, The Netherlands, France and Germany. In addition, in this case, the availability of intermodal data is often poor, but it is interesting to look at the studies carried out from the European Union that provide interesting information about inland waterways itself.

Twelve countries are currently using inland navigation transport and report on loading/unloading and movements of goods taking place on their territory.

The table below shows the evolution, since 1990 until 2006 of tonkm of good transported in these Countries.

Tab. 1.8: Inland waterway goods transport, 1996-2006, (million of tonkm)

	1990	1995	2000	2003	2005	2006	AAGR '90 to '06
EU-27	:	:	:	:	137 668	137 712	:
BE	5 389	5 731	7 215	8 230	8 566	8 908	3.2%
BG**	:	:	:	613	757	785	:
CZ	:	:	80	49	64	44	:
DE	54 803	63 982	66 465	58 154	64 096	63 975	1.0%
FR	7 581	6 630	9 110	8 024	8 905	9 005	1.1%
LU	362	338	378	316	342	381	0.3%
HU	:	:	:	1 517	2 110	1 913	:
NL	35 661	35 457	41 271	39 031	42 225	42 310	1.1%
AT	:	2 046	2 444	2 276	1 753	1 837	:
PL	:	:	:	:	327	289	:
RO	:	:	:	:	8 436	8 157	:
SK	:	:	:	94	88	106	:
HR	:	:	:	:	119	116	:

* National + International (loaded & unloaded) + Transit ** BG: 2003 including vessels used for ferrying purposes

Source: Eurostat (Transport)

Policies

The urgency of interventions for policy regulation on a European and national level rises from the need to put in order the complex transport system with the scope of having more efficiency and moreover a better-organized social system.

Freight transport constitutes the pivot element for the distribution system from the producer to the final consumer, thus it is likely that European institutions on a governmental level take into account transport policies.

Transport policies are developed in order to improve security and safety aspects related to transport, environmental protection, an appropriate level of market competition, and from a more general point of view a broad improvement of managerial and operational transport activities.

One of the main objectives, already considered in the agenda of transport intervention, is related to a better use of the employed resources and a better organization in the management of different transport modes.

With this perspective, both on a national and international level, several policy actions have been undertaken in order to promote a better use of the different modes of transport according to the different circumstances.

In Europe, the most recent approach to the problem considers the concept of co-modality that stands for an efficient use of different transport modes both on their own and in combination, with the aim of reaching high qualitative levels related not just to mobility but also to environmental protection (Macharis, 2008a).

The main target that is pursued with this type of policy is a greater awareness of the positive aspects related to intermodal transport, trying to reduce the impact of all road transport.

This concept is rather new, but clearly interconnects with the definitions of intermodal or multi-modal transport given earlier. The notion of co-modality does not suggest solutions or prevalent modes, but underlines the advantages given by any kind of intermodal solutions.

European activities for the promotion of intermodal transport can be categorized in three groups: transport policies, research activities and supporting activities for companies and operators. In the following paragraphs, a detailed analysis of the evolution of such activities will be provided.

European Transport Policies

Due to the enormous number of freight and passengers that moves around Europe, the aim of the European transport policy is to achieve sustainable mobility. This target has been pursued through a *Common Transport Policy (CTP)*, which started with the Community Treaty of Rome, in 1957 and was clearly stated in the *White Paper "Time to Decide*" in 2001. In this document, four key objectives were underlined: the shift of the balance among transport modes, the elimination of bottlenecks, the development of transport policies for the benefit of the final users and the management of the globalisation in transport. It can be seen quite clearly that the shifting of balance among transport modes involves intermodal transport when freight transport is moved from road to rail, inland waterways or short sea shipping.

A more recent document also dealing with the topic of intermodality is the *White Paper Mid-Term Review "Keep Moving"*, in which the concept of co-modality is presented for the first time, meaning the efficient use of different modes on their own and in combination to achieve a high level of both mobility and environmental protection.

Important recommendations and indications on future trends that Europe is following are presented in the New *White Paper: "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system"*, 2011.

Concerning modal split and the use of intermodality the proposals are rather clear both for short distances and for more longer journeys:

"…Freight shipments over short and medium distances (below some 300 km) will, to a considerable extent, remain on trucks. It is therefore important, besides encouraging alternative transport solutions (rail, waterborne transport), to improve truck efficiency… In longer distances, …freight multimodality has to become economically attractive for shippers. Efficient co-modality is needed. The EU needs specially developed freight corridors optimised in terms of energy use and emissions, minimising environmental impacts, but also attractive for their reliability, limited congestion and low operating and administrative costs.”

Although these documents represent fundamental stages in the definition and regulation of the topic, a series of communications and proposals have been processed during the last 15 years, as shown in Annex 1.1.

Research activities: the scope of research and studies is to support, complete and asses policies measures that European institutions may develop. Research activities have been carried out autonomously or within the framework of elaboration/assessment of policy measures.

During the years several research projects have been developed mainly focusing on the development of technologies and operations to support intermodal transport. A list of the major projects is presented in Annex 1.2, according to the Framework Programmes.

In addition to projects developed under the Framework Programmes, other two European actions have been undertaken for the support and promotion of intermodal transport: *COST*, European Cooperation in the Field of Scientific and Technical Research and *PACT*, Pilot Action for Combined Transport.

COST is a European network for the cooperation among scientist and researchers with the aim of providing research on intermodal freight networks, interconnectivity and interoperability among modes of transport. Under the umbrella of COST about 50 actions have been developed.

PACT actions were undertaken with the aim of providing financial assistance for pilot actions in combined transport, this actions covered the period from 1992-2001 and from 1997 to 2000 and in this period 106 projects focussing on innovative modal shift concept were financed.

Supporting activities for companies and operators: an additional and very direct way to promote intermodal transport is the support that the European Commission gave and is giving to companies currently operating and operators that decide to invest in this mode of transport. The financial support for companies that decide to use intermodal transport can be provided on a national level or on a European scale. As mentioned earlier the PACT, was one of those. The following step that the European Commission put into action was Marco Polo, that nowadays is already at its second edition, with Marco Polo II, from 2007 until 2013.

The Marco Polo project was set up in 2003 with the aim of shifting international road freight transport to short sea shipping, inland waterways and rail transport.

The main differences with the previous PACT project were:

- Initial support to intermodal projects that can be developed in medium term;
- Financial support for strategic or structural projects;
- Diffusion of best practises;
- Support Enlargement to East European countries.

1.7 Liability in intermodal transport

Together with operational and technical aspects, intermodal transport needs to be analysed also for its legal and administrative characteristics.

Despite its relatively young life, intermodal transport has always suffered from the lack of a clear and unanimous legal framework that could regulate the responsibilities during the entire door-to-door transport.

The problem rises when losses or damages occur to the goods, and the only responsible for the shipment is the multimodal operator.

In the case of intermodal, multimodal or combined transport the producer or the consignee of the freight will interact and contract with one operator that will have to organize, coordinate and execute the transport, this operator is namely the multimodal operator.

When this situation occurs, the multimodal operator is the one that has all the management's responsibilities and he/she is liable for any problem that may arise during the all transport process.

Since it is commonly recognised that intermodal transport is a typical mode of transport, different from each single mode that constitute it, there should be a proper and unique legislation that could clearly regulate intermodal transport.

It can be argued that, in intermodal transport, liability rules belonging to each single mode of transport can be applied, as an example, if the damages or losses occur during the maritime leg of the transport, maritime legislation will be applied.

Nonetheless, issues remain when it is not possible to locate exactly where and at which moment the loss or damage occurred, thus it is not possible to apply the appropriate uni-modal legislation. The solution for these problems could be a specific intermodal legislation.

With the Geneva Convention, 1980 dealing with the role of the multimodal operator, definitions and liability restrictions were provided. As this Convention did not reach the minimum number of ratifications from States, it is not internationally recognised nor effective.

Another attempt came from UNCTAD/CCI, (United Nations Conference on Trade and Development, International Chamber of Commerce) that in 1992 elaborated a collection of trading rules for intermodal contracts. In this case the rules are valid, only if the parties decide to insert them in their contract. Even if prevalent, it is not possible to argue that this legislation could be internationally recognised as the base for the regulation of intermodality.

The rule of thumb is to use standard contractual forms that can be modified according to the specific requirements.

The most popular among the operators is the form elaborated from FIATA, International Federation of Freight Forwarder Association, (Confetra, 2000) in this document the rules already presented in the UNCTAD/CCI document are used.

1.8 Chapter's summary

The issues touched in the present chapter were related to the definition of the intermodal concept, namely the meaning of it and the difficulties in finding a unanimous and recognized official definition. Together with the concept of intermodality, other similar concepts and definitions have been presented, such as combined transport or multimodal transport.

An essential part of the present chapter is the economic rationale related to intermodality, showing its relative advantage to road transport, above certain distances and with large volumes.

An important part of the text was dedicated to technical and organizational characteristics of this mode of transport, the purpose was to get more acquainted with specific elements that are basic in the operational activities.

The last part of the chapter reported on European statistics, projects and policy measures present on the European scene, showing the relevance and importance that has been given to it from public entities.

This first chapter had the aim of making the reader more familiar with the concept of intermodality.

It is important to place such information at the beginning of the present work, in order to have a comprehensible idea of the topic, and to proceed further without doubts. (Data collection ended the 1/08/2011)

Once having these concepts in mind it will be easier to continue the reading, focusing the attentions on studies and research that investigated the competitiveness of intermodal transport form different perspectives, as it will be presented in Chapter II.

CHAPTER II

LITERATURE REVIEW ON INTERMODAL TRANSPORT'S COMPETITIVENESS AND COMPONENTS AFFECTING MODE CHOICE

After having a more clear idea on what intermodal transport is, it is expedient to narrow the study to the research question investigated in this thesis, the reasons that prevent intermodal transport to be a real competitor to road transport.

To proceed in this direction, a good starting point would be the examination of the previous researches that tried to investigate this topic.

Research in transport economics already focused on intermodal transport, from different angles: operational, technological, economics; the first part of this chapter will guide the reader to the main findings of the previous scientific production. It will become clear which aspects still need to be investigated or which approaches were not yet considered as possible ones. To this respect the present thesis will try to fulfil this gap, proposing a different approach to tackle the problem, as it will be illustrated further in the text.

The remaining part of the chapter will present the results of the literature review appraisal, obtained from a careful revision of the works that investigated the elements affecting mode choice, hence the elements influencing intermodal transport choice as well.

The report presented in this chapter represents the preliminary work that need to be put in place before developing a new research or study.

The purpose of the chapter is therefore:

- to present the previous literature on the competitiveness of intermodality and also the literature that can be expedient to understand the elements that can hamper its development,
- to learn form the previous findings and take them into consideration when developing the present research,

- to avoid investigating matters already treated earlier,
- to use previous results as litmus test,
- to point out topics or issues not yet considered or solved and try to fulfil these gaps with the present research.

The chapter will be structured so that a first part will mainly focus on the previous literature on intermodal competitiveness and general literature on different aspects related to it, the second paragraph will address the concept of generalized cost and how it has been considered in transport economics.

The remaining of the chapter will consider the literature review on modal choice, showing which criteria influence final decision and for each of these aspect a detailed review of approaches to tackle the issues will be presented.

2.1 Previous researches about intermodal transport and its competitiveness

The concept of intermodality is relatively young in transport economics, nonetheless since the yearly 1990s the interest that this topic was able to attract is remarkable.

The reason of such academic curiosity is witnessed by the large amount of researches that dealt with intermodal transport, under different perspectives.

The work of Macharis and Verbeke (1999) considered intermodal transport from different points of view, trying to investigate the economic, organizational, technical, financial and institutional aspects related to it. Their book comprised a part on the main problematic issues related to it, and the role of intermodal transport in the Flemish ports' modal split.

Their contribution can be considered as a valuable starting point in order to obtain a clear and comprehensive overview of what intermodal transport is and which are the main issues related to it. Although their work is not so recent, still it remains very much up to date especially for some problems that are not completely solved.

A significant review of studies and researches about intermodal transport is the one done by Bontekoning et al. (2004), 92 English papers that investigated intermodal transport were taken into consideration. They made a survey on the different topics concerned with intermodal transport such as drayage, rail haul, transhipment, standardisation, multi-actor chain management and control, mode choice and pricing strategies, intermodal transport policy and planning. Although their main purpose was to provide an overview and classification of the existing situation in intermodal research and to establish the base for an integrated research agenda, they presented a good overview of the major problems that hinder its spreading among operators.

As it can be noticed from the list of topics analyzed, intermodal performance can be considered from different point of views, some of those consider technical and operational aspects, some others refer more to the economic viability, some others to transport operators' role or policy measures.

According to the topic and to the aims of the works, the methodology applied varied and it is rather unlikely that those methodologies can be compared, in order to obtain the best approach or the best results.

Particularly interesting, for the present thesis, is the part dedicated to mode choice and pricing strategies, where a number of previous work have been analysed. The authors stated that: "The general problem of intermodal transport is its competitiveness in relation to other modes…for which markets intermodal transport is attractive, how intermodal performs compared to other modes, how market share can be increased, and which pricing strategy to follow".

Their point of view is perfectly in line with the content of this thesis, and the earlier literature is fundamental for avoiding overlapping or for learning from previous investigations. These studies revealed the most important mode choice determinants and provided insight in the sensitivity of the mode choice to a change in the cost or quality.

They finally suggested further research into the mode choice decision-making process and considered that the main problems that intermodality is facing are low level of efficiency, profitability and competitiveness.

Among the papers reviewed in Bontekoning et al., the ones that dealt with mode choice have been considered in the present work and the references to these are introduced later on.

It is remarkable to mention some others relevant researches on competitiveness of intermodal transport, as such as the work of Beier and Frick (1978) and Fowkes et al. (1991)

that investigated the conditions under which truck shippers would switch to piggyback transport. Both studies indicated that shippers would accept to have quality's losses, when using intermodal transport, if compensated by discounts for the use of it.

Tsamboulas and Kapros (2000) assessed shippers' perceptions of various cost-quality determinants of intermodal rail–truck service and other transport mode(s). Most relevant to the overall perception for all modes are timeliness and availability. It appeared that in general, shippers give intermodal rail–truck mode higher marks than road transport when considering transport costs. This shows that actors who decide almost exclusively on cost criterion are intensive users of intermodal transport. Intermodal transport is a minor portion of transport for actors who decide according both quality and cost criteria.

In a study of Van Schijndel and Dinwoodie (2000) the authors assessed the impact of congestion on the decision to switch from road to intermodal by Dutch transport operators. The study was carried out with a sample of transport companies registered in The Netherlands that indicates their willingness to switch to intermodal transport. Nonetheless their preferred solutions would be to drive during the night and to have dedicated lanes for trucks.

Plunkett et al. (1998) developed a tool set to support cost analysis and mode selection for motor carriers. Part of the competitiveness problem is the determination of the right tariff for intermodal transport services, which is called pricing strategy.

It is worth to remember that also researches carried out on European level contributed to enrich the literature on the topic, as already stressed in chapter I.

At this stage, some reference are reported on the scientific contributions that were particularly valuable for the present thesis.

Two project belonging to the 4th Framework Programme, IQ and Logiq programmes considered two specific issues in intermodal transport.

While IQ looked at the quality aspects influencing intermodal transport and suggested ways to improve intermodal transport, such as information, tools and insight so that its market share could increase. (IQ, 1997), the second project, Logiq was more focused on the role of the actors involved in the decision making process. The main outcome stressed how different actors react differently to the use of intermodal transport according to their preferences and their business structure. (Logiq, 2000).

An other important European project, very much significant in supporting the present work, is the Realise project. The purpose of these European study was to investigate market service characteristics and requirements for the development of intermodal transport. The work has been carried out on a threefold basis, looking at statistics, environmental impacts and the economic performances assessment across transport modes. Among the results of the research, it appeared that non-price factors were key drivers in modal choice. (Realise, 2005).

As stated earlier the different approaches and methodologies that have been put in place to confirm, disprove or progress in intermodal competitiveness are numerous, different and none of those can be considered superior than others. The aspects that need to be considered, in order to obtaining a better performance for intermodal transport, are numerous and fundamental. It will be therefore incorrect to omit some of those or consider one more important than the others. Technical, operational, managerial and economical aspects are all important and essential from each other.

Bearing in mind the previous thoughts, it is nonetheless necessary to narrow the research sphere and concentrate on one of those aspects. In the current thesis, the topic will be approached from an economic point of view, analysing the costs related to intermodal and uni-modal transport and driving the attention to the costs elements that compromise the effective competiveness of it.

In order to do so, the research starts from the basic concepts learned from transport economics, the one of generalized transport cost. Additional explanations and details follow in the next paragraph.

Although the topic and the methodology are both very well known in academic research, the innovative element proposed in this thesis is the combination of the two elements and their application to freight transport in Europe.

2.2 Concepts of generalized cost and applications

In transport economics, a method for capturing all the relevant components affecting transport performances is the use of the generalized cost concept. The sum of out of pocket costs and non-monetary variables merge into the concept of generalized cost.

This notion is not unknown to the transport economic theory, it is commonly applied and constitutes the methodological base of numerous studies and researches. The concept of generalized cost and some related concern to its utility and applications have been deeply analyzed in Bruzelius, (1981) and Gray (1978a, 1978b).

Notwithstanding some doubts emerging from those studies, the concept of generalized cost remains one of the main and accepted concepts in transport economics. It belongs to transport economics theory and more precisely to the analysis of price and cost formation.

Over the years, some relevant definitions of generalized cost were provided, mainly related to passenger transport and successively to freight transport.

In the text of Button (2010), the generalized cost of a trip is “expressed as a single, usually monetary, measure combining, generally in linear form, most of the important but disparate costs, which form the overall opportunity costs of a trip”. According to the author, the shippers are concerned with the financial costs of the trip but also with the speed, the reliability and the timetabling of the service.

With the utilization of different variables, the need to equal the diverse unit measures arises, the reason is that it will not be possible to measure their impact without translating them into monetary units.

All costs items are reduced in a single index that in most cases is a monetary index used for the calculation of the final generalized cost.

According to Button, generalized cost can be defined as:

Generalized Cost Function (2.1)

$$G = g\ (C_1, C_2, C_3, \ldots C_n)$$

Where: G = generalized cost function

C_1, = out of pocket costs

$C_2, C_3, \ldots C_n$ = qualitative attributes.

Another definition of generalized cost can be found in the book of Marchese (2001), where the author states that the concept of generalized costs can be summarized as "the sum of the transport price/cost and the value of time for the trip". The transport cost and the monetary value of time are homogeneous and addable elements.

Considering the definition provided by Cole (2005) generalized cost "includes not only directly valued costs such as fuel, capital utilization, …, but also elements such as journey time changes and environmental factors".

Considering the above-mentioned contributions, the definitions of generalized costs in the present text is the following:

Generalized costs are the sum of out of pocket costs and non-monetary costs of a journey.

The out of pocket costs can be represented by the costs for: fuel, labour, insurance, depreciation, maintenance, etc.

The non-monetary part can be considered as a sum of qualitative attributes that are not immediately valuable with a monetary index, but play an important role in the perception and selection of a transport mode. Usually the non-monetary part is related to the value of time, especially in passenger transport and thus to traveller's income and preference. In freight transport, those elements can be the value of time in relation to the urgency of the delivery, the reliability of a safe and on time journey, the impact on environment, etc.

A simple form for expressing a generalized costs function is the following:

Generalized Costs Function (2.2)

$$G = c + u\,(m_1, m_2, , m_3, \ldots m_{n,})$$

Where: G = generalized costs function

c = out of pocket costs

$u(m_1, m_2, , m_3, \dots m_n,)$ = non-monetary costs, function of several attributes

This approach has been followed in previous studies to address research questions related to the evaluation of qualitative attributes, such as the value of time, the value of reliability, the value of comfort/discomfort, the value of flexibility and so on.

The methodology applied is based on the analysis of the out of pocket costs for the transport service, passengers or freight, complemented with the investigation and monetization of qualitative attributes. The study of Kumar et al., (2004), is considering the generalized costs in a case study of rural bus users.

A review of researches dealing with freight transport, decision process and the evaluation of qualitative criteria is presented in Danielis (2002).

From the literature review it can be argued that the generalized costs approach is a well-established methodology for capturing all the cost components that characterize a service, namely a transport service.

Intermodal transport has been studied under different perspectives, and its competitiveness related to specific economic, technological or managerial aspects; nonetheless, a complete analysis of all those aspects considering not only out of pocket costs but also qualitative attributes has not been yet developed.

In the analysis carried out in the present work, a generalized cost approach will be followed; it shows to be a common and useful tool in helping understanding how variation in travel costs and attributes can influence travellers' behaviour.

Furthermore, the author considered that an additional element should be put under investigation, which is the role of external costs. External costs are costs related to effects which are not currently valued by the market, hence any benefit or costs deriving from external costs is not enjoyed nor paid from the entity that produce it. An analysis of the effects of external cost internalization will be developed further in the text.

In order to proceed with the development of the research it was necessary to acquire information, notions and get more familiar with all the components that need to be considered in the generalized cost function.

A significant contribution to this purpose was obtained by the review of existing research and academic texts on the elements that affect mode choice. Within this research framework it was possible to observe that the main two categories that affect mode choice are actually the transport cost, namely out of pocket cost, and the service's attributes, non-monetary costs, that play a crucial role in the selection.

Each of these two categories has been already reviewed in previous researches and some fundamental findings are reported in this chapter as a preliminary base for the development of the present study.

The analysis of the literature review will revise the internal costs variables, or out of pocket costs, and the influence of qualitative attributes as decision variables.

The last part of the chapter will deal with a review of the external costs and their hypothetical internalization in the calculation of transport cost.

2.3 Literature review on relevant attributes when selecting a mode of transport

This paragraph presents the main publications that dealt with mode choice in freight transport.

The following literature is representative of the studies that gave a main contribution in the elaboration of the present thesis; it does not claim to illustrate the whole literature on freight mode choice.

Cunningham and Kettlewood (1975), made an analysis of the influence of the supplier's image on buyer behaviour in the British rail industry. The companies of the sample were manufacturing companies in Scotland. The outcome of the study showed that the main qualitative variables influencing patronage decisions were the availability of the vehicles, the reliability of the delivery and the ability to load and unload at own convenience.

Gilmour (1976) presented a study conducted in Australia, on the user's preferences on the Melbourne-Sydney services, trying to investigate the factors that were important in their mode choice. The research is developed in three main parts: the first step was to ask the respondents to list factors which they were likely to consider when sending goods in the mentioned corridor. Secondly they were asked to establish similarity ratings for all possible pairs of the seven modes being considered. The last part was the rating of each of the factors gathered from the first stage. Through a cluster analysis the author concluded that direct transport costs are, among the others, not the most important determinants for freight shippers. More relevant elements are the possibility to control the shipment, the availability of the required equipment and the reliability.

In the study of Stock and La Londe (1977) an analysis of companies' preferences has been carried out with 87 companies. The analysis was considering the different stages in the decision making process involved in mode selection. In relation to the identification of the importance of several procedures used by the companies in evaluating mode performances, the main outcome shows that reliability, freight charges and transit time were the three most important elements.

McGinnis (1979) developed a field study with a sample of 351 shippers in the U.S.A. considering eight topics which were assumed to be relevant in influencing their choice of transport.

The eight variables were the following:

1. Freight rates
2. Speed
3. Reliability
4. Loss and damage
5. Inventories
6. Company policy
7. Shipper market conditions
8. Influence of the shipper's customers.

The respondent had to state the degree of importance on a 5 point scale for 30 statements associated with the eight attributes. Applying a factor analysis McGinnis obtained seven main factors, the three most important of which were the ones related to speed and reliability, freight rates, and loss and damages.

In a later work, the same author, McGinnis (1989) started from an overview of existing studies about transport choice, and presented the summary of the variables that were considered more often in the studies, although with different methodological approaches. The review led him to identify seven variables: freight rates, reliability, transit time, damages, shipper market considerations, carrier considerations and product characteristics. The paper continued with the discussion of four freight transport models reviewed in the context of the literature review examined in his work. The four models considered were: the Classic economic model, the Inventory theoretic model, the Trade-off model and the constrained optimization model.

The same author, McGinnis (1990) carried out a study on the relative importance of costs and services in freight focusing on changes occurred after the pro-hire transport deregulation in the U.S.A. The main conclusions that he obtained were that the pattern in the preferences did not change tremendously and freight rates were significantly taken into consideration, even being relatively less important than services elements. Some services variables were more important than freight rates, while other services variables were less important according to the particular situation.

Burg and Daley (1985), made an analysis of the mode selection process and marketing impacts on shippers and carriers within shallow-draft barge transport in U.S.A. They interviewed 113 shippers, divided by national and regional ones, and a self-administrated questionnaire was sent by email. The respondents, both the shippers and the carriers were asked to rate the factors on a Likert scale form 1 to 5, using 13 factors. The results were analysed by means of multidimensional scaling, and the outcome was a perceptual map of their selections in relation to all modes of transport. The results showed that shippers and carriers had different preferences, namely shippers placed more relevance on non-transport cost factors, and the main element was the satisfaction of the customers, followed by transit time and freight charges.

The study of Jeffs and Hills (1990) analyses the determinants that affected the mode choice of shippers belonging to the printing and publishing sector in U.K.. Several attributes were considered and the results of the interviews were analyzed by means of factor analysis. The two main factors determining the mode choice were: “control” containing variables such as reliability, control over dispatches, avoidance of damages, etc., “doublet” which was related to size of the consignment and length of the haul.

A different approach to the topic was carried out by Murphy et al. (1991) in their study about the selection of links and nodes in international transport, they interviewed freight forwarders. The main purpose was to investigate which were the important factors for freight forwarders, when selecting carriers. The results, obtained with a ranking scale for 1 to 5, showed that their main concerns were about equipment availability, shipment information and the possibility to have loss/damage. Furthermore a factor analysis was performed resulting into two factors: the first more related to the transport itself, the second to the shipment.

The work of Abshire and Premeaux (1991) provided an analysis of the different perception of shippers and carriers in motor carrier selection. The sample of shippers consisted of 102 companies active in different economics sectors, the carrier sample was made of 94 carrier sales managers. The interviewees had to rate 35 variables, on a 1 to 5 scale. The most important criteria that shippers considered relevant were: the reliability of the service, the additional services that the carrier could provide them, the carrier financial stability, etc. The results of the study showed that carriers did not have the same perception that shippers put on specific criteria.

A later paper of Mateat et al. (1993) applied a similar analysis to the Irish market, in relation to the commercial trade with Great Britain, and the companies interviewed were both shippers and freight suppliers. Factor analysis appeared to be a common methodological approach for this typology of research; in this study the outcome of the preliminary interviews were then performed into a principal component analysis. The resulting factors for the shipper sample were 5: carrier characteristics, routeing characteristics, timing characteristics, price characteristics, and control over the involvement of other parties. The main conclusions about shipper preferences were related to the importance that they gave to carrier characteristics, the schedule of the services and the price charged.

In the study of Evers et al. (1996) the authors tried to capture the impact that shippers perceptions of individual transport service characteristics had on the shippers general perception of transport modes. The methodology applied in their field study, was based on perceptions and indications provided by the interviewed shippers on the characteristics of three transport modes: intermodal, rail and road transport. The respondent were asked to rate their perception on a 1 to 5 scale. The applying factor analysis to the results of the interviews lead to six main factors: timeliness, availability, suitability, firm contact, restitution and cost.

By means of those factors three regression models were performed. The dependent variable was the shipper's overall perception of transport modes. The final results of the regression model showed that out of those six criteria the most important for the shippers were availability and timeliness.

The application of content analysis developed by Cullinane and Toy (2000) took into consideration 75 papers dealing with route/mode choice literature, mostly for Western production. This typology of analysis, developed in various forms, led the authors to report on the most often considered factor categories in freight route/mode choice literature and to rank those attributes. The first five categories, in order, were: cost/price/rate, speed, transit time, characteristics of the goods and service.

A tool has been developed for the aim of supporting the transport mode decision process by a group of Belgian researchers, Vannieuwenhuyse et al. (2003). They elaborated an iterative internet tool, Promodi that supported decision makers in their transport selections. The top five criteria preferred by the shippers were: transport cost, reliability, flexibility, transport time and safety.

2.3.1 Summary of the main attributes for mode choice

The results of the literature review are summarized in table 2.1, where all the main criteria affecting mode choice are reported, and the most important for each paper are highlighted. The list of the criteria considered in the literature is based on 19 criteria and out of them, five are considered relevant in most of the papers.

The ranking, elaborated according to the relevance that was expressed in the papers, is showing the following:

1. Reliability
2. Transit time

3. Freight rate
4. Loss/damage
5. Customer services.

The outcome of the review presented relatively homogeneous results. Some of the criteria had the same ranking, e.g. reliability and transit time that are the most important elements considered in the whole literature examined. Considering the relevance that these criteria showed in previous research, the selection of the ones to be used for the field analysis of this thesis will start from the outcome of the literature review.

Tab. 2.1: Literature about mode choice selection

author	*ranking*	*methodology*	*num interview*	*Customer services*	*Delivery time*	*Flexibility*	*Frequency*	*Loading Availability*	*Loss/ Damage*	*Freight rate*	*Reliability*	*Transit time*	*Vehicle Availability*	*door-to-door delivery*	*Track and trace*	*Information services*	*Enviromental impact*	*Inventories*	*External market influence*	*Carrier considerations*	*Product characteristics*	*Security*
Cunningham, M., Kettlewood, K.	1 to 5		67 manifacturing company Scotland	X		X		X		X	X	X	X									
Gilmour P.	listing the first 5, ranking 0 to 11	cluster analysis	business organizations in the corridor Melbourne-Sydney	X	X		X	X	X	X	X											
Stock, J., La Londe, B.			87 firms in 3 indusrty groups	X			X	X	X	X	X	X		X	X	X	X					
McGinnis, M.	1 to 5	factor analysis	351 traffic executives companies						X	X	X	X						X	X			
Burdg, H. Daley, J.	1 to 5	multidimensional scaling	113 shippers in U.S.A.	X	X		X	X	X	X	X	X			X							
Jeffs, V. Hills, P.	rating scale	factor analysis	100 shipper of publiscing sector UK	X	X				X	X	X	X	X	X	X						X	X
McGinnis, M.				X					X	X	X	X							X	X		
Murphy, P., Daley, J. Dalenberg, D.	1 to 5		104 freight forwarders U.S.A.	X		X		X	X	X		X			X						X	
Abshir, R. Premeaux, S.	1 to 5	35 crtiteria	102 shippers 94 carriers	X		X		X	X		X	X				X						
Matear, S., Gray, R.	1 to 5	factor analysis	132 shippers 64 freight suppliers in Ireland	X	X		X	X	X	X	X	X										
Lambert, D. Lewis, C., Stock, J.	1 to 7		316 shippers	X					X	X	X	X										
Murphy, Hall, P.			studies comparison						X	X	X	X							X	X		
Evers, P., Harper, D., Needham, P.	1 to 5	factor analysis	153 shippers in U.S.A.	X				X			X	X										
Murphy,P., Hall, P., Daley, J.	1 to 5		325 shippers 335 carriers in U.S.A.	X		X	X	X	X	X	X	X			X							
Cullinane, K. Toy, N.		content analysis		X		X	X	X	X	X	X	X		X	X			X			X	
Vannieuwenhuyse, B., Gelders, L., Pintelon, L.	0 to 10		500 shippers and logistics companies Belgium			X			X	X	X	X	X									
Total				13	4	6	6	10	14	14	15	15	3	3	6	2	1	2	3	2	3	1

Source: own elaboration based on literature review

2.4 Out of pocket costs in transport

Out of the previous analysis it comes to light that the service cost/price is one relevant aspect, this paragraph will deal especially with this monetary characteristic.

When asking shippers and freight forwarders about their mode choice they will refer to the price of the service. From a transport operator point of view, that element is the cost for providing the service summed up with his/her profit.

In the present work, the transport operator point of view will be analysed. This approach will allow considering transport costs and unbundling the cost’s components, in order to investigate if any of those have a crucial role in intermodal competitiveness. Following this approach it will be considered that mark up constitutes a common pattern in all transport operator strategy. This issue will be considered later in the text.

Bearing in mind those preliminary remarks, a detail review of monetary costs in literature will be presented here hence.

In economic theory costs are defined as necessary expenses in order to keep factors of production within a company, so that the production process does not need to be interrupted (Blauwens et al. 2008).

Costs can be associated with a certain level of output, namely the outcome of a production function. The generic production function can be identified as shown in (2.3).

Production Function (2.3)

$$X = f\,(L, K, E)$$

Where: X = output

L = Labour

K = Capital

E = Energy

In the production function the main objective is to maximize the profit and to reduce the costs, thus the cost function that is underneath the production function is fundamental for the company's efficiency. With (2.4) it possible to identify the general cost function of a company.

General Cost Function (2.4)

$$C = f\,(X, P_L, P_K, P_E)$$

Where: X = output

P_L = Unit Labour cost

P_K = Unit cost of capital

P_E = Energy price

From a transport demand point of view, labour, capital, energy together with the margin profit is the price that the shipper has to pay in order to obtain a transport service.

The relation between production and cost function is not new in transport economics, Hoon Oum (1979) presented a study where he investigated the dual relation between production and cost function applied to the freight transport services in Canada. The author described the transport production and cost functions as follows:

Production Function (2.5)

$$Y=f[K, L ,\underline{f}(T)]$$

Where: Y= the economy's level of output

T= R, H, W

R = freight carried by railway carriers

H =freight carried by highway carriers

W = freight carried by waterway carriers

$\underline{f}$(T) is linearly homogeneous in T.

The duality theory that he applied stated that: "…if producers minimize input costs, the cost function satisfying certain regularity conditions contains sufficient information to describe completely the production technology". The author therefore specified a cost function as in 2.6.

Cost function (2.6)

$$C\ (Y, P_K, P_L, P_T)$$

Where: PK = rental price of capital

PL = price of labour

PT = prices of freight transport services

C is linearly homogeneous in T and satisfies the regularity conditions

Before starting the analysis of the out of pocket cost and defining what it is, it is necessary to linger on the concept of total logistics cost.

With this notion is indicated the sum of cost items that the shipper considers when moving the goods from the production location to the final delivery site.

Among the other costs that compose the total logistics cost, transport costs play a key role, together with other elements such as inventory costs or inbound/outbound logistics costs.

Inventory costs, in particular, can influence transport decisions and the mode choice decision process, according to the value of the goods, whether they are perishables or not and the inventory's management. Inventory costs can be also reflected in the qualitative aspects that characterize the transport service.

Looking at the literature dealing with transport costs, it appears clear that together with transport costs, total logistics costs are also considered. From a shipper point of view the aspects that need to be considered go beyond the pure transport. Those additional aspects have been considered and studied extensively in the literature since 70's.

The concept of inventory cost entered in the transport economic analysis with the contribution of Baumol and Vinol (1970), who elaborated a trade-off model between transport costs and inventory costs. They argued that a trade off between speed and costs of the transport operation and a shipper's inventory costs exists. The inventory costs can be reduced when using a faster mode of transport that in most cases will also be a more expensive one.

Following the approach of the two authors, a series of scientific publication on the topic appeared. A large number of authors focused their attention on determining the optimal order point in the inventory operations management, in order to decrease the total logistics costs. (e.g. Buffa and Reynolds, 1977; Constable and Whybark, 1978; Liberatore, 1979; Langley, 1980; Burns et al, 1985, Sheffi et al, 1988).

More recently other papers have dealt with total logistics costs and the influence on mode shares in freight transport (Blauwens et al, 2008) or in cost's minimization for the receiver (Vernimmen et al, 2008).

In both papers the costs of the total logistics chain were considered linking transport costs and inventory costs.

Although being aware of the non negligible importance of the total logistics costs, in this thesis it is assumed that the main criteria considered by a shipper or a freight forwarder when making a mode choice are: transport costs and other qualitative attributes related to each mode of transport.

The competitiveness analysis of a mode of transport is unequivocally related to the pure cost of the service. Notwithstanding the finding of the previous research showing that the relevance of monetary cost is just a part of the entire set of variables that are considered, the out of pocket cost detains a key role in the mode choice. It constitutes the first and tangible element that the shippers or freight forwarders have to face in their ordinary business activity.

In this paragraph a review of the main cost items that need to be incorporated in the out of pocket costs is presented. Several studies, have dealt with accounting costs, approaches for the calculation, and methodologies for the inclusion in a cost function.

In Blauwens et al. (2008) an analysis of cost calculation in transport is presented. The authors classified transport costs in time costs and distance costs that were consequently associated to Euro per hour and Euro per kilometre covered.

Through this methodology a calculation for road transport and inland navigation transport is performed. The cost items that were considered, according to their hourly consumption, were: interest and depreciation, insurance, taxes, wages, other costs. The other costs were considered in relation to the kilometres covered: interest and depreciation, fuel, tyres and maintenance and repair. Depreciation can be expressed both in hourly cost and in kilometre cost, or the total amount can be split in two parts.

Total cost of transport (2.7)

$$\text{Total Cost} = uU + dD$$

Where: u = hour coefficient

d = kilometre coefficient

U = time in hours

D = distance in kilometre

A study of Boardman, (1999) made a comparison among truck/rail, truck/barge and rail/barge combinations for container transport, taking in consideration the total transport cost. The main conclusions were related to the differences among shipment characteristics and the most suitable mode of transport for each of those.

It was pointed out that the mode choice was strongly influenced by the distance covered, road transport being the best for short distances.

In his study Boardman considered the total transport costs as showed in 2.8.

Total Transport Cost (2.8)

$$T_m + D_m + T_{sm} + CC_m$$

Where: T_m = transport cost (in dollars) for mode *m*

D_m = dray cost (in dollars) for mode *m*

T_{sm} = transfer cost (in dollars) at terminal for mode *m*

CC_m = carrying cost (in dollars) for mode *m*

The calculation has been performed for each mode of transport in €/loading Unit (LU) and then compared among them. The application for some case studies in the U.S.A. showed that road transport was more economic for distances below 739 km, rail transport was the best solution up to 2100 km and above this length inland navigation is the preferred mode of transport.

A considerable contribution to the topic was provided by the European project Recordit, (2000) Real cost reduction of door-to-door intermodal transport.

This project took into consideration some European corridors with the aim of analysing their cost structure; both uni-modal and intermodal, with the purpose of considering the cost items that weight more on the total cost and try to find solutions to minimize them.

The project classified the cost components in nine blocks, and each block was considered for all the operators involved in each phase of the journey.

In Recordit the calculation was performed per €/LU for each of the selected corridors. The internal cost categories considered in intermodal and road transport were:

Depreciation costs	[(€/year)/ (km or h/year)]* (km or h/LU) / loading factor = €/LU
Personnel costs	[(€/year)/ (h/year)]* (h/LU) / loading factor = €/LU
Consumption costs	[(€/l or kWh)/ (l or kWh/km)]* (km/LU) / loading factor = €/LU
Maintenance costs	[(€/year)/ (km or h/year)]* (km or h/LU) / loading factor = €/LU
Insurance costs	[(€/year)/ (km/year)]* (km/LU) / loading factor = €/LU
Tolls and charges costs	€/LU/ loading factor = €/LU

Third party services [(€/year)/ (LU/year) * # required = €/LU

Other costs €/LU or €/LU/ loading unit = €/LU

A study carried out by the Flanders Institute for Logistics (Vil, 2006), highlighted which were the cost components in the total logistics cost. The categories considered are transport costs, loading/unloading costs, transport time, inventory costs, internal company costs and qualitative attributes.

When considering the transport costs, named "out of pocket costs", the cost items were divided according to each mode of transport, thus for road, inland navigation and rail transport. Regardless the mode of transport some key cost items were listed: energy, maintenance and repair, depreciation, personnel costs, insurance of the vehicle, liability, other direct costs for the vehicle, additional management costs.

In the Vlaams Vrachtmodel (2009), a cost analysis for the different components of each single mode of transport has been carried out. As it can be seen in table 2.2, the work considered just the transport costs and the costs related to loading/unloading activities. For each mode of transport the following costs were included: loading/unloading, wages, energy costs, taxes, depreciation and interests, repair and maintenance, tolls, other costs.

The outcomes of the study were expressed in €/h, €/km and €/ton. Several scenarios for each mode of transport were presented. For road the analysis of the costs was developed for three truck types: Ecocombi, Heavy trucks and Light trucks.

For rail transport three production schemes are applied: Combined transport, Single wagon load and Block trains. Finally six different ship types are analysed for inland navigation, from 300 to 9000 tons.

Tab. 2.2: Out of pocket cost components

SOURCE	COST FUNCTION	COMPONENTS
BOARDMAN, B. ET ALL, 1999	Total transport cost	Drayage, initial transfer, transport, inventory carrying cost.
RECORDIT, 2001	Internal cost	Personnel, fixed asset/maintenance asset,

		energy, stock turn, time, organization costs, insurance/taxes/charges, costs with external and internal parts, external costs.
BLAUWENS ET AL, 2006	Transport cost	Interest and depreciation, insurance, taxes, driver wage, fuel, maintenance and repair, tyres, other costs.
VIL, 2006	Total logistics cost	Transport costs, Loading/unloading costs, time, stock costs, company costs, quality attributes
VLAAMS VRACHTMODEL 2009	Total transport cost	transport cost, loading/unloading costs

Source: own elaboration based on different sources

As a matter of fact the two main categories of cost are the transport cost and the transhipment cost.

According to the literature review, the cost items that appear to be always present in the cost structure of a company, for what concerns transport and logistics, are listed below.

Transport Costs

- Personnel,
- Energy and other consumption material,
- Insurance,
- Repair and Maintenance,
- Taxes and charges,
- Administration costs,
- Depreciation and interest /Renting/leasing,
- Other costs.

Transhipment Costs

- Loading/unloading cargo.

A further elaboration on each of the afore-mentioned costs is necessary, inasmuch as each of them is estimated in a different way, influenced by different drivers and affecting the final cost differently. A detailed description of each of these cost items will be provided further in the text.

2.5 Qualitative attributes

As already stated earlier qualitative attributes, together with pure costs, affect mode choice. It is relevant, though, to investigate also these aspects, following this analysis the review of elements affecting mode choice will be complete.

In this paragraph a description of the Stated Preference technique, here hence SP, and how has been applied in previous research about freight transport mode choice will be presented.

The reason of deepening the analysis on these methods is related to their broad use in investigating qualitative attributes in mode choice and the related willingness to pay.

The purpose is twofold, first to give an overview of the theoretical framework and also to present the academic researches or studies that applied SP as technique to investigate the relevance of attributes in the selection of modes of transports.

2.5.1 SP and its applications

The decision makers could face better the consequences of their decision if they could have an insight on the elements affecting travel behaviour, to this purpose forecasts and estimations are carried out for this purpose. The undeniable utility of forecasts is, in some cases, limited by the lack of good quality data.

The traditional approach was the use of Revealed Preferences, (RP) that allow having data and information related to the real situations or choices taken from respondents, those choices are the ones the respondents are actually facing, reflecting a real situation.

Such approach encounters several problems in relation to freight transport, for the complexity in collecting enough data and also for the difficulty in making researches about real situations.

To overcome those problems SP techniques can be a good alternative.

SP techniques refer to a number of different approaches that use people's statements on how they would respond to different situations. The most widely used are referred as "conjoint analysis". SP allows "creating" decision makers choices even in un-real situations. This aspect can be of a certain utility when making analysis on possible transport interventions, as such as transport infrastructure or new services.

SP is based on the classic economic theory of individual behaviour and on the assumption that the choice maker is taking rational decisions, whom final aim is to maximize his/her utility function. SP is based on random utility function that is found on the individual behaviour when facing a choice among a discrete number of options. The basic idea is that the decision maker, among a choice set, could rationally select the one that can give him/her the maximum utility among the alternatives that he/she has. The utility represents the satisfaction or a benefit that a person perceives when spending his/her resources on different things.

The utility is composed by two parts: a deterministic and a stochastic part, as presented in 2.9.

The utility U_{in} is the utility for a certain alternative *i* for *n* person.

$$U_{in} = V_{in} + \varepsilon_{in} \qquad (2.9)$$

Where:

V_{in} = is the deterministic part of the utility, and it is a function of the alternative's attributes

ε_{in} = is the stochastic component, different for each person and named as random utility (Error term).

The ε_{in} describes the deviation of each person from the average value given to V_{in}; it can be due to errors caused by the researcher, variables missing or other individual variables affecting the choice that can not be identified. Considering the fact that is not possible to obtain a utility function for the stochastic part, what is considered is the probability distribution.

Different models are used for investigating random utility functions, the differentiation among them is related to the probability distribution of the error term. Very well know are: Logit models, Probit models, Multinomial Logit models; among those the most popular and widely available is the Logit one.

It is important to highlight that the design of a SP exercise is rather complex and needs a validation process before actually implementing the exercise with a field survey.

Among the aspects that can be chosen for constructing the exercise there are: number and type of attributes and levels, the type of design, the sample size, the model for the estimation and the software for the implementation and analysis.

In particular the design's selection can be carried out among three choices: rating, ranking or choice of the alternatives suggested; a careful construction of the SP exercise is very much related to the aim of the study and the topic that the researcher wants to investigate.

SP is therefore differing from RP in relation to the "space" in which the decision is taken: in RP the decision maker is acting in real situation, in SP he/she is deciding about an hypothetical situation.

According to the literature that dealt with SP in freight transport, advantages and pitfalls can be recognised for this approach.

In relation to the hypothetical situation where the choices are taken it is possible to outline advantages:

- test new services or products
- perceive demand's characteristics also for non yet existing products
- have a wide group of alternatives, not present in the real market
- possibility to measure the trade-off between attributes
- obtain multiple answers from the same respondent

- estimate utility functions for each respondent.

Moreover the respondent can be asked to express his/her preference in relation to several hypothetical situations, providing additional information through the same interview.

The fact that the respondent is deciding about non-real situations can also be considered as a negative aspect creating some deviation from the truth. Among those:

- difficult to estimate hypothetical situation, trying not to consider the real facts
- just few attributes can be considered
- “fatigue” effect
- the interviewed can adapt his/her answers in relation to possible expected interventions.

According to what has been said about SP, it seems to be a valuable alternative to RP studies and the results summarized earlier can be presented as an evidence of methodological validity.

2.5.2 Literature review on RP and SP applied on freight transport

In this paragraph some of the main studies dealing with RP and SP technique applied to freight transport will be presented.

The literature on the topic is rather wide, due to this, only the contributions considered of major interest for the present work will be presented.

The selection of the papers has been developed according to the methodology used and the geographical connection with the present study.

Hereon a brief explanation of the selected papers is provided.

One of the first studies on the value of time was provided by a research of Blauwens and Van De Voorde, (1988) they used a revealed preference exercise to investigate the preferences of shippers moving goods from 43 areas in Belgium to the port of Ghent.

Their model was based on time and cost factors and it was applied to the specific case of road and inland navigation competition. The investigation brought them to conclude that shippers gave a value of .0000848 times the value of the goods for one hour saving of travel time.

In Maier et al. (2002) the application of a SP exercise on the behavioural decisions of logistics managers of producing company in Austria has been presented. The paper, aiming at capturing the preferences of the operators towards the options offered by the Austrian transport network, was showing that the most valued criterion was the reliability of the service, therefore the interviewed people were more willing to pay additional money to increase the reliability than for other improvements.

Bolis and Maggi (1999, 2003) analysed the logistics strategies and transport services choice for the Trans-Alpine area interviewing 22 logistics managers of production companies. The purpose of the paper was to investigate the parameters influencing those shippers in the choice of freight transport services. They conducted 22 interviews, obtaining 31 experiments using Leeds Adaptive SP, and the estimations allowed them to obtain monetary values for time, reliability, flexibility and frequency. The higher willingness to pay was to obtain more reliable services. In particular the results of the work showed that, the predominant use of road transport was caused by restrictions and poor rail service quality, rather than a mode-specific preference.

Zotti and Danielis, (2003) explored the mechanics' sector in Friuli Venezia Giulia, a North-East Italian region trying to investigated the preference of the shippers towards road and intermodal transport. They interviewed 30 companies, those companies expressed their preference for intermodal transport in terms of cost, while road transport was considered better in relation to time, minor number of possible damages or loss and flexibility.

The same author, Danielis, (2006) in other works focused on the same topic applied to different production sectors and geographical areas in Italy. Different SP designs were applied, rating and choice among alternatives, concluding that the outcomes of the researches were strictly related to the production sector and the commodity shipped.

Beuthe and Bouffioux (2005), tried to capture the relevance of qualitative attributes for freight shippers in Belgium, in relation to cost, time, frequency, flexibility, reliability and possibility to have damages or losses. Out of 113 SP interviews the authors were able to extract the value that the sample gave to qualitative attributes, thought some monetary values. Different results were presented, according to the value of the goods, the distance, the mode of transport, the loading unit and other characteristics. One of the main conclusions that the authors could drawn was related to the importance that shippers gave to qualitative attributes, this element was considered to weight for 36% in average on the final decision.

Some interesting results were presented in a study from Rudel (2005) that analyses the Switzerland market for medium and large food and wholesale producer and their preferences towards qualitative attributes.

Through a choice based exercise the companies were asked to express their opinion abut 4 attributes: price, travel time, punctuality and possible risk of damages and loss. Out of these interviews, the avoidance of damages and loss and the willingness to increase the punctuality were the qualities that they were more willing to pay for.

The work of Bergantino and Bolis (2005) focused on the ro-ro services related to short sea shipping in the North-West of Italy. The methodology comprised a first phase, which was of a RP interviews and a second step, when the SP exercise was performed. The sample interviewed was composed by logistics operators and freight forwarders, dealing with maritime services and especially using the Port of Genoa for their traffics. What appeared from their work was that the operators did not have any prejudice in using short sea shipping instead of road transport, nonetheless a key role was played by the frequency of the services, more than reliability or price.

A good part of the scientific production of De Jong (2004a, 2009) is dedicate to the value of time and value of reliability. His applications were mainly on The Netherlands, but also investigations in Sweden took place in the last years. Through his investigations the author was able to provide values for each modes of transport and also in relation to different type of goods, as such as row materials or final products. He also compared the finding of his own works with the results of similar studies applied in different countries.

Two recent works have been focusing on the role of intermodal transport in Brazil and Turkey, respectively from Gonçalves, D'agosto (2010) and Kofteci and others (2010). In both studies shippers preferences were investigated with the aim of obtaining insights on the scarce use of intermodal transport compared to road. While in the case of Brazil, the attribute that played a key role were the logistical cost, in the case of the Turkish regions is suggested to focus more on the reliability of intermodal transport in order to obtain an increase of it in the modal share.

Tab. 2.3: Literature on RP and SP applied to freight transport

Authors	***year***	***topic***	***sector***	***attributes***	***methodology***	***software***	***sample number***	***Model***	***Design***
Shinghal, N., Fowkes, T.	2002	The Leeds adaptive stated preferences methodology	Mode choice freight services in India	4: cost, transit time, reliability, frequency	Adaptive stated preference	LASP	32	Logit	
Danielis, Bolis	2002	Domanda di trasporto merci in Friuli Venezia Giulia	freight transport attributes		Ci3, ACA	Sawtooth			
Bolis, Maggi	1999/2003	Logistics strategy and transport service choices an adaptive stated preference experiment	logistics managers in shipping companies	6: price, time, reliability, frequency, flexibility, mode	Adaptive stated preference	LASP	22 (31 asp)	Tobit ML	rating
Tweddle, Fowkes, Nash	1996	Impact of the channel tunnel: a survey of Anglo-European unitised freight					30		

Bergantino, Bolis	2005	La domanda di servizi short sea shipping un'indagine sulle preferenze di un campione di operatori della logistica dell'Italia nord-occidentale	ro-ro in sss logistics operators and freight forwarders interviewed in nord ovest, Genova	4: price, time, reliability, frequency	ASP		18 initial, 7 SP	Tobit	rating 0-200
Danielis, Rotaris	1999	Analysing freight demand using stated preference data: a survey and a research project for the Friuli-Venezia Giulia region	literature on previous work on SP						
Maier, Bergman	2002	Modelling preferences and stability among transport alternatives	analysis on mode selection in Austria with shippers	6:cost, time, reliability, frequency, flexibility, modes of transport			98	Logit	choice

Fowekes, Nash, Tweddle	1991	Investigating the market for intermodal freight technologies	estimation introduction of new technologies intermodal in UK in 1988/89 different commodities	cost, reliability, speed, use of intermodal modes		LASP	50	Logit	rating
Bergantino, Bolis	2005	An adaptive analysis of freight service alternatives: evaluating the maritime option	freight forwarders interested in sss in area Milano Parma Genoa	4: cost, reliability, time, frequency	Adaptive stated preference	Tobit ML estimator	5 40 observations	Logit binary	rating 0-200
Zotti, Danielis	2003	Freight transport demand in the mechanics' sector of Friuli Venezia Giulia: the choice between intermodal and road transport	shippers of mechanics' sector of Friuli Venezia Giulia	6:cost,reliability, time, frequency, mode of transport, loss or damage, flexibility			30 companies	mixed logit, latent class	rating
Danielis, Marcucci, Rotaris	2005	Logistics managers' stated	shippers of Friuli Venezia	4: cost, reliability, time, loss or damage	Adaptive conjoint analysis	Sawtooth	65 companies, 93	probit	rating

		preferences for freight service attributes	Giulia and Marche				observations		
Rudel	2005	Evaluation of quality attributes in the freight transport market. Stated preference experiments in Switzerland	shippers of food and wholesale in Switzerland	4: cost, punctuality, time, loss or damage		Sawtooth	35 companies, 66 experiments	binomial logit	choice
Danielis, Marcucci	2006	Trasporto stradale o intermodale ferroviario? I risultati di un'indagine sulla struttura delle preferenze di alcune aziende manifatturiere italiane	shippers of different sectors in Friulia Venezia Giulia, Marche, Lazio	7:cost,punctuality, time, loss or damage, mode, frequency, flexibility		Sawtooth	95 companies, 1425 experiments	logit	choice

Marcucci, Scaccia	2004	Mode choice models with attribute cut-offs analysis: the case of freight transport in the Marche region	shippers of metallurgy and furniture sectors in Marche	7:cost,punctuality, time, loss or damage, mode, frequency, flexibility		Sawtooth	51 companies, 2295 experiments	multinomial logit	choice
De Jong	2004	New Values of time and reliability in freight transportation in The Netherlands	shippers in The Netherlands	5:cost,time,loss or damage, reliability, frequency,		WinMint	435?	mixed logit,	choice
De Jong	2009	The value of time and reliability	shippers in The Netherlands	4:cost,time,reliability,arrival time				Alogit model	
Fowkes, Tweddle	1987	A computer guided stated preference experiment for freight mode choice	shippers in UK	2: cost, reliability		Sas	6	logit	rating
Blauwens, Van de Voorde	1988	The valuation of time saving in commodity transport	shippers in Belgium to Ghent comparison between road and	2: cost, time	RP				

			iww						
Beuthe, Bouffioux	2005	Analyzing freight transport's qualitative attributes from stated orders of preference	shippers in Belgium with at least 20 employees	7:cost,reliability, time, loss or damage, mode, frequency, flexibility			113	logit	ranking
Gonçalves, D'agosto	2010	Intermodal decision making in Brazil	intermodal transport in Brazil	3:modal tendency, logistics costs, service level	sensitivity analysis with results trade off	LMPC software	25	binomial logit	choice
Kofteci, Ergun, Ay	2010	Modelling freight transportation preferences: Conjoint analysis for Turkish region	intermodal transport in Turkey	4:cost,reliability, time, loss or damage, mode	ACA	Sawtooth and SPSS	50	multinomial logit	rating 7 levels

Source: own elaboration based on different sources

2.6 The role of external costs

External costs have not been mentioned as important elements considered in mode choice, just one paper considered those costs, although as not so important. Nonetheless external costs can be considered as additional factor that could possibly influence the mode choice.

The reason of neglecting these costs could be due to the fact that they are becoming more “popular” in the last years, or that they are not actually considered as an important variable that can influence the mode choice.

The reason why it is not possible, anymore, to ditch them, is that their importance is becoming more and more important on a welfare level.

The reason for dealing with external cost and their internalization underpin on the social urgency to tackle an unbearable situation caused by air pollution, greenhouses emissions, congestion and so on. The general governmental tendency is to put attention on this issue and to find out measures that could reduce the impact of external costs on the society, as it is stated in the latest White Paper (2011).

A possible internalization of external cost will not entirely solve the problem, but could help in create a more sustainable environment. In addition, the internalization will follow the “use-pay” and “pollute-pay” principle, this will help in gathering a better awareness of each one action’ consequences.

2.6.1 Definitions and need for internalization

The concept of externalities is not new in economics, the first definition was suggested by Pigou (1932) in his “Economics of Welfare”. The author did not use the word “externality”, but he was rather referring to “divergence between social and private product”. According to Pigou:

"Here the essence of the matter is that one person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices to other persons (not producers of like services), of such a sort that payment cannot be extracted from the benefited parties or compensation enforced on behalf of the injured parties." (1932, Page 183).

The definition given by Pigou is still a milestone in defining what a positive/negative externality is. Externalities are costs or benefits, not paid by the person that produces them. More precisely, in transport economics, it is the positive or negative transport activity consequence; the person that is benefiting or suffering the consequences of such transport activity is not paying or receiving any monetary compensation. The concept of externalities is strictly related to social costs and social benefits.

Social costs are composed of internal costs and external costs, the former are related to the monetary costs that need to be paid for obtaining a transport operation and are easily identifiable through monetary values. Internal costs are the consequence of market negotiations among the economic actors.

External costs are not straightforward and their value is not settled within market rules.

The same holds for social benefits, which consist of internal and external benefits. Some examples of internal benefits could be the transport companies' revenues or the added value of using transport services; on the other hand, external benefits related to transport activities are the real estate value increases or the development of further connections among regions or areas.

More recently, with the Handbook on estimation of external costs in the transport sector, (IMPACT 2008) a further research has been established for capturing the different approaches and estimations of external costs. The definition that the authors use in their study is the following:

"External costs are costs to society and - without policy intervention - they are not taken into account by the transport users. Transport users are thus faced with incorrect incentives for transport supply and demand, leading to welfare losses. "

From the two sources mentioned above, it is clear that there is a disparity between the price that the transport users are currently paying for the transport infrastructure use, and what actually they should pay from a welfare point of view. The tendency to put attention on the external costs and to its possible internalization is more and more popular and the pressure for intervention is coming from the European Commission and from the national transport Ministries. The main reason of such interest is justifiable by the urgent need to reduce environmental impacts in order to improve human's life quality. Most of the consequences of neglecting environmental impacts approach are reflected in every day life with an increase of health problems.

Furthermore, in transport economics, the internalization of externalities for each transport mode, could lead to a different modal split, thus to a reduction of market distort competition.

Although the possible monetary estimations are many and the real applications still confused, the need for intervention is real, and some measures have been already taken on a European level.

In 1993 the first EU Directive, (Council Directive 93/89/EEC, 1993) was issued, enabling countries to introduce tolls on motorways to finance the cost of infrastructure corrosion caused by Heavy Good Vehicles (HGVs).

The first European document dealing specifically with this topic was the Green Paper "Towards Fair and Efficient Pricing in Transport" in 1995. (European Commission, 1995)

The basic argument was that many elements of cost such as congestion, accidents, environmental and infrastructure maintenance were not reflected at all in current prices or were reflected only in part. Nonetheless its relevance, the document did not set out a clear programme of action.

In the 1999 the directive on the charging of HGVs in the EU (Eurovignette Directive, Directive 1999/62/EC) was published, it was stated that it would "*encourage member states to introduce and develop tolls and charges which will make it possible to improve the management of commercial freight traffic, reduce pollution and generate funds for investment in new infrastructure*". The latest Eurovignette Directive was issued in 2006 (Directive 2006/38/EC) allowing the toll to be applied to large HGVs from 2012. Recently, the Greening Transport Package (2008) was published. It aims at reducing pollution, noise and congestion caused by HGVs through making all transport users pay for the negative impacts they cause. A key element of the package was a proposal to amend the Eurovignette Directive by removing the current prohibition of 'external cost charging'.

An additional legislation dealing with Information Tecnology, is the Directive 2004/52/EC that provides a framework for the interoperability of toll collection systems within the EU.

The new White Paper "Roadmap to a single European transport area- towards a competitive and resource efficient transport system" continues in line with the previous White Paper and endorses the relevance of sustainability as a key element in European transport policy.

The main focus is put on the greenhouses gas emissions and to the reduction target to be achieved in 2050. The goal is to reduce of at least 60% of GHGs by 2050 with respect to 1990 in the whole transport sector. The tendency in Europe would be to use less and cleaner energy, a better exploitation of the infrastructure and to reduce negative impact on the environment.

For the long distances large volumes are required and multimodal solutions, relying on inland waterways and rail, need to be implemented.

It is underlined that "Efficient co-modality is needed. The EU needs specially developed freight corridors optimised in terms of energy use and emissions, minimising environmental impacts, but also attractive for their reliability, limited congestion and low operating and administrative costs."

For each mode of transport specific measures are present, such as the renewal of the European rolling stock or a gradual automatic coupling system. Seaports should invest in efficient hinterland connections and inland waterways are having potentialities to become more competitive on linking European seas.

In general, the European Commission aims at obtaining a shift of the 30% of the current road freight traffic over 300 km, to other modes by 2030. The target will be 50% by 2050.

Among the other measures that will be put in action, the "polluter-pays" principle will be applied. This means that Commission will develop guidelines and a common approach for the internalization of external costs.

2.6.2 Description of external costs, problems in estimation and methodology for calculation

Before looking at the studies and researches that dealt with internalization of external costs and related methodologies, it is worth to state which the most common external costs are and to give a short overview of their meaning and characteristics. To do so, the main reference is the Handbook on estimation of external costs.

Congestion costs

Congestion costs arise from the mutual disturbance of users competing for limited transport system capacity. Depending on several technical and geographical aspects there can be consequences such as: the increase of travel time, a different approach towards vehicle provision and operating costs, dis-amenities in crowded systems, additional fuel costs and the decrease in reliability.

Congestion costs consist of internal and external components. Internal or private congestion costs are those increasing time and operating costs experienced by an operator when approaching or exceeding system capacity. External congestion costs are those costs experienced by all other system users due to the entrance of this operator into the system. External congestion costs are commonly not taken into account by transport users and decrease social welfare.

Accident costs

External accident costs are those social costs of traffic accidents which are not covered by risk oriented insurance premiums. Therefore the level of external costs does not only depend on the level of accidents, but also on the insurance system.

The main accident are material damages, administrative costs, medical costs, production losses and the so called risk-value as a proxy to estimate pain, grief and suffering caused by traffic accidents in monetary values.

Air pollution costs

Air pollution costs are caused by the emission of air pollutants such as particulate matter (PM), NO_x, SO_2 and VOC and consist of health costs, building/material damages, crop losses and costs for further damages for the ecosystem. Among the cost categories, the most important is health costs (mainly caused by PM, from exhaust emissions or transformation of other pollutants).

Noise costs

Noise can be defined as the unwanted sound or sounds of duration, intensity, or other quality that causes physiological or psychological harm to humans. It consists of costs for annoyance and health. The annoyance costs are usually economically based on preferences of individuals, whereas health costs are based on dose response figures. Since marginal noise costs decrease with increasing traffic volumes, the definition and measurement of costs is quite crucial.

Climate change costs

Climate change or global warming impacts of transport are mainly caused by emissions of the greenhouse gases carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). In the case of aviation also other aircraft emissions at high altitude have an impact on global warming.

Climate change costs are very complex to estimate, due to the fact that they are long term and global and that risk patterns are very difficult to anticipate.

To conclude other costs need to be taken into account such as up-down stream processes, soil and water pollution and nature and landscape pollution, some additional explanations will be presented later in the text.

In the Handbook on estimation of external costs a review on the approaches that have been followed for the analysis of external costs is presented. A first distinction is pointed out between a top-down and a bottom-up approach, while the former has been applied in the first studies, and provides an average external cost, the latter is argued to be better, more popular and provides the calculation of marginal external costs.

A second distinction is the one between resource approach and prevention approach, presented in INFRAS and IWW study (2000). The resource approach estimates damage costs which are defined as an opportunity cost for the society. The prevention methodology is used to estimate avoidance costs. According to the INFRAS and IWW study, the first one is preferred because it takes into consideration the real damage value.

In the framework of the ExternE (Externalities of Energy, 2005) project a new approach has been followed, that is the Impact Pathway Approach (IPA), bottom-up approach for quantifying the emissions of energy.

Currently the Impact Pathway Approach is stated to be the best available method for the calculation of external costs of air pollution due to transport. The Impact Pathway Approach is used to estimate damage costs, based on the resource approach. The approach consists of four steps: emission modelling, dispersion modelling, quantifying impacts and economic valuation.

Some other approaches are based on different methodologies. For each type of external costs the method for the collection and calculation of external costs is different and even within the same cost category the methodologies can be different and lead to different results. It is therefore hard to state which is the best methodology to apply for the calculation. Therefore the results obtained by the calculations are very much method dependent and also vary according to the different situations or areas where the studies are carried out.

It seems prevailing the calculation and internalization thought marginal social costs, but still different ways of calculations are possible.

In the next session a relevant selection of literature about external costs internalization is presented in order to give an overview of the methodologies applied and the external costs included most.

2.6.3 Literature review on estimation methodologies and available tools for calculation

The literature for the estimation of external costs is rather rich, even if the question about the internalization of external costs exists only since 30 years. Recently the social problems related to environmental pollution, transport accidents and congestions are becoming more and more topical, and both from the public sector and from private citizens a need for intervention is felt.

For the purpose of this thesis a review of the most relevant researches will be analysed in detail, nonetheless it is not the core purpose of this work to report on the entire existing literature related to this topic. In order to limit the literature review to the most update and relevant research about internalization of external costs, the analysis will consider papers, documents or projects that have been elaborated and published during the last ten years.

An extensive selection of works dealing with external costs in transport has been produced by Danielis and Rotaris (2001). In their work they considered papers from 1980s to 1990s, both in the U.S.A. and in Europe. Each external cost has been considered and analysed in relation to the methodologies applied for the calculation and estimation, with a critical perspective aiming at identifying the possible methodological problems, in which the scientists may occur. Particular attention has been drown to the Italian case and the different existing monetary values obtained for each external cost.

The work carried out by Forkenbrock (2001) presented the results of a comparison between internal and external costs for road and rail transport. The research took place in the U.S.A. and considered general freight trucks and different typologies of freight trains operating in urban areas. Internal costs were the sum of accidents costs, air pollution costs, greenhouse and noise costs. The comparison of the external costs produced by each mode is in favour of rail transport, with a substantial difference, 0.24 $/ton/mile compared to 0.86 $/ton/mile in the case of road transport.

The European Project Recordit in 2001, considered not only internal costs, but also external costs including air pollution, accidents, delay and congestion and noise costs. Those externalities have been calculated for all the modes of transport and compared among them for three corridors.

A calculation of the total generalized cost of transport applied to the Belgian area has been produced by Beuthe et al. in 2002. In their study, the authors consider the Belgian multimodal freight network and for the cost calculation the Nodus network model has been applied. The external costs included in the calculations were: congestion, accidents, noise pollution and air pollution. For each cost item a specific methodology for the calculation of the exact values has been applied based on the previous findings on the topic.

In the work of Bickel et al. (2006) the authors considered several results and methodologies for the measurement and evaluation of environmental costs. They developed their study based on the marginal external costs in transport, and focus on air pollution, greenhouse emissions and noise pollution. Their findings were going towards the direction of a bottom-up approach, taking into consideration that vehicle types, time of the day and road were notably influencing the cost and price determination of transport.

On a European level an important contribution to the topic was given by the European project Grace (2008). The project focused on the implementation of pricing and taxation schemes that reflect the costs of infrastructure use with the aims of supporting policy makers to develop measures leading to obtain sustainable transport systems.

The methodology followed was the measurement of marginal social costs for all modes of transport in order to asses the impacts of cost pricing. Based on these studies, a number of policy recommendations have been produced with the aim of assisting policy makers in implementing more efficient pricing policies.

Cantillo and Marquez (2010), made a study for the internalization of external costs applied to the Colombian intercity intermodal network. Their work was considering both internal and external costs for selected corridors and commodities, with the final aim of comparing different modes of transport in relation to their total costs. They used a freight transport model, run for a zoning system of 70 internal and 8 external areas, with 34 groups of products considered. A calculation of the internal costs was developed together with the evaluation of time. Subsequently also the calculation of external costs was performed in relation to noise, accidents and some environmental aspects, such as air pollution and climate changes. The results of the research brought the authors to assert that, for that specific application, the average external costs for road transport were firmly above the inland waterways ones, and also bigger than rail external costs.

Recently the interest in internalization of external costs and the possible consequences for transport pricing and modal shift has been manifested through a study carried out by the European Commission (Impact of proposal for amending directive 1999/62/EC on road infrastructure charging, 2010). The aim of the research was to asses the possible results of external costs internalization on some selected corridors in Europe. The study was carried out in order to provide a general and comprehensive overview of the possible results of internalization of external costs, and the related impact of a possible directive on road haulers and society. For the selected six corridors, several aspects have been taken into considerations, such as route choices, time schedule, loading capacity, the maximum charges applicable an the calculation of air pollution, noise and congestion costs. The exercise allowed performing the calculation for specific areas and distances and to elaborate final considerations about users and large society benefits.

An extended literature review about projects and papers that dealt with the topic of external costs was presented in the already mentioned Handbook on estimation of external costs in the transport sector, where for each type of external costs a detailed list and description is reported.

In the last part of this paragraph some calculation tools that have been implemented on a European level for the purpose of calculating external costs will be presented.

In the framework of the Realise project, the tool for the calculation of external costs included costs for air pollution, noise, accidents, congestion and global warming. The tool used an excel application. The inserted inputs were related to the mode of transport, either uni-modal road transport or multimodal solutions, to the TEU, the kilometers covered and the number of segment for each mode of transport.

Tremove, is a tool developed by the university of Leuven, in Belgium, which purpose was to provide information and values for fuel consumption and exhaust and evaporative emissions for all modes. The tool, developed in 2007, is a model for the assessment of transport and environmental actions in the transport sector. It also estimates modal split, vehicle stock turnover and makes an analysis on welfare level related to different transport policy scenario.

Some applications, using the Handbook on estimation of external costs in the transport sector, have been performed. Namely in the work of Fridell et al. (2009), a tool named TrExTool has been developed with the aim of including external costs for noise, congestion, accidents and greenhouse values for all modes of transport.

On the basis of the literature analysis, it is clear that the internalization of external costs is a fundamental aspect in freight transport, and this element can not be neglected. The benefit that the entire society could gain from such intervention could be both direct, to transport users, and indirect to the society as a whole.

Some direct consequences could be related to the optimization of route choice or trip scheduling in order to avoid congestion, there could be an increase in transport operation efficiency related to the loading capacity of the vehicles, and furthermore a possible re-equilibrium of the modal split could take place.

From a welfare point of view, the benefits could be identified in a reduction of fuel consumption, a better time management that could lead to time saving and a possible improvement of transport and delivery reliability.

2.7 Chapter's summary

As stated earlier in the text, among the objectives of this chapter, there was the intention of presenting the main literature that contributed in different ways to the development of the present research, to this extent has been possible to observe which have been the main papers, works, studies that dealt with the general concept of intermodal competitiveness and generalized cost, with the calculation of out of pocket costs in transport, and with the appraisal and definition of qualitative attributes and external costs.

What was possible to learn from the literature review is related both to technical, operational and organizational problems that intermodal transport is facing, but also with the elements that influence its development and use, hence elements that could hamper its improvement or spread. Namely, the author is referring to the costs elements that have been found out as important determinants in mode choice, as previous work attested.

The perusal of the literature review therefore guided the author in addressing topics and matters that have not yet been considered earlier, namely referring to the use of generalized cost as an approach to investigate the elements that hinder the efficient development of intermodal transport and its competitiveness in respect to other modes of transport.

In doing so several components will be touched, as such as out of pocket costs, qualitative variables and also the effects of an internalization of external costs were added to the investigation.

The literature review is moreover a starting point in the research process, as well as litmus test for the forthcoming results.

Chapter III, starting form the knowledge acquired in the previous chapters, will help the reader in understanding in detail which methodological steps have been followed and how the thesis' framework has been constructed.

CHAPTER III

ANALYSIS OF INTERMODAL TRANSPORT CHOICE WITH THE GENERALIZED COST APPROACH: APPLIED METHODOLOGY

The references presented in the previous chapter are the starting point for the elaboration of the methodology that will follow.

Chapter III contains the methodology that has been applied in the present thesis. The fundamental concept on which the methodology has been based is the generalized cost function. The application of it, for each single mode of transport and intermodality, will be further detailed.

The previous chapter was the starting point for the elaboration of the present methodology, since the findings of previous works can constitute the base from which begin the current research.

From this the author stated her own methodological approach, which is composed by several steps and analysis in order to obtain the generalized cost for the considered cases.

The work is therefore mainly composed by the analysis of the out of pocket costs, with a perusal of each cost item, the analysis of the market structure and profit characteristics, the investigation of the qualitative elements affecting mode choice and, to conclude, the hypothesis of internalization of external costs and the related policy considerations.

The present chapter will therefore enter in detail in explaining the procedures followed in each part of the work.

3.1 Generalized cost function approach and application

The concept of generalized cost has been earlier clarified in the text; the empirical exercise will be on freight transport in Europe, namely on some European freight corridors from the port of Antwerp and the port of Genoa.

The basic methodology that has been followed is based on the careful examinations of the quantitative and qualitative costs that compose the cost function. **The analysis of each cost component and the influence that it has on the total cost can facilitate in comprehending critical elements that constitute a barrier for intermodal transport.** Once having clarified these aspects it would be easier to act upon the criticalities and improve uni-modal and intermodal performances.

In order to do so, the work has been threefold: the first part of the work considers the out of pocket cost that a transport provider has, the tangible costs that he/she has to face on an every day bases.

In the second part, the additional variables considered in the generalized cost functions are the qualitative elements that influence mode choice, that are nonetheless not measurable in monetary terms.

This part has been investigated with the support of personal interviews with shippers and freight forwarders. To complete the analysis, a qualitative approach, based on previous results on values of time, will follow.

The third part takes into consideration and puts particular attention on environmental concerns, with the development of external cost internalization's.

3.2 Analysis of out of pocket costs: description of calculation tool

According to existing literature on mode choice it appeared clear that, among the other criteria, cost remains one of the main elements considered by the decision taker.

It is unquestionable that the economic profitability of a company is strictly related to the expenses that it has to undertake, and in order to obtain a satisfactory performance, costs need to be minimized.

With this prospective also transport costs need to be investigated so as to understand their structure and possible ways to minimize them.

It is worth mentioning that the money that the shipper or the freight forwarder pays to the service provider is the price of the service.

The price is composed by the costs that the transport operator has to support, plus a mark up.

Is important to bear in mind that a margin profit has to be added to the cost of the service; such mark up can vary among companies, according to the market structure and to exogenous variables. A more detailed focus on this part will be presented further in the text.

The final price offered to the client is based on the cost for providing the service plus the profit of the supplier. In order to understand which are the costs that affect most the final price and that can eventually constitute a criticality for the competitiveness of intermodal transport, a detailed analysis of these costs has been carried out.

A list of relevant cost items considered in transport and a detailed description for each of them has been developed here. Those cost items will be inserted in the cost functions for each mode of transport. The final purpose will be to compare the out of pocket costs for each mode of transport on the specified corridors in order to obtain a ranking in preference according to the pure monetary costs.

All the cost variables are calculated according either to the distance covered and/or to the time spent for the transport operations, thus the measurements are mainly in Euro per kilometre, €/km, or in Euro per hour, €/h. This distinction has been already illustrated earlier in the dissertation and refers to the related literature (Blauwens, et al., 2008).

Other costs are fixed and consequently not linked to any distance covered or time passed, thus considered ah hoc, for instance the ones linked to a specific route or area.

The methodology used, for most of the cost items considered, was based on the yearly amount spent for that specific item, from this figure it was possible to obtain hourly or kilometre cost based on the annual numbers of hours worked and kilometres covered.

For other cost figures, such as tolls, the cost figure was obtained by the actual expenses based on the specific route covered.

The cost categories can be divided in two groups: transport costs and transhipment costs.

Transport costs can be classified into:

- Personnel,
- Energy and other consumption material,
- Insurance,
- Repair and Maintenance,
- Taxes and charges,
- Overhead costs,
- Depreciation and interest /renting/leasing,
- Fixed costs (tolls),
- Other costs (such as extraordinary operational expenses, etc.)

With transhipment costs are identified:

- Loading/unloading activities,
- Shunting activities costs.

As appeared already clear from the first chapter the stakeholders involved in the transport chain are numerous. Among the others, in this thesis, several of them have been involved with different purposes.

Transport operators, road, rail, inland navigation and intermodal ones, have been interviewed in order to gather information on their cost structure and figures, moreover the analyses of the out of pocket costs will be carried out from their point of view, namely they are the ones bearing these costs. Their contribution was also crucial in defining which types of services were supplied on the corridors analyzed.

Other stakeholders involved in the present study are the shippers of the freight, who actually produce the goods, and the freight forwarders, that are the ones taking care of the shipment on behalf of the shipper or receiver. The contribution that they could gave to this work has been mainly the information about their structure, preference and mode choice gained through the interviews carried out.

The method for the calculation will be presented further. A short description for each of the cost items will be provided, together with the main parameters that need to be taken into account.

Transport costs

3.2.1 Personnel costs

Personnel costs refer to the costs that the company has to pay for the employment of the people that run the service and drive the vehicles.

Personnel costs represent one of the main cost items; the people employed in a transport company do not include just drivers or operational categories abut also administrative and managerial divisions.

The elements that need to be taken into account are the number of people employed, their wage and the additional costs due to social security; all these cost items need to be transformed into their average amount of working hours in a year. In the present work the measurement is expressed in €/h.

Personnel costs:

[(Net yearly wage + Yearly costs for social security)/ number of operative hours in a year] * Number of people employed for the transport operation(>1) * Number of driving hours for the specific journey (1 trip)

3.2.2 Energy costs

The cost for fuel or energy is also a very important cost item, and it is the consumption of energy for the production of the service. It can be related to the diesel or gasoline consumption for road, inland navigation and rail transport, or electric power in rail or combined transport.

Fuel consumption or energy usage is affected by the market price of the material. A consideration about the average consumption per kilometre is required in order to obtain the real energy consumption for the kilometres covered.

The measurement of the energy consumption is expressed in €/Km.

Energy costs (Fuel):

[(Energy price per litre * average consumption in litre per km)]* Number of kilometres for the specific journey

Energy costs (Electric power):

(Energy price per kilometre)* (Number of kilometres for the specific journey)

3.2.3 Insurance costs

For the vehicle's insurance cost the selection of the unit measurement is not straightforward. The cost is yearly spent and it is fixed according to specific characteristics of the vehicle. One can decide to consider the cost either per kilometre or per hour. In some cases the calculation is simply equally split in two parts. In this thesis the calculation is done for operative hours, €/h. The insurance cost reflects all the expenses related to the civil liability for the vehicle.

Insurance costs:

[(Yearly costs for insurance)/ (Number of operative hours in a year)]* Number of hours for the specific journey

3.2.4 Maintenance and Repair costs

It is considered that, in an operative year, there will be constant expenses related to the maintenance of the vehicles, while repair costs can occur also unexpectedly. The costs related to maintenance are the ones that occur periodically and related to the ordinary up keeping, repair costs may occur if the vehicle has accidents or damages that need to be fixed.

Maintenance and repair are costs related to the operative life of vehicles, thus they vary according to the age of the vehicle and the distance covered, the measurement is expressed in €/Km.

Maintenance and Repair costs:

[(Yearly costs for maintenance and repair)/ (Number of kilometres covered in a year)]* Number of kilometres for the specific journey

3.2.5 Depreciation/Renting/Leasing costs

A cost that all companies have to face is the one related to depreciation and interest, renting or leasing related to the vehicles and other physical asset. The distinction is in relation to the ownership of the asset. In case the asset belongs to the company, a depreciation rate is calculated according to the acquisition price and the interests that need to be paid. In case the assets do not belong to the company, a fixed amount has to be paid for the use of it. The way of calculation for the yearly depreciation or renting payment can vary from the different approaches used. Generally the measurement for these cost items is calculated in €/h.

Depreciation/Renting/Leasing costs:

[(Yearly costs for depreciation/rent/leasing)/ (Number of operative hours in a year)]* Number of hours for the specific journey

3.2.6 Fixed costs (tolls)

The company has to bear some fixed costs, such as tolls that are related to specific parameters, like access of tunnels or bridges, that do not relate to working hours of the company nor the total kilometres covered. They are fixed costs that the company has to bear in case of specific situations. For this thesis the cost item was inserted in the cost function using available tools that could give information on the considered cost item. Tolls are associated to ports, bridges, channels or roads.

3.2.7 Taxes/Charges costs

The cost associated to taxes and charges can differ very much, according to national regulations, areas of application, etc. There are specific taxes for the different modes of transport or for different areas or locations. It is quite difficult to determine the value of this element if not strictly related to a specific route. The calculation of costs associated to those expenses can be expressed in euro per hour or per kilometre, €/h or €/Km. In the specific case, €/h will be used.

Taxes/Charges costs:

[(Yearly costs *taxes/ charges*)/ (Number of kilometres covered in a year)]* Number of kilometres for the specific journey

3.2.8 Overhead costs

In addition to the costs strictly related to the service provided, there are overhead costs that the company has to bear. Overhead costs are fixed; they exist regardless of distance or hours of work. These costs represent an important cost item and comprise administrative costs together with costs for the daily operative work of the entire company. In this study, these costs are considered in €/h, according to company’s total working hours.

Overhead costs:

[(Yearly overhead costs)/ (Number of operative hours in a year)]* Number of hours for the specific journey

3.2.9 Other costs

As an additional element it is necessary to include other costs of different nature, that do not belong to any of the categories listed above and that can occur sporadically. For example expenses due to events that do not represent ordinary operational activities in the company. These costs can be calculated either in €/h or in €/Km.

Other costs:

[(Yearly other costs)/ (Number of operative hours in a year)]* Number of hours for the specific journey

There are also some specific cost items that are related to each mode of transport, such as the tyres cost in road transport or rail tracks in rail transport. Those cost items need to be calculated for the specific route where one of those modes is used.

3.2.10 Tyres, Rail Tracks costs

In the case of road transport the costs for tyres considers the acquisition price and their maintenance. Usually the cost is calculated per kilometres covered, €/Km. In rail transport, the company that runs a service has to pay the use of the rail infrastructure to the infrastructure operator. This is the rail tracks cost. The cost for using the infrastructure between two points and for a certain number of hours, is expressed in €/Km.

Tyres costs:

[(Yearly costs for acquisition and maintenance of a tyre)* (Number of tyres)]/ (Number of kilometres covered for life time)* Number of kilometres for the specific journey

Rail Tracks costs:

(Average cost for rail track)* Number of kilometres for the specific journey

Transhipment costs

3.2.11 Loading/Unloading costs

The second category of costs, included in the intermodal cost function, is the one related to transhipment operations. The operations considered are the ones of loading and unloading the loading unit from one mode of transport to another, from a mode of transport to the ground and then from the ground to the second mode of transport.

Loading and unloading costs are measured in relation to the movements needed to shift the loading unit. In most of the cases the terminal operator charges the cost for unit loaded/unloaded, the cost can change according to the typology of the loading unit; nonetheless the difference in cost does not vary substantially. (€/LU)

Thus an alternative way could be the measurement in terms of hours spent for the operations.

Loading/Unloading costs:

(€/LU)* Number of loading units

or

Loading/Unloading costs:

(Hourly cost for each loading/unloading operation)*Number of hours needed for the entire operation

3.2.12 Shunting operations costs

In rail transport, the cost for shunting operations needs to be taken into account. Those operations are the ones related to the placement of the locomotive and wagons on the correct truck and with the proper locomotive. This cost item is usually expressed in €/h, considering the time needed to carry out the shunting.

Shunting operations costs:

(Hourly cost for shunting operations)*Number of hours needed for the entire operation

Once all the cost items are listed and explained, the next step is to develop a cost function that can incorporate all the previous costs. The reasoning behind the construction of each cost function is the same for each mode of transport, although each of them is characterized by their technical nature. For each mode of transport, road, rail, inland navigation and intermodal transport a calculation of the total cost, €, the cost per tonnage, €/ton, the cost per tonnage per kilometre, €/tKm, the cost per kilometre, €/Km and the cost per hour, €/h have been calculated.

It is important to highlight that €/km and €/h have been calculated making a ratio between the total costs obtained and the total kilometres or total hours.

***Total Cost Road Transport**:*

Personnel costs+ Energy costs (Fuel)+ Insurance costs+ Maintenance and Repair costs+ Depreciation/Renting costs+ Taxes/Charges costs+ Tolls+ Overhead costs+ Tyres costs+ Other costs+ Loading/Unloading costs

***Total Cost Rail Transport**:*

Personnel costs+ Energy costs (Fuel)+ Energy costs (Electric power)+Insurance costs+ Maintenance and Repair costs+ Depreciation/Renting costs + Tolls+ Overhead costs + Other costs+ Rail Tracks costs+ Shunting operations costs+ Loading/Unloading costs

***Total Cost Inland Navigation Transport**:*

Personnel costs+ Energy costs (Fuel) + Insurance costs+ Maintenance and Repair costs+ Depreciation/Renting costs+ Charges costs+Tolls+ Overhead costs+ Other costs Loading/Unloading costs

***Total Cost Intermodal Transport (Road +Rail)**:*

Personnel costs road+ Energy costs (Fuel) road+ Insurance costs road + Maintenance and Repair costs road + Depreciation/Renting costs road + Taxes/ Charges costs road + Tolls+ Overhead costs road + Tyres costs road + Other costs road + Loading/Unloading costs+ Personnel costs rail+ Energy costs (Fuel) rail + Energy costs (Electric power) rail +Insurance *cost rail s+ Maintenance and Repair costs rail + Depreciation/Renting costs rail + Overhead costs rail + Other costs rail + Rail Tracks costs+ Shunting operations costs+ Loading/Unloading costs*

***Total Cost Intermodal Transport (Road +Inland Navigation)**:*

Personnel costs road+ Energy costs (Fuel) road+ Insurance costs road + Maintenance and Repair costs road + Depreciation/Renting costs road + Taxes/Charges costs road + Tolls+ Overhead costs road + Tyres costs road + Other costs road + Loading/Unloading costs+ Personnel costs inland navigation+ Energy costs (Fuel) inland navigation + Insurance costs inland navigation + Maintenance and Repair costs inland navigation + Depreciation/Renting costs inland navigation + Charges costs inland navigation + Tolls+ Overhead costs inland navigation + Other costs inland navigation Loading/Unloading costs

The purpose of the cost functions presented above is the application to the different modes of transport, in order to obtain a comparison among modes for the same origin/destination of the goods.

To implement such functions and return useful results, cost data need to be collected and inserted in the mathematical formulation; once having the theoretical support and trustworthy figures, a tool for the elaboration needs to be developed.

The implementation of a tool that can easily produce reliable outcomes is a fundamental step in the research process.

Using the Excel Programme, Office package, a simple but clear procedure for the construction of the calculation tool has been developed.

The method for the construction of the Excel tool envisages different steps, program knowledge and capability of Visual Basic for Applications, (VBA) programming.

The steps for the elaboration of the tool are the following and are developed in subsequent order; nonetheless interrelated adjustments are always possible.

Construction of the tool:

1. Creation of an excel sheet and naming.
2. Insertion and naming of the variables considered.
3. Insertion of the cost values corresponding to the variable considered.
4. Insertion of the step unit that the program has to consider.
5. Use of the Macro function.
6. Creation of a Macro for the specific purpose of the tool.
7. Running of the Macro function and test of the outcome.

A more detailed and accurate overview of the composing elements included in the excel tool for each of the modes of transport is presented in chapter V.

The figure below illustrates how the excel tool for rail transport would look like, the required information, both general and on the specific corridor, and the final output.

The general information part, lists the variables included, from the lowest to the highest value that it can have; corridors information contains the required input for the specific corridor analyzed.

General information			**Corridor information**				
Variables	From	To	Distance	49,7	49,7	1	
energy price	2,9	2,9	Tonnage	1000	1000	1	
salary	18	18	Hours	1	1	1	
social costs	6	6	Distance fuel	0	0	1	
n. of drivers	1	1	Hours shunt oper	1	1	1	
insurance	12	12					
maint-rep. loc	0,6	0,6	**Output**				
maint-rep. wag	0,05	0,05	Total cost	Cost per ton	Cost per ton km	Cost per km	Cost per h
overhead	8,5	8,5	2965,9	2,9659	0,0596760	29,8380	1482,9
diesel price	0	0					
track cost	3,75	3,75					
other costs	3,5	3,5					
leasing rent	162,5	162,5					
Shunt oper	850	850					

Fig. 3.1: Out of pocket calculation tool

Source: own elaboration

The collection of the data above mentioned has been carefully developed in order to be consistent and to perform calculations with reliable cost figures.

In order to do so, a literature review on cost components and figures has been analysed, furthermore personal interviews with transport operators took place, additional details on this part will be provided later in the text.

Of course it could be argued that accounting figures could be more reliable and precise, nonetheless these type of information are not provided by transport companies.

Once obtained the results of the calculations, the outcomes have been checked with the transport operators in such a way that the results obtained could be confirmed as reasonable by expert’s opinions.

In this second phase of the work, the cost inputs have been adjusted based the comments received and the calculations run again.

This procedure allowed the author to be confident on the inputs used and with the methodological base that supports the work.

So far the methodology used for the investigation of out of pocket costs has been presented, nonetheless still some additional information on the price of the service are required.

As previously mentioned the cost structure taken into consideration was the one of transport operator, for each mode of transport. In order to provide a service the transport operator needs to add a mark up on the costs.

The investigation of this element is fundamental in the development of the present work since the cost structure and the outcome of out of pocket costs could not fully explain the mode choice of forwarders and shippers.

Therefore it is important to capture the differences in mark ups for the different modes of transport in order to see which the final price of the service could be on the market.

For this purpose a methodology has been followed, which is based on the analysis of the available accounting reports for the road, rail and inland navigation industries (The data were collected from the Belfirst and Aida databases, respectively for the Belgian and Italian territory).

Together with this investigation a more theoretical approach has been followed, namely the analysis of previous research's that investigated transport mode market structures.

3.3 Qualitative attributes: description of applied methodology

The second part of the work lies in the investigation of qualitative attributes that influence mode choice and in their weight in the final decision.

The procedure of such investigation is not always easy, in particularly for their measurement. Once having selected the relevant attributes, the complex procedure is the methodological approach for their estimation.

In literature, as presented in the previous chapter, the most common methods are the revealed preference and stated preference. Both approaches can reveal interesting results; nonetheless they both present some pitfalls. In the case of revealed preference a large number of reliable observations are required and in stated preference the investigated situations are based on hypothetical situations. The literature reviewed shows however that the use of stated preference is a widespread technique.

In the case of the present thesis, the author preferred not to apply nor the revealed preference nor the stated preference approaches, the reasons are following explained.

The amount of data and information concerning modal split and preferences for the selected corridors are negligible. There are few data of traffic flows among those destinations and the available ones could not constitute the basis for such exercise, since they are not precise, sufficient nor comparable.

The use of a stated preference exercise has been also discarded. The reasons of such choice lies in the fact that the present thesis is aiming at providing e detail analysis of the costs' role and on an individual companies.

Using the generalized cost approach it will be possible to focus on the costs components, as stated, nonetheless the qualitative factors influencing mode choice will also be considered by means of previous studies that investigated this aspect in detail.

An additional advantage of using the generalized cost approach is the possibility to consider also external costs internalization, as it will be detailed later.

The methodological way applied in this thesis is based on twofold analysis.

The first part of the work consisted in a field investigation on the elements affecting mode choice. Interviews have been carried out with a sample of freight forwarders and shippers in the two areas of interest: port of Antwerp and port of Genoa. A detail description of the questionnaire is further explained in the text.

The second step is based on a qualitative analysis that takes into consideration value of time for the different modes of transport, such values are taken from previous study on the topic and applied on the corridors considered in this work. This analysis will lead to obtain generalized costs composed by out of pocket and value of time for each mode of transport.

In order to capture freight forwarders and shippers preferences about their mode choice, interviews with these operators have been performed in the areas of the Port of Antwerp and Genoa. Taking as a starting point the findings of the existing literature, the interviews were used to complete and complement the previous studies.

The reason for developing a field analysis was mainly due to the added value that this exercise could bring to the research; since it was possible to capture additional information and referred precisely on the two areas of interest. The results obtained will be presented in chapter V and the questionnaire used added in Annex 3.1.

The questionnaire was structured in two parts: a first descriptive part and a more focused part on mode choice process and preferences. The main aim of the interview was to capture the most important criteria or elements that are taken in consideration when selecting a mode of transport. The questionnaire had a semi-structured form, that allowed to have comparable questions and at the same time to enrich our findings with more qualitative information.

In this paragraph a short description of the questionnaire will be presented.

The construction of the questionnaire was developed taking in consideration some general company aspects that could be used for a better understanding of the companies profile, and trying to capture their preferences about mode choice.

As already said the questionnaire is divided in two parts: the first one is addressing questions about the respondent's general information and the company size; other investigated aspects are related to the market structure, distinguishing export and import flows and the specific markets, divided by countries. Moreover the respondents were asked to provide information about their main types of cargo handled, and the mode of transport used for each cargo typology.

An important part of the questionnaire was dedicated to intermodal transport, and the use of it. The question tried to capture the share of intermodal transport and the combinations used. Other questions were related to the logistics organization and the asset owned.

The main part of the questionnaire was dedicated to the transport decision and the elements or criteria that are mainly taken in consideration by the freight forwarders and shippers; in order to do so the respondents were asked to provide information on who selects the mode of transport and the transport providers, information about their company logistics structure and environmental concerns. The questionnaire was completed by a query in which the respondent had to express the relevance that some elements have on their mode choice. In order to capture this information the operators were asked to rank these elements on a Likert scale from 1, not important at all, to 5, very important.

During the development of the work it was expedient to contact some of the stakeholders of the sample, namely the ones that experienced the use of some of the corridors considered in the present research.

Their role was fundamental in confirming which mode of transport was preferred on the specific routes, and to assert the motivations of their choice, that could be finally not just related to the pure out of pocket cost.

3.4 Internalization of external costs

The method's selection for the external costs internalization is rather complex, the difficulty is due to the large variety of methodologies and approaches already undertook in previous researches.

For the purpose of the present thesis the aim was to select a neutral and mindful method that could be applied to each mode of transport on a European scale.

To this respect the best suitable methodology that could be followed is the one proposed in the Handbook on estimation of external costs in the transport sector IMPACT, published in 2008 by the European Commission.

In the report it is clearly stated that the its aim is: *"…to provide a comprehensive overview of approaches for estimation and internalization of external costs and to recommend a set of methods and default values for estimating external costs when conceiving and implementing transport pricing policy and schemes...".*

The Handbook's contribution is essential in order to use the same methodology and values once it will be decided to implement an internalization of external costs in the whole of Europe. The values presented can be considered a work of reference and an official document for the implementation of such measures of internalization. Therefore the choice of using the European Handbook as the main reference for this work is based on its neutrality and applicability to any European countries and for each mode of transport. The methodology applied is providing marginal external costs and the measurement will mainly be expressed in €/vkm.

Following this approach, it will be presented the methodological base supporting the application of each pollutant and the related values proposed for the internalization. In the following sub-paragraphs the specifications for each pollutant will be presented.

3.4.1 Congestion and scarcity costs

According to the European Handbook, congestion costs consist of internal and external components. Internal or private congestion costs are those increasing time and operating costs experienced by an operator when approaching or exceeding system capacity. External congestion costs are those costs experienced by all other system users due to the entrance of this operator into the system. External congestion costs are commonly not taken into account by transport users and decrease social welfare. While scarcity costs denote the opportunity costs to service providers for the non-availability of desired departure or arrival times (pp. 24, Handbook on externalities).

For the calculation and estimation of congestion and scarcity costs the general and basic suggested approach is valuing the time losses based on speed flow characteristics, bottlenecks and queuing functions, and applying opportunity cost approaches for scarce tracks and slots.

*External Congestion costs = increased journey time * value of time * traffic volume*

In the case of road transport, there is a differentiation among areas: urban and local roads, passenger's traffic and freight traffic. A further distinction is also presented in relation to small, large or rural areas, providing a range of values, as shown in table 3.1.

Tab. 3.1: Proposed ranges of marginal social costs prices of congestion by road class and type of area (€/vkm 2000)

Area and road type	Passenger cars			Goods vehicles			HGV
	Min.	Centr.	Max	Min.	Centr.	Max.	PCU
Large urban areas (> 2,000,000)							
Urban motorways	0.30	0.50	0.90	1.05	1.75	3.15	3.5
Urban collectors	0.20	0.50	1.20	0.50	1.25	3.00	2.5
Local streets centre	1.50	2.00	3.00	3.00	4.00	6.00	2
Local streets cordon	0.50	0.75	1.00	1.00	1.50	2.00	2
Small and medium urban areas (< 2,000,000)							
Urban motorways	0.10	0.25	0.40	0.35	0.88	1.40	3.5
Urban collectors	0.05	0.30	0.50	0.13	0.75	1.25	2.5
Local streets cordon	0.10	0.30	0.50	0.20	0.60	1.00	2
Rural areas							
Motorways*	0.00	0.10	0.20	0.00	0.35	0.70	3.5
Trunk roads*	0.00	0.05	0.15	0.00	0.13	0.23	2.5

vkm = vehicle-kilometre, HGV = Heavy Goods Vehicle, PCU = Passenger Car Unit.
* Calculated with a price elasticity of demand of -0.3.

Source: Handbook on estimation of external costs in the transport sector- IMPACT

As it can be noted the values are expressed in €/vkm, and the last column is the most relevant for thesis's purpose, showing the values related to Heavy Goods Vehicles, the ranges of values are varying between 2 and 3 €/vkm, in relation to the traffic's area.

For rail transport the figures provided are based on UNITE D7 project, suggesting a value around 0,20 €/train-km in morning peak based on UK and Swiss evidence.

For what concerns inland navigation, it appears that there are no congestion problems in the European inland waterway network; nonetheless some problems related to bottlenecks and locks can occur on a local level.

3.4.2 Accidents costs

Based on the definition given by the Handbook on external costs internalization, external accident costs are those social costs of traffic accidents which are not covered by risk oriented insurance premiums, hence the level of external costs does not only depend on the level of accidents, but also on the insurance system (pp. 36).

In order to obtain a value of marginal accident cost it is necessary to follow a bottom-up approach, as it is suggested in the Handbook. The input elements that need to be incorporated are: the traffic volume, risk elasticity, unit cost per accident and external part (Mainly related to assumption on external part of accident costs).

Marginal External Accident costs =

*traffic volume * risk elasticity * unit cost per accident*external part*

For road transport the main references have been the European projects: UNITE and GRACE with a bottom-up approach.

In the tables below values for passenger cars, motor cycles and heavy goods vehicles are provided, for each of them a distinction is presented among roads type.

The values for each country are varying from a minimum value to a maximum. For the lower margin, the assumption was that the average accident risk is internalised by the transport users.

Tab. 3.2: Unit values for accidents for different network types in (€ct/vkm) for passenger cars, motorcycles and heavy duty vehicles

	Passenger cars			Motor cycles			HDV		
	Urban roads	Motorways	Other roads	Urban roads	Motorways	Other roads	Urban roads	Motorways	Other roads
	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm
Ireland	6.2 (-0.44-9.74)	0.44 (-0.74-0.74)	2.36 (-2.8-3.84)	45.59 (-2.8-130.12)	0.3 (-0.89-0.89)	8.11 (-16.38-23.01)	15.79 (-0.59-20.95)	0.44 (-0.44-0.44)	3.98 (-3.84-5.31)
Italy	4.78 (-0.34-7.51)	0.34 (-0.57-0.57)	1.82 (-2.16-2.96)	35.17 (-2.16-100.39)	0.23 (-0.68-0.68)	6.26 (-12.63-17.76)	12.18 (-0.46-16.16)	0.34 (-0.34-0.34)	3.07 (-2.96-4.1)
Lithuania	3.45 (-0.25-5.43)	0.25 (-0.41-0.41)	1.32 (-1.56-2.14)	25.4 (-1.56-72.51)	0.16 (-0.49-0.49)	4.52 (-9.13-12.83)	8.8 (-0.33-11.67)	0.25 (-0.25-0.25)	2.22 (-2.14-2.96)
Luxem-bourg	10.81 (-0.77-16.99)	0.77 (-1.29-1.29)	4.12 (-4.89-6.69)	79.54 (-4.89-227.05)	0.51 (-1.54-1.54)	14.16 (-28.57-40.16)	27.54 (-1.03-36.55)	0.77 (-0.77-0.77)	6.95 (-6.69-9.27)
Latvia	3.49 (-0.25-5.49)	0.25 (-0.42-0.42)	1.33 (-1.58-2.16)	25.69 (-1.58-73.33)	0.17 (-0.5-0.5)	4.57 (-9.23-12.97)	8.9 (-0.33-11.81)	0.25 (-0.25-0.25)	2.24 (-2.16-2.99)
Malta	1.28 (-0.09-2.01)	0.09 (-0.15-0.15)	0.49 (-0.58-0.79)	9.4 (-0.58-26.84)	0.06 (-0.18-0.18)	1.67 (-3.38-4.75)	3.26 (-0.12-4.32)	0.09 (-0.09-0.09)	0.82 (-0.79-1.1)
Nether-lands	3.2 (-0.23-5.03)	0.23 (-0.38-0.38)	1.22 (-1.45-1.98)	23.56 (-1.45-67.25)	0.15 (-0.46-0.46)	4.19 (-8.46-11.89)	8.16 (-0.3-10.83)	0.23 (-0.23-0.23)	2.06 (-1.98-2.74)
Norway	3.92 (-0.28-6.16)	0.28 (-0.47-0.47)	1.49 (-1.77-2.43)	28.85 (-1.77-82.34)	0.19 (-0.56-0.56)	5.13 (-10.36-14.56)	9.99 (-0.37-13.26)	0.28 (-0.28-0.28)	2.52 (-2.43-3.36)
Poland	3.25 (-0.23-5.1)	0.23 (-0.39-0.39)	1.24 (-1.47-2.01)	23.89 (-1.47-68.19)	0.15 (-0.46-0.46)	4.25 (-8.58-12.06)	8.27 (-0.31-10.98)	0.23 (-0.23-0.23)	2.09 (-2.01-2.78)
Portugal	6.35 (-0.45-9.98)	0.45 (-0.76-0.76)	2.42 (-2.87-3.93)	46.73 (-2.87-133.4)	0.3 (-0.91-0.91)	8.32 (-16.79-23.59)	16.18 (-0.6-21.48)	0.45 (-0.45-0.45)	4.08 (-3.93-5.44)
Romania	1.14 (-0.08-1.8)	0.08 (-0.14-0.14)	0.44 (-0.52-0.71)	8.41 (-0.52-24.01)	0.05 (-0.16-0.16)	1.5 (-3.02-4.25)	2.91 (-0.11-3.87)	0.08 (-0.08-0.08)	0.74 (-0.71-0.98)
Sweden	2.68 (-0.19-4.21)	0.19 (-0.32-0.32)	1.02 (-1.21-1.66)	19.72 (-1.21-56.28)	0.13 (-0.38-0.38)	3.51 (-7.08-9.95)	6.83 (-0.26-9.06)	0.19 (-0.19-0.19)	1.72 (-1.66-2.3)
Slovenia	4.45 (-0.32-6.99)	0.32 (-0.53-0.53)	1.69 (-2.01-2.75)	32.73 (-2.01-93.42)	0.21 (-0.64-0.64)	5.83 (-11.76-16.52)	11.33 (-0.42-15.04)	0.32 (-0.32-0.32)	2.86 (-2.75-3.81)
Slovakia	2.61 (-0.19-4.1)	0.19 (-0.31-0.31)	0.99 (-1.18-1.61)	19.19 (-1.18-54.78)	0.12 (-0.37-0.37)	3.42 (-6.89-9.69)	6.65 (-0.25-8.82)	0.19 (-0.19-0.19)	1.68 (-1.61-2.24)
United Kingdom	2.61 (-0.19-4.1)	0.19 (-0.31-0.31)	0.99 (-1.18-1.61)	19.19 (-1.18-54.77)	0.12 (-0.37-0.37)	3.42 (-6.89-9.69)	6.64 (-0.25-8.82)	0.19 (-0.19-0.19)	1.68 (-1.61-2.24)

	Passenger cars			Motor cycles			HDV		
	Urban roads	Motorways	Other roads	Urban roads	Motorways	Other roads	Urban roads	Motorways	Other roads
	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm	€ct/vkm
Austria	5.7 (-0.41-8.95)	0.41 (-0.68-0.68)	2.17 (-2.58-3.53)	41.92 (-2.58-119.64)	0.27 (-0.81-0.81)	7.46 (-15.06-21.16)	14.51 (-0.54-19.26)	0.41 (-0.41-0.41)	3.66 (-3.53-4.88)
Belgium	6.58 (-0.47-10.35)	0.47 (-0.78-0.78)	2.51 (-2.98-4.08)	48.43 (-2.98-138.25)	0.31 (-0.94-0.94)	8.62 (-17.4-24.45)	16.77 (-0.63-22.26)	0.47 (-0.47-0.47)	4.23 (-4.08-5.64)
Bulgary	1.24 (-0.09-1.95)	0.09 (-0.15-0.15)	0.47 (-0.56-0.77)	9.11 (-0.56-26.01)	0.06 (-0.18-0.18)	1.62 (-3.27-4.6)	3.16 (-0.12-4.19)	0.09 (-0.09-0.09)	0.8 (-0.77-1.06)
Switzer-land	4.36 (-0.31-6.85)	0.31 (-0.52-0.52)	1.66 (-1.97-2.7)	32.05 (-1.97-91.48)	0.21 (-0.62-0.62)	5.7 (-11.51-16.18)	11.1 (-0.41-14.73)	0.31 (-0.31-0.31)	2.8 (-2.7-3.73)
Cyprus	5.08 (-0.36-7.98)	0.36 (-0.6-0.6)	1.93 (-2.3-3.14)	37.35 (-2.3-106.62)	0.24 (-0.73-0.73)	6.65 (-13.42-18.86)	12.93 (-0.48-17.17)	0.36 (-0.36-0.36)	3.26 (-3.14-4.35)
Czech Republic	3.33 (-0.24-5.23)	0.24 (-0.4-0.4)	1.27 (-1.51-2.06)	24.5 (-1.51-69.94)	0.16 (-0.48-0.48)	4.36 (-8.8-12.37)	8.48 (-0.32-11.26)	0.24 (-0.24-0.24)	2.14 (-2.06-2.85)
Germany	4.12 (-0.29-6.47)	0.29 (-0.49-0.49)	1.57 (-1.86-2.55)	30.29 (-1.86-86.45)	0.2 (-0.59-0.59)	5.39 (-10.88-15.29)	10.49 (-0.39-13.92)	0.29 (-0.29-0.29)	2.65 (-2.55-3.53)
Denmark	4.44 (-0.32-6.97)	0.32 (-0.53-0.53)	1.69 (-2.01-2.75)	32.65 (-2.01-93.21)	0.21 (-0.63-0.63)	5.81 (-11.73-16.49)	11.31 (-0.42-15.01)	0.32 (-0.32-0.32)	2.85 (-2.75-3.8)
Estonia	3.24 (-0.23-5.09)	0.23 (-0.39-0.39)	1.23 (-1.47-2.01)	23.84 (-1.47-68.05)	0.15 (-0.46-0.46)	4.24 (-8.56-12.04)	8.26 (-0.31-10.96)	0.23 (-0.23-0.23)	2.08 (-2.01-2.78)
Spain	5.24 (-0.37-8.24)	0.37 (-0.62-0.62)	2 (-2.37-3.25)	38.57 (-2.37-110.08)	0.25 (-0.75-0.75)	6.86 (-13.85-19.47)	13.35 (-0.5-17.72)	0.37 (-0.37-0.37)	3.37 (-3.25-4.49)
Finland	3.43 (-0.25-5.4)	0.25 (-0.41-0.41)	1.31 (-1.55-2.13)	25.27 (-1.55-72.12)	0.16 (-0.49-0.49)	4.5 (-9.08-12.76)	8.75 (-0.33-11.61)	0.25 (-0.25-0.25)	2.21 (-2.13-2.94)
France	6.69 (-0.48-10.52)	0.48 (-0.8-0.8)	2.55 (-3.03-4.14)	49.25 (-3.03-140.56)	0.32 (-0.96-0.96)	8.77 (-17.69-24.86)	17.05 (-0.64-22.63)	0.48 (-0.48-0.48)	4.3 (-4.14-5.74)
Greece	5.29 (-0.38-8.32)	0.38 (-0.63-0.63)	2.02 (-2.39-3.28)	38.94 (-2.39-111.14)	0.25 (-0.76-0.76)	6.93 (-13.99-19.66)	13.48 (-0.5-17.89)	0.38 (-0.38-0.38)	3.4 (-3.28-4.54)
Hungary	2.78 (-0.2-4.37)	0.2 (-0.33-0.33)	1.06 (-1.26-1.72)	20.44 (-1.26-58.36)	0.13 (-0.4-0.4)	3.64 (-7.34-10.32)	7.08 (-0.26-9.4)	0.2 (-0.2-0.2)	1.79 (-1.72-2.38)

Source: Handbook on estimation of external costs in the transport sector- IMPACT

Some output values are also provided for rail transport, even though very few studies on marginal accident costs have been produced on the topic, therefore the results presented are average accident costs. The European values are estimated between 0,08 to 0,30 €/train-km.

3.4.3 Air pollution costs

Air pollution costs are composed by several sub-costs categories such as health costs, building material damages, crop losses and costs for the ecosystem, among the others health costs are the most important and the ones that received most attention by researches.

The formula below summarizes the elements that need to be taken into account for the calculation of these costs.

External Air Pollution costs =

*Specific emission * cost factor per pollutant*

The values presented in the Handbook are expressed in €/ton of pollutant for the different mode of transport, a further elaboration gave the possibility to obtain also results in €/vkm.

The values obtained are based on examples for different type of vehicles, taking Germany as the valuation country, the values presented in the table below are representative for European average emission for each category.

In the case of road transport, the differentiation is between passengers and trucks, and also according to Euro Class and geographical coverage, where metropolitan cities are the ones with more than 0,5 million inhabitants and urban cities the ones below this limit.

It is important to bear in mind that the emission air pollutants vary considerably according to the average speed.

Tab. 3.3: Air pollution costs in €ct/vkm for passenger and heavy duty vehicles (Example Germany)

Vehicle	Size	EURO-Class	Metropolitan	Urban	Interurban	Motorways	Average
			(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)
Passenger Car Petrol	<1,4L	EURO-0	5.9	2.3	1.7	1.9	2.0
		EURO-1	1.7	1.4	0.6	0.8	0.9
		EURO-2	0.9	0.6	0.3	0.4	0.4
		EURO-3	0.3	0.2	0.1	0.1	0.1
		EURO-4	0.3	0.1	0.1	0.1	0.1
		EURO-5	0.3	0.1	0.1	0.0	0.1
	1,4-2L	EURO-0	5.1	1.8	1.4	1.6	1.6
		EURO-1	1.7	1.5	0.6	0.8	0.9
		EURO-2	0.9	0.6	0.3	0.4	0.4
		EURO-3	0.3	0.2	0.1	0.1	0.1
		EURO-4	0.3	0.1	0.1	0.1	0.1
		EURO-5	0.3	0.1	0.1	0.0	0.1
	>2L	EURO-1	1.4	1.2	0.6	0.8	0.8
		EURO-2	0.8	0.6	0.3	0.4	0.4
		EURO-3	0.3	0.2	0.1	0.1	0.1
		EURO-4	0.2	0.1	0.1	0.1	0.1
		EURO-5	0.2	0.1	0.1	0.0	0.1
Passenger Car Diesel	<1,4L	EURO-2	4.0	1.8	0.8	0.9	1.1
		EURO-3	3.1	1.5	0.9	1.0	1.1
		EURO-4	1.7	0.8	0.5	0.5	0.6
		EURO-5	0.7	0.4	0.3	0.3	0.4
	1,4-2L	EURO-0	13.8	4.8	1.4	1.5	2.4
		EURO-1	4.8	2.0	1.0	1.3	1.4
		EURO-2	4.0	1.8	0.8	0.9	1.1
		EURO-3	3.1	1.5	0.9	1.0	1.1
		EURO-4	1.7	0.8	0.5	0.5	0.6
		EURO-5	0.7	0.4	0.3	0.3	0.4
	>2L	EURO-0	14.1	5.1	1.7	1.8	2.7
		EURO-1	4.8	2.0	1.0	1.3	1.4
		EURO-2	4.0	1.8	0.8	0.9	1.1
		EURO-3	3.1	1.5	0.9	1.0	1.1
		EURO-4	1.7	0.8	0.5	0.5	0.6
		EURO-5	0.7	0.4	0.3	0.3	0.4
Trucks	<7.5t	EURO-0	20.1	11.3	9.1	9.0	9.1
		EURO-1	12.0	6.7	5.4	5.3	5.4
		EURO-2	8.1	5.6	5.0	5.0	5.0
		EURO-3	7.5	4.8	4.0	3.9	4.0
		EURO-4	3.2	2.5	2.3	2.3	2.3
		EURO-5	2.3	1.6	1.4	1.4	1.4
	7.5-16t	EURO-0	28.2	15.7	11.9	11.1	11.6
		EURO-1	18.4	10.6	8.1	7.6	7.9
		EURO-2	12.4	8.5	7.2	6.9	7.1
		EURO-3	10.2	7.2	6.0	5.5	5.8
		EURO-4	5.3	4.1	3.5	3.3	3.4
		EURO-5	3.8	2.7	2.2	2.0	2.1
	16-32t	EURO-0	29.0	16.5	12.7	11.8	12.1
		EURO-1	16.3	9.9	7.8	7.3	7.5
		EURO-2	12.9	9.1	7.5	7.1	7.2
		EURO-3	9.4	7.0	5.8	5.3	5.5
		EURO-4	5.2	4.1	3.5	3.2	3.3
		EURO-5	3.8	2.7	2.2	2.0	2.1
	>32t	EURO-0	38.3	22.3	16.8	14.9	15.3
		EURO-1	28.1	16.1	12.0	10.6	10.9
		EURO-2	18.9	13.2	10.7	9.6	9.8
		EURO-3	14.6	10.6	8.5	7.6	7.7
		EURO-4	7.4	6.1	5.1	4.5	4.6
		EURO-5	5.2	3.8	3.1	2.8	2.8

Source: Handbook on estimation of external costs in the transport sector- IMPACT

For rail transport the air pollutant emissions differentiate by traction type and indirect and direct emission.

Tab. 3.4: Air pollution costs in €ct/train-km for passenger and freight trains (Example Germany)

			Metropolitan			Other Urban			Non Urban		
			Indirect emis.	Direct emis.	**Total**	Indirect emis.	Direct emis.	**Total**	Indirect emis.	Direct emis.	**Total**
			€ct/ train-km	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*
Passenger	Electric	Locomotive	4.9	0.0	**4.9**	4.9	0.0	**4.9**	4.9	0.0	**4.9**
		Railcar	7.6	0.0	**7.6**	7.7	0.0	**7.7**			
		High Speed Train							9.2	0.0	**9.2**
	Diesel	Locomotive	8.7	204.7	**213.3**	8.7	108.8	**117.5**	8.7	90.7	**99.4**
		Railcar	11.5	271.0	**282.4**	11.5	144.8	**156.4**			
Freight	Electric	Locomotive	13.7	0.0	**13.7**	13.7	0.0	**13.7**	13.7	0.0	**13.7**
	Diesel	Locomotive	29.2	690.0	**719.2**	29.2	366.8	**396.0**	29.2	305.8	**335.0**

Source: Handbook on estimation of external costs in the transport sector- IMPACT

To conclude, the emissions for inland navigation are presented, these vary according to the weight-class.

Tab. 3.5: Air pollution costs in €/ship-km for inland waterways (Example Germany)

Ship Type	**Direct Emissions**
	€/ship-km
Dry Cargo <250 ton	0.89
Dry Cargo 250-400 ton	0.89
Dry Cargo 400-650 ton	1.22
Dry Cargo 650-1,000 ton	1.86
Dry Cargo 1,000-1,500 ton	2.54
Dry Cargo 1,500-3,000 ton	4.63
Dry Cargo > 3,000 ton	4.63
Push barge <250 ton	6.05
Push barge 250-400 ton	6.05
Push barge 400-650 ton	6.06
Push barge 650-1,000 ton	6.04
Push barge 1,000-1,500 ton	6.05
Push barge 1,500-3,000 ton	6.05
Push barge > 3,000 ton	12.60
Tanker <250 ton	0.89
Tanker 250-400 ton	0.90
Tanker 400-650 ton	1.22
Tanker 650-1,000 ton	1.86
Tanker 1,000-1,500 ton	2.54
Tanker 1,500-3,000 ton	7.28
Tanker > 3,000 ton	7.28

Source: Handbook on estimation of external costs in the transport sector- IMPACT

3.4.4 Noise costs

According to the Handbook noise costs consist of costs for annoyance and health.

In the case of road transport the noise costs depend on vehicle speed, vehicle type, the tires and the maintenance of the vehicle.

In rail transport the main drivers are the rolling surface and the steel wheel on the steel track, they depend on speed, wagon type, surface condition and type of track.

When calculating noise costs the following elements have to be taken into account:

External Noise costs =

*Specific noise emission * number of people affected * damage per dB(A)*

The recommended output values of the Handbook show figures for road and rail transport, since inland navigation noise's costs are considered negligible.

Tab. 3.6: Unit values for noise marginal costs for different networks types for road and rail traffic

	Time of day	Urban	Suburban	Rural
Car	Day	**0.76** (0.76 – 1.85)	**0.12** (0.04 – 0.12)	**0.01** (0.01 – 0.014)
	Night	**1.39** (1.39 – 3.37)	**0.22** (0.08 – 0.22)	**0.03** 0.01 – 0.03
MC	Day	**1.53** (1.53 – 3.70)	**0.24** (0.09 – 0.24)	**0.03** (0.01 – 0.03)
	Night	**2.78** (2.78 – 6.74)	**0.44** (0.16 – 0.44)	**0.05** (0.02 – 0.05)
Bus	Day	**3.81** (3.81 – 9.25)	**0.59** (0.21 – 0.59)	**0.07** (0.03 – 0.07)
	Night	**6.95** (6.95 – 16.84)	**1.10** (0.39 – 1.10)	**0.13** (0.06 – 0.13)
LGV	Day	**3.81** (3.81 – 9.25)	**0.59** (0.21 – 0.59)	**0.07** (0.03 – 0.07)
	Night	**6.95** (6.95 – 16.84)	**1.10** (0.39 – 1.10)	**0.13** (0.06 - 0.13)
HGV	Day	**7.01** (7.01 – 17.00)	**1.10** 0.39 – 1.10	**0.13** (0.06 – 0.13)
	Night	**12.78** (12.78-30.98)	**2.00** 0.72 – 2.00	**0.23** (0.11 – 0.23)
Passenger train	Day	**23.65** (23.65 – 46.73)	**20.61** 10.43 – 20.61	**2.57** (1.30 – 2.57)
	Night	**77.99**	**34.40**	**4.29**
Freight train	Day	**41.93** (41.93 – 101.17)	**40.06** 20.68 – 40.06	**5.00** (2.58 – 5.00)
	Night	**171.06**	**67.71**	**8.45**

Source: Handbook on estimation of external costs in the transport sector- IMPACT

3.4.5 Climate change

An important premise for climate change costs is related to the complexity in the calculation. The reason is explained by the fact that they produce effects in long terms and that they have a global impact, moreover risk patterns are difficult to anticipate.

The main costs drivers are fuel consumption and carbon content of the fuel.

External Climate Change costs =

*Specific GHG emission * External costs factor of CO_2 equivalent*

Although several problematic issues need to be tackled for the calculation of climate changes and a wide literature review has been presented in the Handbook, a guideline for the internalization of climate change costs has been suggested in the guide.

Different values are provided for road transport, differentiated according to type of vehicles, passengers or freight, and also to the geographical area. Also in the case rail transport emissions are divided between passengers and freight traffic and also in relation to the power propulsion. Inland navigation climate change emissions vary according to the type of ship and the dimension.

Tab. 3.7: Climate change costs in €/ct/vkm for passenger cars and trucks

Vehicle	Size	EURO-Class	Metropo-litan	Urban	Interurban	Motorways	Average
			(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)
Passenger Car Petrol	<1,4L	EURO-0	0.7 (0.2-1.2)	0.6 (0.2-1.1)	0.4 (0.1-0.8)	0.5 (0.2-1)	0.5 (0.1-0.9)
		EURO-1	0.6 (0.2-1.2)	0.6 (0.2-1.2)	0.4 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-2	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
		EURO-3	0.6 (0.2-1.1)	0.6 (0.2-1)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
		EURO-4	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.4 (0.1-0.6)	0.4 (0.1-0.7)	0.4 (0.1-0.7)
		EURO-5	0.5 (0.1-0.9)	0.5 (0.1-0.8)	0.3 (0.1-0.6)	0.3 (0.1-0.6)	0.4 (0.1-0.7)
	1,4-2L	EURO-0	0.9 (0.2-1.5)	0.7 (0.2-1.3)	0.5 (0.1-0.9)	0.7 (0.2-1.2)	0.6 (0.2-1.1)
		EURO-1	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1)
		EURO-2	0.7 (0.2-1.3)	0.7 (0.2-1.3)	0.5 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-3	0.7 (0.2-1.2)	0.7 (0.2-1.2)	0.4 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-4	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.4 (0.1-0.7)	0.4 (0.1-0.8)	0.5 (0.1-0.8)
		EURO-5	0.6 (0.2-1)	0.6 (0.2-1)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
	>2L	EURO-1	1.0 (0.3-1.8)	1 (0.3-1.8)	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.7 (0.2-1.3)
		EURO-2	1.0 (0.3-1.7)	1 (0.3-1.7)	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.7 (0.2-1.3)
		EURO-3	0.8 (0.2-1.5)	0.8 (0.2-1.4)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1)
		EURO-4	0.9 (0.2-1.6)	0.8 (0.2-1.5)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1.1)
		EURO-5	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.5 (0.1-0.8)	0.4 (0.1-0.8)	0.5 (0.2-1)
Passenger Car Diesel	<1,4L	EURO-2	0.4 (0.1-0.8)	0.4 (0.1-0.8)	0.3 (0.1-0.6)	0.3 (0.1-0.6)	0.3 (0.1-0.6)
		EURO-3	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.3 (0.1-0.5)	0.3 (0.1-0.5)	0.3 (0.1-0.6)
		EURO-4	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.3 (0.1-0.5)	0.3 (0.1-0.5)	0.3 (0.1-0.5)
		EURO-5	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.3 (0.1-0.5)	0.3 (0.1-0.5)	0.3 (0.1-0.6)
	1,4-2L	EURO-0	0.5 (0.1-1)	0.5 (0.1-0.9)	0.3 (0.1-0.6)	0.4 (0.1-0.7)	0.4 (0.1-0.7)
		EURO-1	0.6 (0.2-1)	0.6 (0.2-1)	0.4 (0.1-0.8)	0.5 (0.1-0.8)	0.5 (0.1-0.9)
		EURO-2	0.6 (0.2-1)	0.6 (0.2-1)	0.4 (0.1-0.7)	0.4 (0.1-0.8)	0.5 (0.1-0.8)
		EURO-3	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.4 (0.1-0.7)	0.4 (0.1-0.7)	0.4 (0.1-0.8)
		EURO-4	0.5 (0.1-0.8)	0.5 (0.1-0.8)	0.3 (0.1-0.6)	0.4 (0.1-0.6)	0.4 (0.1-0.7)
		EURO-5	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.4 (0.1-0.6)	0.4 (0.1-0.7)	0.4 (0.1-0.7)
	>2L	EURO-0	0.7 (0.2-1.3)	0.7 (0.2-1.3)	0.5 (0.1-0.8)	0.5 (0.1-0.9)	0.5 (0.2-1)
		EURO-1	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.7 (0.2-1.2)
		EURO-2	0.8 (0.2-1.4)	0.8 (0.2-1.4)	0.6 (0.2-1)	0.6 (0.2-1.1)	0.6 (0.2-1.1)
		EURO-3	0.7 (0.2-1.3)	0.7 (0.2-1.3)	0.5 (0.1-0.9)	0.5 (0.1-0.9)	0.6 (0.2-1)
		EURO-4	0.6 (0.2-1.1)	0.6 (0.2-1.1)	0.5 (0.1-0.8)	0.5 (0.1-0.9)	0.5 (0.1-0.9)
		EURO-5	0.6 (0.2-1.2)	0.6 (0.2-1.2)	0.5 (0.1-0.8)	0.5 (0.1-0.9)	0.5 (0.1-0.9)
Trucks	<7.5t	EURO-0	1.3 (0.4-2.4)	1.3 (0.4-2.4)	1.2 (0.3-2.2)	1.2 (0.3-2.1)	1.2 (0.3-2.2)
		EURO-1	1.1 (0.3-2)	1.1 (0.3-2)	1 (0.3-1.9)	1 (0.3-1.9)	1 (0.3-1.9)
		EURO-2	1.1 (0.3-1.9)	1.1 (0.3-1.9)	1 (0.3-1.8)	1 (0.3-1.8)	1 (0.3-1.8)
		EURO-3	1.1 (0.3-2.1)	1.1 (0.3-2)	1.1 (0.3-1.9)	1.1 (0.3-1.9)	1.1 (0.3-1.9)
		EURO-4	1.1 (0.3-1.9)	1.1 (0.3-1.9)	1 (0.3-1.8)	1 (0.3-1.8)	1 (0.3-1.8)
		EURO-5	1.1 (0.3-2)	1.1 (0.3-2)	1 (0.3-1.8)	1 (0.3-1.8)	1 (0.3-1.8)
	7.5-16t	EURO-0	2 (0.6-3.7)	2 (0.6-3.7)	1.8 (0.5-3.2)	1.7 (0.5-3)	1.7 (0.5-3.1)
		EURO-1	1.8 (0.5-3.2)	1.7 (0.5-3.1)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-2	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.6)	1.5 (0.4-2.6)
		EURO-3	1.8 (0.5-3.2)	1.8 (0.5-3.2)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-4	1.6 (0.5-3)	1.6 (0.5-2.9)	1.5 (0.4-2.6)	1.4 (0.4-2.5)	1.4 (0.4-2.5)
		EURO-5	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.5)	1.4 (0.4-2.6)
	16-32t	EURO-0	2 (0.6-3.7)	2 (0.6-3.7)	1.8 (0.5-3.2)	1.7 (0.5-3)	1.7 (0.5-3.1)
		EURO-1	1.8 (0.5-3.2)	1.8 (0.5-3.2)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-2	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.5)	1.4 (0.4-2.6)
		EURO-3	1.8 (0.5-3.2)	1.8 (0.5-3.2)	1.6 (0.4-2.8)	1.5 (0.4-2.6)	1.5 (0.4-2.7)
		EURO-4	1.6 (0.5-3)	1.6 (0.5-2.9)	1.5 (0.4-2.6)	1.4 (0.4-2.4)	1.4 (0.4-2.5)
		EURO-5	1.7 (0.5-3)	1.7 (0.5-3)	1.5 (0.4-2.7)	1.4 (0.4-2.5)	1.4 (0.4-2.5)
	>32t	EURO-0	2.9 (0.8-5.3)	2.9 (0.8-5.3)	2.5 (0.7-4.6)	2.3 (0.6-4.1)	2.3 (0.6-4.2)
		EURO-1	2.6 (0.7-4.7)	2.6 (0.7-4.7)	2.2 (0.6-4)	2 (0.6-3.6)	2 (0.6-3.7)
		EURO-2	2.5 (0.7-4.5)	2.5 (0.7-4.5)	2.2 (0.6-3.9)	2 (0.5-3.5)	2 (0.6-3.6)
		EURO-3	2.6 (0.7-4.7)	2.6 (0.7-4.7)	2.2 (0.6-4)	2 (0.6-3.6)	2 (0.6-3.7)
		EURO-4	2.4 (0.7-4.3)	2.4 (0.7-4.3)	2.1 (0.6-3.7)	1.9 (0.5-3.3)	1.9 (0.5-3.4)
		EURO-5	2.5 (0.7-4.4)	2.4 (0.7-4.4)	2.1 (0.6-3.8)	1.9 (0.5-3.4)	1.9 (0.5-3.5)

Source: Handbook on estimation of external costs in the transport sector- IMPACT

Tab. 3.8: Climate change costs in €/ct/train-km for passenger cars and trains.

			Metropolitan			Other Urban			Non Urban		
			indirect emis.	direct emis.	**total**	indirect emis.	direct emis.	**total**	indirect emis.	direct emis.	**total**
			€ct/ train-km	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*	*€ct/ train-km*
Passenger	Electric	Locomotive	11 (3.1-19.8)	0 (0-0)	11 (3.1-19.8)	11 (3.1-19.8)	0 (0-0)	11 (3.1-19.8)	11 (3.1-19.8)	0 (0-0)	11 (3.1-19.8)
		Railcar	17.1 (4.8-30.8)	0 (0-0)	17.1 (4.8-30.8)	17.2 (4.8-30.9)	0 (0-0)	17.2 (4.8-30.9)			
		High Speed Train							20.6 (5.8-37.1)	0 (0-0)	20.6 (5.8-37.1)
	Diesel	Locomotive	1.7 (0.5-3)	8.6 (2.4-15.5)	10.3 (2.9-18.5)	1.7 (0.5-3)	8.6 (2.4-15.5)	10.3 (2.9-18.5)	1.7 (0.5-3)	8.6 (2.4-15.5)	10.3 (2.9-18.5)
		Railcar	2.2 (0.6-4)	11.3 (3.2-20.4)	13.6 (3.8-24.4)	2.2 (0.6-4)	11.4 (3.2-20.6)	13.7 (3.8-24.6)			
Freight	Electric	Locomotive	30.7 (8.6-55.2)	0 (0-0)	30.7 (8.6-55.2)	30.7 (8.6-55.2)	0 (0-0)	30.7 (8.6-55.2)	30.7 (8.6-55.2)	0 (0-0)	30.7 (8.6-55.2)
	Diesel	Locomotive	5.6 (1.6-10.1)	29 (8.1-52.1)	34.6 (9.7-62.2)	5.6 (1.6-10.1)	28.9 (8.1-52.1)	34.6 (9.7-62.2)	5.6 (1.6-10.1)	28.9 (8.1-52.1)	34.6 (9.7-62.2)

Source: Handbook on estimation of external costs in the transport sector- IMPACT

Tab. 3.9: Climate change costs in €/ct/ship for freight transport on inland navigation

Ship Type	**Direct Emissions**
	€/ship-km
Dry Cargo <250 ton	0.08 (0.02-0.15)
Dry Cargo 250-400 ton	0.08 (0.02-0.15)
Dry Cargo 400-650 ton	0.11 (0.03-0.2)
Dry Cargo 650-1,000 ton	0.17 (0.05-0.3)
Dry Cargo 1,000-1,500 ton	0.23 (0.07-0.42)
Dry Cargo 1,500-3,000 ton	0.42 (0.12-0.75)
Dry Cargo > 3,000 ton	0.42 (0.12-0.75)
Push barge <250 ton	0.56 (0.16-1)
Push barge 250-400 ton	0.56 (0.16-1)
Push barge 400-650 ton	0.56 (0.16-1)
Push barge 650-1,000 ton	0.56 (0.16-1)
Push barge 1,000-1,500 ton	0.56 (0.16-1)
Push barge 1,500-3,000 ton	0.56 (0.16-1)
Push barge > 3,000 ton	1.14 (0.32-2.05)
Tanker <250 ton	0.08 (0.02-0.15)
Tanker 250-400 ton	0.08 (0.02-0.15)
Tanker 400-650 ton	0.11 (0.03-0.2)
Tanker 650-1,000 ton	0.17 (0.05-0.3)
Tanker 1,000-1,500 ton	0.23 (0.07-0.42)
Tanker 1,500-3,000 ton	0.65 (0.18-1.18)
Tanker > 3,000 ton	0.65 (0.18-1.18)

Source: Handbook on estimation of external costs in the transport sector- IMPACT

3.4.6 Other external costs

The costs presented above are the main external cost and the ones that have been investigated most. Although other external cost categories are more difficult to study and to measure, the Handbook took into consideration also other costs, namely costs for nature and landscape, costs for soil and water pollution, up-down stream processes costs.

The authors were equally precise in specifying that the calculation methods found in literature are not sophisticated as in the case of the most important external costs categories.

3.4.6.1 Costs for nature and landscape

The negative impacts that can be expected by damages in nature and landscape are habitat loss, habitat fragmentation and habitat quality loss. The costs are therefore associated to the repair measures.

Some results presented in table 3.10 are based on cost factors for Switzerland, therefore a more precise estimation should be based on national data. The figures below provide, nonetheless, a good approximation of the costs needed to recover for damages caused to nature and landscape.

Tab. 3.10: Habitat fragmentation and habitat loss (main methodology): average costs per km infrastructure for road and rail transport in Switzerland

	Average costs (in 1,000 EUR/(km*a)		
Transport mode	*Habitat loss*	*Habitat fragmentation*	*Total*
Road total	3.6	7.1	11
Motorways	19	92	110
1st class / national roads	3.2	13	16
2nd class / regional roads	4.2	2.7	6.9
3rd class roads	2.2	1.6	3.9
Railway total	6.0	10	16
Railway single track	3.3	5.6	8.9
Railway multi track	14	23	37

Source: Handbook on estimation of external costs in the transport sector- IMPACT

3.4.6.2 Costs for soil and water pollution

These costs relate mainly to emissions of heavy metals produced by each mean of transport and causing damages on plants and decrease in soil fertility. Also in this case the costs are considered as repair cost need to overcome the problem. The table below is showing the possible costs in the specific case of Switzerland, those can be taken as a reference in case available studies and results on a national base are not available.

Tab. 3.11: Habitat fragmentation and habitat loss (main methodology): average costs per km infrastructure for road and rail transport in Switzerland

	Transport mean	*Unit costs, in €ct/vkm*
Road	Passenger cars	0.06
	Busses (Public transport)	1.07
	Coaches	1.05
	Motorcycles	0.04
	Vans	0.17
	Heavy duty vehicles	1.05
Rail	Rail total	0.43
	Rail passenger	0.29
	Rail freight	1.02

Source: Handbook on estimation of external costs in the transport sector- IMPACT

3.4.6.3 Costs of up-down stream processes

Costs for up and down stream processes refer to production of energy, vehicles and transport infrastructure that may produce additional external costs. The main categories are the pre-combustion, the production maintenance and disposal of vehicles and the infrastructure costs such as construction, maintenance and disposal.

Some cost figures have been presented in the Handbook, both for road and rail transport, as reported in the tables below.

Tab. 3.12: Costs of up-down stream processes (fuel production, air pollution and climate changes costs) in €ct/vkm for passenger cars and heavy duty vehicles (Example Germany, price base 2000)

Vehicle	Size	EURO-Class	Metropolitan	Urban	Interurban	Motorways	Average
			(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)	(€ct/vkm)
Passenger Car Petrol	<1,4L	EURO-0	0.81	0.85	0.63	0.78	0.74
		EURO-1	0.90	0.90	0.62	0.64	0.70
		EURO-2	0.83	0.83	0.56	0.58	0.64
		EURO-3	0.82	0.81	0.56	0.57	0.63
		EURO-4	0.74	0.74	0.52	0.54	0.58
		EURO-5	0.69	0.68	0.48	0.50	0.54
	1,4-2L	EURO-0	1.00	0.99	0.74	0.97	0.88
		EURO-1	1.08	1.07	0.71	0.72	0.81
		EURO-2	1.01	1.01	0.67	0.66	0.76
		EURO-3	0.97	0.97	0.65	0.66	0.74
		EURO-4	0.90	0.90	0.61	0.62	0.69
		EURO-5	0.83	0.83	0.57	0.57	0.64
	>2L	EURO-1	1.40	1.39	0.90	0.90	1.03
		EURO-2	1.38	1.37	0.91	0.90	1.03
		EURO-3	1.16	1.16	0.74	0.71	0.85
		EURO-4	1.25	1.24	0.78	0.73	0.89
		EURO-5	1.11	1.10	0.69	0.65	0.79
Passenger Car Diesel	<1,4L	EURO-2	0.51	0.50	0.38	0.40	0.42
		EURO-3	0.47	0.46	0.35	0.36	0.38
		EURO-4	0.43	0.42	0.32	0.33	0.35
		EURO-5	0.45	0.45	0.34	0.35	0.37
	1,4-2L	EURO-0	0.64	0.64	0.41	0.45	0.48
		EURO-1	0.69	0.69	0.52	0.55	0.58
		EURO-2	0.67	0.66	0.50	0.52	0.55
		EURO-3	0.61	0.61	0.45	0.47	0.50
		EURO-4	0.55	0.55	0.41	0.42	0.45
		EURO-5	0.58	0.58	0.43	0.44	0.48
	>2L	EURO-0	0.89	0.88	0.56	0.62	0.67
		EURO-1	0.96	0.95	0.72	0.76	0.80
		EURO-2	0.92	0.91	0.68	0.72	0.76
		EURO-3	0.83	0.83	0.62	0.64	0.68
		EURO-4	0.75	0.75	0.56	0.58	0.62
		EURO-5	0.76	0.76	0.57	0.59	0.63
Trucks	<7.5t	EURO-0	1.58	1.58	1.44	1.40	1.42
		EURO-1	1.34	1.34	1.24	1.24	1.25
		EURO-2	1.28	1.28	1.19	1.20	1.20
		EURO-3	1.35	1.35	1.26	1.25	1.26
		EURO-4	1.27	1.27	1.18	1.17	1.18
		EURO-5	1.30	1.30	1.20	1.19	1.20
	7.5-16t	EURO-0	2.46	2.45	2.16	2.01	2.09
		EURO-1	2.10	2.09	1.87	1.74	1.81
		EURO-2	2.03	2.02	1.81	1.70	1.76
		EURO-3	2.11	2.10	1.87	1.74	1.81
		EURO-4	1.97	1.96	1.75	1.63	1.69
		EURO-5	2.00	2.00	1.78	1.65	1.72
	16-32t	EURO-0	2.44	2.44	2.16	2.00	2.05
		EURO-1	2.10	2.09	1.86	1.74	1.78
		EURO-2	2.02	2.02	1.80	1.68	1.72
		EURO-3	2.11	2.10	1.87	1.74	1.78
		EURO-4	1.97	1.96	1.75	1.62	1.66
		EURO-5	2.00	2.00	1.78	1.65	1.69
	>32t	EURO-0	3.54	3.54	3.05	2.73	2.78
		EURO-1	3.11	3.10	2.69	2.41	2.46
		EURO-2	3.03	3.02	2.63	2.35	2.40
		EURO-3	3.11	3.11	2.68	2.39	2.44
		EURO-4	2.90	2.90	2.50	2.23	2.27
		EURO-5	2.95	2.95	2.54	2.26	2.31

Source: Handbook on estimation of external costs in the transport sector- IMPACT

Tab. 3.13: Costs of up-down stream processes (fuel production, air pollution and climate changes costs) in €ct/train-km for rail transport (Example Germany, price base 2000)

			Metropolitan	Other Urban	Non Urban
			€ct/ train-km	€ct/ train-km	€ct/ train-km
Passenger	Electric	Locomotive	4.9	4.9	4.9
		Railcar	7.6	7.7	
		High Speed Train			9.2
	Diesel	Locomotive	8.7	8.7	8.7
		Railcar	11.5	11.5	
Freight	Electric	Locomotive			13.7
	Diesel	Locomotive			29.2

Source: Handbook on estimation of external costs in the transport sector- IMPACT

3.4.7 Total external costs' calculation for mode of transport

In the previous paragraphs costs figures have been presented for each mode of transport and for each pollutant element.

Once having the values that can be used for specific cases and corridors, it is necessary to develop an application procedure, as it is suggested in such Handbook. In case one wants to apply the internalization to other countries a detail procedure is explained for each pollutant.

In the present case, since the values are already present and the application will be on Western European countries, the application to the selected corridors will require relatively little additional information.

The calculations will be performed for freight transport, with the following specifications:

- Road Transport: Heavy duty vehicles, driving on motorways during days and nights, Euro Class 4;
- Rail Transport: Electric trains driving days and nights;
- IWW Transport: Dry barges with a capacity between 1000 and 1500 tons.

The specifications above presented are particularly suitable for the specific corridors analyzed in the thesis; nonetheless a wide range of cost figures is presented in the Handbook and can be used according to specific criteria.

Therefore for the purpose of this thesis a tool for the internalization of external costs has been developed.

The calculation's implementation will be performed using an excel application with the required information that are the following:

- Total external cost per mode of transport,
- distance in km,
- loading capacity,
- loading factor,
- total amount of cargo that need to be moved,
- number of vehicles.

The final output will consist in:

- External cost per vehicle, €/v
- total external cost for the entire cargo,
- cost per tonkm, €/tkm,
- cost per ton, €/t.

The image below is showing how the excel tool looks like.

	€/Veh km	distance km	N. Veh	Average capacity	Total external costs €	External cost €/tkm	External cost €/t
Barge	2,99	890	1	1500	**2661**	0,0019933	**1,774**
Rail	1,21	718	2	1000	**1737**	0,00121	**0,868**
Road	0,5675	609	40	25	**13824**	0,0227	**13,82**

Fig. 3.2: Internalization of external cost tool

Source: Own elaboration based on Handbook on estimation of external costs in the transport sector-IMPACT

3.5 Chapter's summary

In this chapter the main theoretical foundations that will be used for the development of the research were presented.

The out of pocket cost items considered were listed and deeply analyzed and the tool implemented for their calculation was presented. This calculation tool constitutes a central element in the development of the work, without which the complete implementation of the research could not take place. This tool is a very flexible instrument that can be adaptable to any corridor, volume, geographical area or type of cargo.

The next step was the investigation of the market structure and mark up composition, the purpose was to obtain more reliable and realistic information on the transport sector. This analysis constitutes also the bridge between the analysis of the out of pocket costs and the investigation of the attributes that influence mode choice, as investigated with interviews mentioned earlier. Once the qualitative attributes were defined, the next step will be their monetary evaluation, so that the generalized cost could be obtained.

To conclude, this chapter illustrated the methodology that will be followed for the internalization of external costs. Input values, obtained from the Handbook on internalization of external costs, were put in a tool developed ad hoc for the external costs internalization and evaluation.

This last part will help in suggesting possible measures for re-balancing of mode share in Europe or to help promoting intermodal transport.

The awareness of the approach and methodology followed are necessary to understand and interpret the results of the work that will be presented in the following chapters, together with this, a necessary definition of the case studies considered and their characteristics is also important. This explains the rational of chapter IV, where the specifications of the corridors considered will be presented.

CHAPTER IV

CORRIDORS' DESCRIPTION

The aim of the present chapter is to facilitate the reader in understanding the areas and corridors where the presented methodology, chapter III, will be applied. It is indeed necessary to have in mind some indicators and information that could help in the reading of the results.

This chapter will deal with the analysis of traffic flows for some specific corridors in Europe. The ones that will be analysed are relevant axes connecting North and South Europe to some geographical areas in the Centre of Europe. The focus will be on traffic flows from the Port of Antwerp, in Belgium, and from the port of Genoa, Italy towards South of Germany, South of France and Switzerland.

The chapter will be structured as follow: the first paragraph will consider some transport indicators for the main European Countries, the next part will deal with a description of the two ports, their characteristics, their modal split; to continue the following paragraph will consider some data on traffic flows and the related identification of the freight corridors, finally a description of the market and services offered on those corridors will be provided.

4.1 Description of traffic flows in Europe

For a better understanding of the freight corridors, it is worth to present a preliminary paragraph dealing with some transport indicators for each of the States involved in the case study.

A first important element is the modal split, this analysis can give an idea of the differences and similarities among the different States. The tables below report the modal split for the last years.

Tab. 4.1: Modal split for road transport (% in total inland freight tons-km) (Data collection ended the 1/08/2011)

Modal split road	**2005**	**2006**	**2007**	**2008**	**2009**
Belgium	72,4	71,1	69,7	68,5	72,9
Germany	66	65,9	65,7	65,5	67
Spain	95,2	95,4	95,9	95,9	96,6
France	80,5	80,9	80,9	80,7	81
Italy	90,3	88,8	87,6	88,3	91
The Netherlands	63,6	63,1	59,4	59,9	63,4
Austria	64,1	63,2	60,9	58,6	59,5
United Kingdom	87,8	85,8	86,6	86,5	86,7

Source: Eurostat

Tab. 4.2: Modal split for rail transport (% in total inland freight tons-km)

Modal split rail	**2005**	**2006**	**2007**	**2008**	**2009**
Belgium	13,4	14,2	15,9	12,8	15,1
Germany	20,3	21,4	21,9	22,2	20,9
Spain	4,8	4,6	4,1	4,1	3,4
France	16	15,7	15,7	15,9	
Italy	9,7	11,4	12,3	11,7	9
The Netherlands	4,4	4,8	5,5	5,4	4,9
Austria	32,8	33,8	34,8	37,4	36,4
United Kingdom	12,1	14,2	13,4	13,4	13,2

Source: Eurostat

Tab. 4.3: Modal split for inland navigation transport (% in total inland freight tons-km)

Modal split Iww	**2005**	**2006**	**2007**	**2008**	**2009**
Belgium	14,1	14,7	14,9	15,6	14,3
Germany	13,6	12,8	12,4	12,3	12,1
France	3,5	3,4	3,4	3,5	4,1
The Netherlands	31,9	32,1	35,1	34,7	
Austria	3	3	4,2	4	4,1
United Kingdom	0,1	0,1	0,1		

Source: Eurostat

It appears evident that the most used mode of transport is road and in Spain it reached rate of 96.6% of the total traffic in 2009. The situation is not different in Italy, France or United Kingdom where the percentage has been always above 80%.

The rates are smaller in Belgium, Germany, The Netherlands and Austria where the other modes of transport have relatively higher rates. Nonetheless rail transport remains limited to small percentages, with some exceptions as such as Germany or Austria where it is showing a stable share.

Inland navigation has an important role in the countries with navigable rivers. Table 4.3 shows the percentage use of inland navigation in Belgium, Germany, The Netherlands, France and Austria. Among those, The Netherlands, with its network of canals and rivers, is the country with the higher utilization rate of inland navigation.

In order to focus on the traffic flows on specific corridors in Europe, an analysis of trade relations between the mentioned states can be functional. The aggregated official data on trade among European states reports on import and export flows classified per typology of commodities, while the indication of the mode of transport is not available.

For the purpose of this thesis, aggregated data regarding all the commodities traded will be reported.

This data will allow understanding the volumes of freight exchanged, and can give an idea of the existing business relations.

A brief overview on the import/export relations will be provided for Italy and Belgium, being the States of major interest for the present work.

Starting from the commercial exchanges between Italy and Belgium, the analysis of their mutual trade shows that there exists a tradition of trade in which Italy imports more than Belgium from the other country.

Table 4.4 reports that in December 2009 the goods imported had a value of 980 Million of Euro, while the export trade valued 661 Million of Euro.

In the case of the business relation between Italy and Belgium the economic crisis of 2008, affected remarkably the value of the traffic trade, as shown in table 4.6.

For Italy, Germany is the main business partner, also in this case the value of goods imported prevails on the export, and nonetheless the figures have a much higher consistency. According to the data published by OECD, this type of relation has always characterized the economic relations between Italy and Germany.

In December 2009, the variations in respect to December 2008 are positive for the values imported, while there was a decline of 1.3% for the good exported from Italy.

The second Italian partner, both for import and export is France, with which Italy entertains almost equivalent amount of import and export activities. Table 4.4 shows that in December 2009, the export value was slightly higher than import.

The comparison with the data of 2008 demonstrates that the business relations were not heavily affected by the economic crisis.

On the others side, when considering the main import countries, it emerges that Italy imports goods from Germany and France, as already said, and in sequence from The Netherlands, China, Russia, Spain, Belgium and Switzerland.

This brings to conclude that, on a Western European scale the main Italian economical partners are: Germany, France, Spain, Switzerland, United Kingdom, Belgium and The Netherlands.

Tab. 4.4: Import and export per country, December 2009 (Ml of Euro, % variation related to the same month of the previous year)

Countries	**Exports**		**Import**	
	Value	Var. %	Value	Var. %
Germany	2.797	-1,6	4.343	7,9
France	2.767	6,9	2.323	7,4
United States	1.392	-23,8	794	-17,1
Spain	1.358	1,6	1.092	5,3
Switzerland	1.217	10,9	871	-8
United Kingdom	1.190	2,7	867	10
Belgium	661	-6	980	4,5
Cina	661	16,2	1.373	-21,7
Turkey	625	36,9	354	16,8
Poland	613	-2,2	578	31,4
The Netherlands	572	-4,4	1.458	3,9
Portugal	518	129,7	95	-8,4

Austria	507	-8,7	588	-7,2
Russia	500	-33,8	1.117	-15,2
Greece	436	-10,8	138	13,7
Other countries	9.231	-7,7	8.189	-12,7

Source: Istat

A better idea of the relevance of the traffic flows can be find in table 4.5.

As already described Germany constitutes the main European partner, with 32.6% of the total trade between Italy and the listed Countries; Italy exports 22.1% of its goods to Germany.

The relevance of the trade with France is counting for 21.9% in export and 17.4% in import.

Tab. 4.5: Italian Import and export per country, December 2009 (% of the values)

Country	Export	Import
Germany	22,1	32,6
France	21,9	17,4
Spain	10,7	8,2
Switzerland	9,6	6,5
United Kingdom	9,4	6,5
Belgium	5,2	7,4
Poland	4,9	4,3
The Netherlands	4,5	10,9
Portugal	4,1	0,7
Austria	4,0	4,4
Greece	3,5	1,0
Total	100,0	100,0

Source: Own elaboration based on Istat data

When looking at the Belgian commercial partners, Italy is one of the main countries, especially for the export trade. This conclusion, as already mentioned before from the Italian sources, it is confirmed both by the figures of December 2009, figure 4.1. Notwithstanding the difference in the values provided by the two National sources, the Italian and the Belgium, the indication about the type of commercial relations within these two member states it is quite obvious.

The countries where Belgium exports more are: France, Germany and The Netherlands followed by United Kingdom.

This data is confirmed both from the yearly statistics and by the commercial activities of December 2009.

The same nations constitute the main producers of the goods that Belgium imports in its territory. Actually a large quantity of the imported products come from The Netherlands, the provisional figures of the Belgium National Bank state that Belgium imported goods for a value of 41.5 million of Euro. On a ranking scale the main import countries are: Germany, France, United Kingdom, Italy and Spain.

In the analysis of the main Western European commercial trade, it is not surprising that the important business flows are developed among those states.

	2009						
	déc.						
	Exportations			Importations			Balance commerciale
	Total	Variations par rapport à la période correspondante de l'année précédente		Total	Variations par rapport à la période correspondante de l'année précédente		Total
	millions d'euros [1]	en p.c.	millions d'euros	millions d'euros [1]	en p.c.	millions d'euros	millions d'euros
Total général	**15.881,3**	**10,4**	**1.497,4**	**17.141,0**	**8,4**	**1.323,9**	**-1.259,7**
Europe	**11.833,9**	**4,9**	**550,6**	**13.916,1**	**12,9**	**1.587,9**	**-2.082,2**
Union européenne	**11.184,3**	**5,7**	**605,1**	**12.589,6**	**10,1**	**1.157,0**	**-1.405,3**
Union Economique et Monétaire	9.229,3	5,1	450,4	10.899,4	11,0	1.082,8	-1.670,1
France	2.720,4	1,9	51,5	2.317,2	15,5	310,4	403,2
Luxembourg	362,6	9,1	30,2	153,5	-7,4	-12,3	209,1
Pays-Bas	2.139,6	3,2	65,3	4.047,5	9,8	359,9	-1.907,9
Allemagne	2.378,3	8,3	181,9	2.846,2	10,3	265,1	-467,9
Italie	600,7	6,5	36,5	534,9	1,0	5,5	65,8
Irlande	74,2	-21,1	-19,8	248,2	22,5	45,6	-174,0
Grèce	128,3	45,3	40,0	13,5	0,0	0,0	114,8
Portugal	87,4	2,0	1,7	70,4	27,3	15,1	17,0
Espagne	436,3	12,5	48,4	420,3	18,5	65,5	16,0
Finlande	74,1	-6,3	-5,0	77,7	19,5	12,7	-3,6
Autriche	144,6	7,0	9,5	111,2	6,1	6,4	33,4
Slovénie	27,1	29,1	6,1	8,1	-27,7	-3,1	19,0
Malte	4,2	-19,2	-1,0	5,9	110,7	3,1	-1,7
Chypre	16,4	45,1	5,1	2,4	-4,0	-0,1	14,0
Slovaquie	34,9	-1,7	-0,6	42,5	26,5	8,9	-7,6
Autres pays de l'Union Européenne	1.955,0	8,6	155,5	1.690,2	4,6	74,3	264,8
Royaume-Uni	1.124,7	20,7	192,8	746,1	-2,7	-20,5	378,6
Danemark	124,3	-14,3	-20,7	106,1	45,3	33,1	18,2
Suède	205,2	6,5	12,5	299,8	0,5	1,5	-94,6
Estonie	7,4	-1,3	-0,1	4,3	-2,3	-0,1	3,1
Lettonie	8,1	26,6	1,7	4,2	20,0	0,7	3,9
Lituanie	20,0	-19,7	-4,9	8,1	-50,0	-8,1	11,9
Pologne	235,0	-3,0	-7,3	178,3	6,4	10,7	56,7
Tchéquie	116,6	-9,5	-12,3	143,7	-2,7	-4,0	-27,1
Hongrie	49,3	-22,7	-14,5	70,1	-1,1	-0,8	-20,8
Bulgarie	19,3	-2,0	-0,4	96,6	136,8	55,8	-77,3
Roumanie	45,1	23,9	8,7	32,9	22,3	6,0	12,2
Autres pays européens	649,6	-7,7	-54,6	1.326,5	48,1	430,9	-676,9
Norvège	71,4	-11,3	-9,1	221,2	-32,2	-104,9	-149,8
Suisse	175,8	-28,9	-71,4	553,7	236,0	388,9	-377,9
Turquie	157,8	33,7	39,8	92,2	-14,5	-15,6	65,6
Russie	131,3	-22,3	-37,7	416,7	79,0	183,9	-285,4
Autres pays d'Europe	113,4	26,7	23,9	42,6	-33,5	-21,5	70,8

Fig. 4.1: Import and export per country, December 2009 (Ml of Euro, % variation related to the same month of the previous year, constant values)

Source: National Bank of Belgium (NBB website)

Tab. 4.6: Belgian Import and export per country, December 2009 (% of the values)

Country	Export	Import
France	28,0	20,0
The Netherlands	22,0	35,0
Germany	24,5	24,6
Italy	6,2	4,6
Spain	4,5	3,6
Switzerland	1,8	4,8
Austria	1,5	1,0

United Kingdom	11,6	6,4
Total	100,0	100,0

Source: Own elaboration based on NBB data

As stated earlier, the focus of this work will be on some freight corridors passing through Western Europe, a number of indicators regarding national characteristics have been already presented. It is though, expedient to narrow the analysis to some economics and transport indicators for the specific areas investigated.

The origins or destinations of the corridors will be the Port of Antwerp, in the case of Belgium and the Port of Genoa for the Italian side. Those two ports belong, respectively, to the Area of the Province of Antwerp and to Ligurian Region, according to NUTS 2 regions, established on European level.

It will be reductive to use just some economics figures to describe those areas, especially because the freight flows arriving or ending in those two ports have a broader hinterland that is not limited to the belonging NUTS 2 regions.

In order to evaluate the two regions, it will be interesting to compare the modal split for those areas; the analysis can not be easily performed due to lack of data, and in case they exist, they are not comparable.

In Italy, the only available data on the region's modal split, reports the % of tons of goods moved by rail or by road transport, this study is developed by the National Institute of Statistics, ISTAT.

The reported figure shows the evolution of the modal split from 1995 to 2005, being the most update data. The figure refers to the tons of goods, incoming and leaving the region, divided by mode of transport.

Tab. 4.7: Modal split in Liguria (%)

Freight Modal split											
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Rail transport	12,8	11,7	10,2	11,7	....	13,2	12,0	10,7	9,9	8,8	8,2
Road transport	70,6	67,8	64,2	67,5	....	69,4	69,3	70,5	70,5	74,3	75,6

Source: own elaboration on Istat data

It is clear that the majority of the traffic is moved by road transport, and according to the Italian Institute of Statistics, the percentage of road transport increased in the most recent years, taking traffic from rail transport. Indeed the percentage of cargo moved by road was decreasing between 1996 and 2000; since that date the volume start growing again. The share of rail transport is undoubtedly lower than road and in the last years it decreased constantly.

Similar indications were not found for the Antwerp's province. It was nonetheless possible to find some data on the total volume of freight for inland navigation and road transport for the Province of Antwerp.

According to the Belgian institute of statistics, in 2006 the goods moved by inland navigation were 52.098 tons (pp. 36, Vervoor Binnenscheepvaart, 2008), while the amount on national volume moved by trucks were 29.181 tons in 2009, data published by the same source. (Goederenvervoer over de weg door Belgische voertuigen met minstens een ton laadvermogen in 2009, 2010). No available data were found for rail traffic or modal split for the province of Antwerp.

4.2 Port of Antwerp and Port of Genoa: description, characteristics, modal split

The attention will be addressed to the two main ports located in the areas of the Province of Antwerp and the Ligurian region. Considering that the case studies for freight corridors are related to those two ports, a preliminary overview on their nature and characteristics is provided.

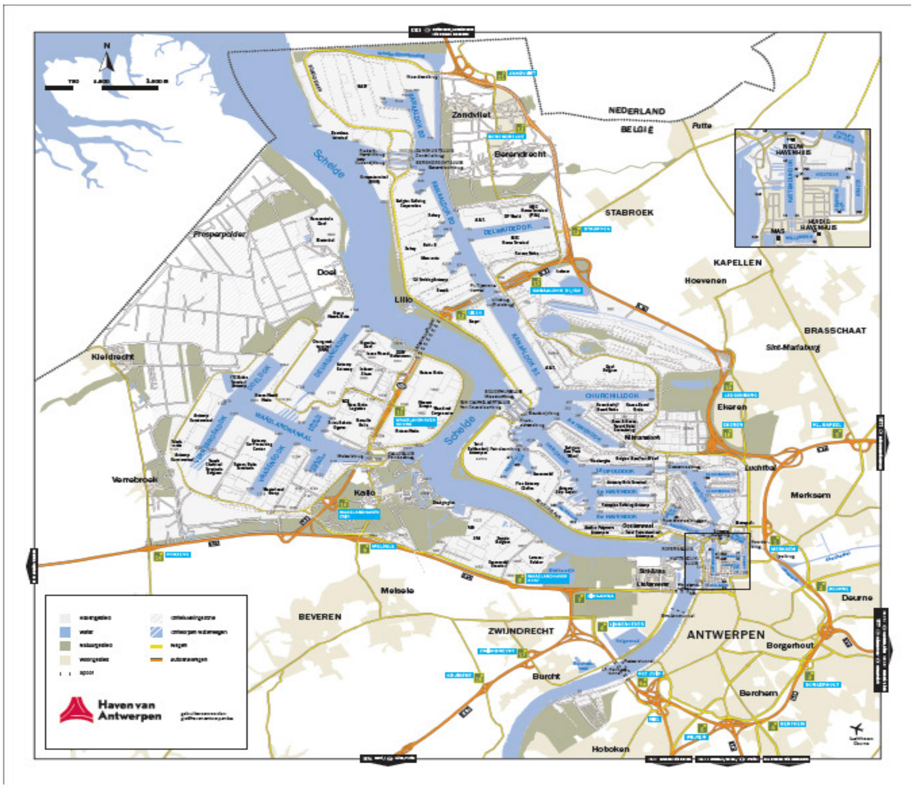
The two ports differ for several aspects, firstly their economic position in the European port scenario, namely related to their throughput and volume of traffic. Even without considering additional dissimilarities, this element will prevent to make a comparative analysis of the two scenarios. Being well aware of the current differences between the two ports and the actual impossibility to develop a head to head comparison, the ongoing process of gaining freight traffic to the detriment of competitor ports is a priority for each of them.

Moreover Antwerp and Genoa represent two of the main ports respectively in the Northern and Southern ranges; the Hamburg-Le Havre range and the Mediterranean range are constantly competing for increasing their volumes and therefore their market share.

When looking at the container sector, the Hamburg-Le Havre range handles about half of the total European container throughput. During the years 1980s-1990s the Mediterranean ports grew remarkably, while in the last decade the position of the Northern ports improved.

The two maps below represent the actual situation of the two ports, in terms of infrastructures and commercial activities. The two ports are constantly modifying their structures according to new developments and enlargements.

Map 4.1: Port of Antwerp in 2010



Source: Antwerp Port Authority

Map 4.2: Port of Genoa in 2010

Source: Genoa Port Authority

In the European scene the Port of Antwerp is among the firsts for each typology of goods moved in its docks. One of the main business activities is related to the container traffic, in 2009 Antwerp was the second port in Europe per TEU moved, with an amount of 7.309 Million of TEU.

In respect to the other business trade, it can be observed that the predominance is given to general cargo, in which Antwerp had the second best performance in 2009, with an amount of 100.900 Million of tons. (Espo, 2010)

Tab. 4.8: Antwerp cargo typology (%)

Year	General cargo	Ro-Ro	Liquid bulk	Dry bulk
2009	69	1,6	21,3	7,8
2008	63,1	2,3	20,3	14,1
2007	63,4	2,3	21,1	13,0
2006	60,1	2,2	22,3	15,2
2005	58,7	2,2	22,6	16,4
2004	57,4	2,4	22,5	17,4
2003	55,9	2,3	24,0	17,7
2002	54,32	2,50	23,70	19,48
2001	51,26	2,44	25,84	20,46
2000	51,34	2,50	25,42	20,73

Source: own elaboration on Antwerp Port Authority data

As already stated before, the volume of traffic handled in the Port of Genoa is steadily lower than the Antwerp's one. Nonetheless Genoa is the main Italian port for container traffic, excluding of course the transhipment port of Gioia Tauro, and one of the most important in the Mediterranean scale.

When having a look at the composition of the cargo traffic, it is noticeable that the major part of the traffic is liquid bulk, followed by container traffic.

Despite the fact that liquid traffic is a substantial part of the Genoese traffic, the total amount is not comparable with the volumes handled by the top competitor's ports. Ro-Ro traffic represents an important compartment of the maritime sector, in 2007 Genoa had a market share of 1.7% among the other top twenty European Ro-Ro ports.

Table 4.9 presents the traffic of the port of Genoa, for the last years, dived by cargo typology. The element that attracts the attention is the high relevance of liquid bulk traffic that is superior to container traffic, reaching almost 45% in 2009. The second core sector for Genoa is the container traffic, accounting for 37% in 2010.

Tab. 4.9: Genoa cargo typology (tons and %)

	2004	2005	2006	2007	2008	2009	2010
Container (tons)	15.913.679	16.074.744	16.546.974	18.772.228	17.823.904	15.179.538	17.655.776
General Cargo	9.582.750	9.449.040	9.985.050	10.949.391	9.889.963	8.279.276	8.279.276
Dry Bulk	9.320.055	8.201.104	6.797.321	5.992.603	1.922.906	1.606.062	1.648.553
Liquid Bulk	21.020.385	21.464.331	21.640.834	21.475.333	21.005.919	20.310.343	19.696.708
Total	55.836.869	55.189.219	54.970.179	57.189.555	50.642.692	45.375.219	47.742.806
Container (%)	28,5	29,1	30,1	32,8	35,2	33,5	37
General Cargo	17,1	17,1	18,1	19,1	19,5	18,2	17,3
Dry Bulk	16,6	14,8	12,3	10,4	3,8	3,5	3,5
Liquid Bulk	37,6	38,8	39,3	37,5	41,5	44,8	41,3

Source: own elaboration on Genoa Port Authority data

A crucial aspect, in this thesis, is the hinterland modal split for each of the ports investigated. The topic is assuming more and more relevance, especially in relation to environmental concerns, infrastructural problems and connectivity to the hinterland.

Nonetheless, a structural and consistent procedure for the collection of this data does not exist on a European level.

The analysis will therefore concentrate on the data available for each case, namely using as sources of information Antwerp Port Authority of and Genoa Port Authority.

Antwerp Port Authority publishes annual figures on the modal split dived by three modes of transports: road transport, rail transport and inland navigation transport. It is important to bear in mind that these data are showing the modal split for the freight leaving the port, regardless the final destination and the possibility to change mode of transport during the journey.

Table 4.10 reports the modal split from 2001 for the total traffic of the port.

Tab. 4.10: Antwerp total modal split 2001-2006

	Road	Rail	Inland navigation
2001	41	17	42
2002	40	20	40
2003	40	20	40
2004	40	20	40
2005	40	20	40
2006	40	20	40

Source: Meersman et al., 2009 and 2010

Table 4.10 shows that the total modal split did not vary consistently during the last years, the share or road and rail transport is similar and predominant, while rail transport is lagged behind.

When looking in detail at the container modal split, table 4.11, it can be observed that there is a clear pattern for the shares expressed by each mode of transport.

Road transport is the most popular mode of transport for inland container movements; during the last 14 years, the share of road transport diminished to advantage of inland navigation and rail transport, even so more than half of the traffic reaching the port, is doing it with trucks.

Rail transport is really finding difficulties in establish itself as a competitive substitute to road.

Tab. 4.11: Antwerp Container modal split 2001-2009

	Road	Rail	Inland navigation
2001	66,1	8,8	25,1
2002	61,2	9,3	29,5
2003	60,8	8,8	30,4
2004	59,7	9,2	31,2
2005	58,7	8,7	32,6
2006	59,2	8,6	32,3
2007	56,6	10,5	33
2008	56,6	11	32,4

2009	55,4	10	34,6

Source: Antwerp Port Authority

The state of the port of Genoa is different from the situation in Antwerp, especially for the hinterland network, where just roads and railways exist.

The modal split of the hinterland traffic is therefore divided in two modes of transport, instead of three.

What it is similar with the modal split of the North European port, is the lack in the use of rail services.

The official sources, states that approximately 80% of the Genoese traffic is arriving or leaving the port by road, while for the remaining 20% rail transport is used. (Puliafito et al., 2008)

An accurate yearly modal split for the Port of Genoa was not available from the Port Authority, therefore the only accessible information is the one reported above.

4.3 Data on traffic flows and description of the corridors

The selection process for choosing freight corridors should rise from a careful analysis of the European traffic flows; unfortunately this type of data is not homogeneous and not always available from Port Authorities or from other official sources.

The hinterland traffic information available from port authorities in Europe is often fragmented and only few ports collect this information and some times only for few hinterland regions.

Even when comparing the different statistics from port authorities, this data are not always consistent both in absolute figures as well as in the deployed definition. Therefore there is a lack of useable information allowing for a comprehensive analysis based on real data. Given the mentioned considerations, a description of the current state of freight flows from the two ports, according to data collected from Port Authorities, Customs offices and various reports, will be presented.

The port of Antwerp reports data on modal split for rail and inland navigation, divided by country of origin/destination.

The latest rail traffic information date 2006 and what appears clear is that the majority of hinterland rail traffic has France as origin and destination, with 29.3% of the total rail traffic.

The following destinations are Germany and Italy, respectively with 20.1% and 16.9%.

The most update data on inland navigation traffic are from 2009 and the results show that almost half of the inland navigation traffic is heading towards The Netherlands, 48% and the rest is either staying in Belgium, 24.2% or going to Germany, 21.2%.

An additional elaboration on the data will allow providing information about the modal split for specific regions or areas in Europe.

The last useful report dates 2007, and the table below shows the modal split for each of the main regions. The figures below represent a census data, therefore it is not possible to generalize these values and it is important to read the data bearing in mind this limitations.

Tab. 4.12: Modal split divided by destination regions, 2007

Destination	Iww	Rail	Road
Province1 (Austria)	-	-	100,00
Province2 (Austria)	-	70,73	29,27
Upper Austria	-	100,00	-
Total Austria	**-**	**37,41**	**62,59**
Province2 (Belgium)	-	-	100,00
Brussels Region	-	-	100,00
Flemish Region	-		
Flemish Region	12,88	1,16	85,96
Walloon Region	5,72	44,07	50,21
Total Belgium	**10,54**	**15,87**	**73,60**
Province (Switzerland)	78,07	14,22	7,71
Total Switzerland	**78,07**	**14,22**	**7,71**
Province2 (Germany)	0,39	-	99,61
Baden-Württemberg	82,95	8,31	8,73
Bayern	32,34	39,15	28,51
Bremen	60,09	-	39,91
Hamburg	1,75	-	98,25
Hessen	82,06	4,30	13,65
Niedersachsen	86,66	-	13,34
Nordrhein-Westfalen	57,25	7,39	35,36
Rheinland-Pfalz	79,64	1,71	18,65

Saarland	2,16	-	97,84
Sachsen	-	-	100,00
Sachsen-Anhalt	-	-	100,00
Schleswig-Holstein	30,42	-	69,58
Thuringen	-	-	100,00
Total Germany	**66,49**	**6,37**	**27,14**
Province2 (France)	0,31	-	99,69
Alsace	42,68	24,93	32,39
Aquitaine	-	40,02	59,98
Auvergne	-	-	100,00
Basse-Normandie	-	-	100,00
Bourgogne	-	39,56	60,44
Bretagne	-	-	100,00
Centre	-	-	100,00
Champagne-Ardennes	1,24	-	98,76
Franche-Comté	1,06	66,35	32,59
Haute-Normandie	-	-	100,00
Ile-de-France	0,71	-	99,29
Languedoc-Roussillion	-	93,90	6,10
Lorraine	1,38	-	98,62
Midi-Pyrénées	-	-	100,00
Nord-Pas-de-Calais	19,44	-	80,56
Pays de le Loire	-	-	100,00
Picardie	-	-	100,00
Poitou-Charentes	-	-	100,00
Provence-Alps-Côte d'Azur	-	79,80	20,20
Rhone-Alps	-	52,79	47,21
Total France	**12,68**	**11,35**	**75,97**
Province(Italy)	-	98,84	1,16
Total Italy	**-**	**98,84**	**1,16**
Province2 (The Netherlands)	0,18	-	99,82
Drenthe	-	-	100,00
Flevoland	-	-	100,00
Friesland	-	-	100,00
Gelderland	41,22	-	58,78
Groningen	9,76	-	90,24
Limburg	49,01	-	50,99
Nord-Brabant	37,82	-	62,18
Nord-Holland	78,76	-	21,24
Overijsel	35,43	-	64,57
Utrecht	23,99	-	76,01
Zeeland	58,04	-	41,96
Zuid-Holland	77,65	7,23	15,11
Total The Netherlands	**63,84**	**3,77**	**32,39**

Source: Own elaboration on Antwerp Port Authority data

For each of the main countries reported, a brief explanation is provided.

For Switzerland, most part of the freight is shipped by inland navigation; this aspect is clearly explained by the connection trough the River Rhine from Basel to the North Sea. Quite relatively low percentage is moved by road transport, this could also be explained by the fact that there are also numerous train connections between Belgium and Switzerland.

The goods from and to Germany are mainly transported by inland navigation, also in this case the river connection and network of channels explains the use of such high rate of inland navigation transport 66.4% followed by road transport, 27.1%, there are indeed some areas where major part of the traffic is going by road, especially in areas where river connections are not present.

The situation with France is completely reverse compared to the previous ones; here most of the cargo is moved by road transport, 75.9% and the rest equally shared by the two remaining modes. The destinations that are reached by rail transport are in general the most distant destination from Antwerp, therefore the south of France.

From the data of the Antwerp's port Authority, the traffic to Italy is moved essentially by rail transport not having distinctions among Italians' regions, while for/to The Netherlands the most used mode of transport is again inland navigation with 63.8% of the share. It is rather intuitive that the network of rivers and channels contribute to the development of such connections between Antwerp and the neighbouring country.

Looking in detail at the regions of origin and destination in those countries, it does not surprise that many of these areas represent industrial, production or commercial centres.

Taking the case of Germany, the traffic flows are mainly connecting Antwerp with the Nordrhein-Westfalen, Rheinland-Pfalz, Hessen and the Baden-Wurttemberg area. The main centres, in those regions, can be identified with the city of: Duisburg, Köln, Dortmund, Ludwigshafen, Mannheim, Karlsruhe and Frankfurt.

In France the main origins/destinations of traffic flows are: Nord Pas de Calais, Alsace, Ile de France, within those regions the principal cities are: Lille, Donquerque, Calais, Strasbourg, Mets, Paris.

To conclude, in relation to The Netherlands, most of the traffic from/to Antwerp goes to Sud-Holland, Zeeland and Nord-Brabamnt, namely the city of Rotterdam, Dordrecht, Eindhoven, Breda, Terneuzeen.

The analysis of the traffic flows of the port of Genoa does not allow to be precise and to specify the European regions of destinations; this element does not permit a consistent and comparable analysis for the hinterlands of the two ports.

Nonetheless, some data about the modal split from the port of Genoa to the neighbouring countries are collected by the Customs offices located on the territory.

Unlikely the level of detail of this information is not extremely precise; one of the reasons behind this lack of accuracy is due to the free circulation of goods inside Europe, and therefore the minor level of information that the Customs collect on a European scale.

Having in mind this limit, some indications are provided.

In general it is true to assert that almost all the traffic leaving from the port of Genoa is reaching its final destination by road transport, regardless the distance or the country.

From 2006 to 2008, road transport has been used from 80% to 99% to reach destinations in Switzerland, Germany, Belgium and France. Additional information about the precise region or area of destination is not collected in the elaboration of the customs database, and a more extensive report of the data collected is not permitted, due to privacy reasons. (Italian Customs direct contacts)

4.4 Freight corridors: characteristics and services provided

Due to the lack of official data on traffic flows, the selection of the freight corridors derives from the abovementioned criteria and from the suggestions given by the few official information collected.

One of the main aims of the selection was to analyse and compare freight corridors that could be leaving from the port areas and ending in some economical important destinations in the centre of Europe.

As it seems from the description provided before, the hinterland of the Port of Antwerp is quite extended and larger that the Genoese one; while the hinterland of the Port of Genoa is limited to the North of Italy.

Taking this in consideration, one could argue that the two ports are not really competing in their hinterlands and therefore there is no need to compare traffic flows and hinterland modal split.

This assumption is incorrect, since a large volume of freight designated to the centre of Europe is passing from the Northern ports instead of the Southern ports, even though the distances could be shorter. The Mediterranean ports are well aware of the competition that they are suffering and in order to reduce it, they will have to come up with strategies and actions to reduce the market power of the Northern ports, as it was earlier proved in Valleri and Van de Voorde, 1993. Moreover the role of hinterland connections in the Ligurian region has been deeply studied (Ferrari et al., 2011) and it has been showed how the penetration capacity into the hinterland is a crucial factor in inter-port competition.

Some relevant catchment areas can be identified in the centre of Western Europe, such as South France, South Germany or Switzerland.

Those regions constitute current destinations for traffic flows from the Port of Antwerp, as stated earlier, and could be possible destinations for the goods unloaded in the port of Genoa; in this case it is not easy to prove the existence of traffic flows, due to the lack of certified data.

The detailed analysis of freight corridors will therefore consider origins and destinations in those areas and namely from/to the Ports of Antwerp and Genoa to Basel, in Switzerland, to the area of Hessen and Baden Wurttemberg, in South West Germany and to Strasbourg in Alsace.

For each corridor a brief description will be presented, taking into account some geographical characteristics and the transport services that are currently provided.

A preliminary remark is needed; during the elaboration of the work some difficulties were encountered in defining the exact distance between origin and destination for each mode of transport.

While for road transport, it is relatively easy, due to use of several route planner tools available online, for rail transport and inland navigation those tools do not exists for general consultation, but just on a company or industry level. For thoroughness' sake there exists a site toll that provides rather detailed information about rail transport, though this tool is mainly associated to infrastructure and track costs. (www.railneteurope.com) Therefore the indications of distances have been collected through expert consultations.

Some indications about the supply side are illustrated later, in order to give an overview of possible solutions when wanted to move cargo between two points.

The data refers to spring 2011, obviously, this information can change according to the market evolution and business strategy; the following schedules can be interpreted such as a current picture.

The information reported refers to rail transport and inland navigation transport, as it can be expected the amount of road companies offering services is numerous and fragmented.

4.4.1 Antwerp-Basel Corridor

For what concerns the services offered in the Port of Antwerp's hinterland, the main source of information is the site of the Antwerp Port Authority; in its "multimodal" section, links to the each mode of transport are presented.

The site offers the possibility to check available services for rail and inland navigation from the Port of Antwerp to several destinations in Europe, defining the operator that runs the service, the frequency, the typology and other useful information. (www.containerafvaarten.be, Railways Departures List, http://www.portofantwerp.com/)

Taking this site as a starting point, additional information has been found on the each operator's web sites.

The first corridor taken into consideration is the one leaving from the Port of Antwerp to the city of Basel in North West Switzerland, and vice-versa.

The distances between the two locations are different according to the mode of transport used, namely: 609 km for road transport, 890 km for inland navigation and 718 km for rail transport.

Map 4.3: Antwerp-Basel Corridor

Source: own elaboration based on internet sources

Below inland navigation services and rail services are reported.

Tab. 4.13: Inland navigation services from/to Antwerp-Basel

Company name	Frequency
A.R.S. Agencies	3/w
CFNR	3/w
Contargo	3/w
Danser Container Line b.v.	3/w
Haeger & Schmidt Int. GmbH	2/w

Source: own elaboration based on internet sites

Tab. 4.14: Rail services from/to Antwerp-Basel

Company name	Frequency

Hupac	8/w
Kombiverkeher	5/w

Source: own elaboration based on internet sites

As far as inland navigation is concerned, the amount of services offered on this route is quite high; 5 operators offer services from Antwerp to Basel and on the way back. It can also be observed that the frequency of these services varies from two to three services a week. The route followed to exploit these services goes from the Antwerp's channels to the river Rhine up to Basel.

The companies operating the services have their headquarters in Belgium, The Netherlands, Germany and France.

The companies that perform rail transport between these two points are the one reported in table 4.14. There could be, of course, that other rail or intermodal companies provide rail services between different origins/destinations located very near by the ones considered in this study.

Two intermodal operators provides shuttle services, with a frequency of 5 and 8 services a week, covering the full distance in approximately 16 hours from Antwerp to Basel and 18 for the return trip.

4.4.2 Antwerp-Frankfurt Corridor

The second corridor is connecting the port of Antwerp to Frankfurt, in Germany, as it can be seen in map 4.4; according to sources used the distances that connect the two points are: 402 km by road, 600 km by inland navigation and 400 km by rail transport. In the two following tables the services supplied by barge operators and rail operators are reported.

Map 4.4: Antwerp-Frankfurt Corridor

Source: own elaboration based on internet sources

Tab. 4.15: Inland navigation services from/to Antwerp-Frankfurt

Company name	Frequency
A.R.S. Agencies	2/w
Contargo	3/w
Haeger & Schmidt Int. GmbH	3/w
Rhinecontainer b.v.	2/w

Source: own elaboration based on internet sites

Tab. 4.16: Rail services from/to Antwerp-Frankfurt

Company name	Frequency
MSC Medlog	2/w

Source: own elaboration based on internet sites

What appears from the tables above is that the inland navigation supply is slightly bigger than rail services, since the inland navigation operators are four, while there is only a single rail operator. It can be observed that for rail transport the service is provided by a maritime company operating its own train. Concerning inland navigation, the services are provided with a frequency of 2/3 times a week, exploiting the service in 4 days upstream and 3 days downstream. In addition to the direct connections between the two points, there are other services, both by inland navigation and by rail to destinations close to Frankfurt, as such as Mannheim or Ludwigshafen.

There are regular inland navigation services to/from these two destinations, with respectively three operators on the route Antwerp-Mannheim and two operators between Antwerp and Ludwigshafen.

Even higher is the number of rail services, daily connections, excluding the weekend, between Antwerp and the two German cities. The intermodal operator that provides the service on these routes is Hupac.

4.4.3 Antwerp-Strasbourg Corridor

The corridor Antwerp-Strasburg connects the Belgian port with a south east French city that is 472 km away by road, 775 km by inland navigation and 580 km by rail.

As for the previous corridors, there are scheduled inland navigation and rail services that are provided on this route.

A brief overview is provided in the tables 4.17 and 4.18.

Map 4.5: Antwerp-Strasburg Corridor

Source: own elaboration based on internet sources

Tab. 4.17: Inland navigation services from/to Antwerp-Strasburg

Company name	Frequency
A.R.S. Agencies	3/w
CFNR	2/w
Contargo	3/w
Danser Container Line b.v.	3/w
Haeger & Schmidt Int. GmbH	3/w

Source: own elaboration based on internet sites

Tab. 4.18: Rail services from/to Antwerp-Strasburg

Company name	Frequency
IFB/Naviland cargo	4/w
IFB	4/w

Source: own elaboration based on internet sites

What captures the attention is the high number of inland navigation services; there are five barge operators. The only intermodal operator offering rail services is IFB, with a double service four times a week.

4.4.4 *Genoa-Basel Corridor*

In this corridor, Genoa-Basel, the only two utilizable modes of transport are road transport and rail transport; this rule will be, of course, valid for all the corridors connecting the port of Genoa with its destinations.

The road distances between the two locations are 474 km, while for rail transport the distance is 456 km.

Map 4.6: Genoa-Basel Corridor

Source: own elaboration based on internet sources

The collection of the information for the Italian side, required a more complex procedure consisting in checking the websites of the main rail and intermodal companies operating in this area.

The results of the analysis were quite disappointing although foreseen; at the current moment there are no fixed rail services from Genoa and Basel. The reasons are different and numerous and will be analyzed further on.

It is worth to mention that some rail services exist between Busto Arsizio and Gallarate, close to Milan, to Aarau by the company Hupac. An other service of CrossRail, is connecting the city of Novara to Basel.

4.4.5 Genoa-Frankfurt Corridor

The distances, in kilometres, between the port of Genoa and Frankfurt are 800 km by road and 788 km by rail; the geographical location is visible in map 4.7, showing the two locations on the European map.

Also in this case, direct rail connections are missing; there are nonetheless rail services between origins and destinations from the closer hinterland of the port of Genoa to some of the analysed destinations in Centre Europe.

This is the case of the intermodal operator Hupac that is providing a direct service every day between Busto Arsizio/Gallarate and Ludwigshafen. Kombiverkher, a German intermodal company, is providing the same service, Busto Arsizio-Frankfurt with a regular schedule and a frequency of 6/7 days. Kombiverkher provides similar connections between Frankfurt and Milan Smistamento.

Map 4.7 Genoa-Frankfurt Corridor

Source: own elaboration based on internet sources

4.4.6 Genoa-Strasbourg Corridor

From Genoa it is possible to reach Strasbourg by road transport covering 612 km, while by rail the distance is 580 km.

According to the consulted sources, it seems that there are no direct or closer connections for this route. This can be possibly due to a lack of transport demand between Genoa and Strasbourg.

On the contrary, what emerged from the analysis of the supply side is that there are direct rail connections between the Port of Antwerp and some destinations in North Italy. This implies that the Antwerp hinterland market is rather expanded.

Map 4.8: Genoa-Strasbourg Corridor

Source: own elaboration based on internet sources

After having analysed the services provided on these corridors, what appears clear is that there is a big differentiation between the hinterland connections of the port of Antwerp and the Genoese one. The port of Antwerp has a natural advantage given by the inland navigation connections trough rivers and channels, nonetheless also in relation to the rail hinterland connections Antwerp is undeniable better off than Genoa. These dissimilarities bring substantial difference in the market areas and the competitiveness of the two ports. This is also confirmed in Ferrari et al. (2001).

According to the indications on modal split presented before and on the information on service available on the selected corridors, one could argue that the corridors from Antwerp to the specific destinations are actually resembling a situation where intermodal transport is relatively diffuse, hence there will be no need to further investigate these corridors. The reasons of this choice are easily explained by the fact that the data on Antwerp modal split for different areas are taken from a census study, therefore they could change during time, as well as the number and typology of services offered. Moreover, taking the corridors from Antwerp to the selected destinations can actually represent an exercise aiming at testing the competitiveness of intermodal transport on these routes.

4.5 Chapter's summary

The current chapter presented some information on the areas, ports and corridors that will be examined in this study. The content of this chapter is useful to better understand and locate the specific corridors analyzed.

The first part of the chapter was mainly looking at general information on traffic flows and trade relationships between Belgium, Italy and the neighbouring countries, showing the importance that traffic flows always had between the two countries and also in relation to Germany and France.

The analysis was then narrowed to the two ports of Antwerp and Genoa, at their commercial characteristics and their hinterland connections with the related information on the modal split.

The last part of the chapter focused on the six freight corridors considered, proving the reader information on their physical location, their main characteristics, as well as the service offered on these routes.

At this stage no further information are required before starting the analysis of the results, since the methodological framework has been established in chapter III and a detailed description of the areas of application has been presented above.

In the next chapters the author is presenting the results obtained during the development of the research.

CHAPTER V

RESULTS OF THE OUT-OF-POCKET COSTS ANALYSIS FOR TRANSPORT OPERATORS

With chapter V the core of the thesis will start, illustrating the main results obtained by the development of the methodology presented in chapter III and applied on the corridors described in chapter IV.

In particularly, this chapter will provide the outcome of the calculations elaborated with the developed tool, in order to obtain the out of pocket costs for each freight corridor.

The out of pocket costs related to intermodal transport and a comparison with the uni-modal solutions will guide the reader into the analysis of the different modes of transport and their comparison on the specific routes. Transport costs constitute a crucial aspect in the mode choice of the shippers or freight forwarders, due to the relevance of this aspect, a monetary analysis can help in understanding the decision processes that influence their choices. In order to do so, some case studies will be analysed, taking into consideration the listed freight corridors in Europe to which the described methodology will be applied. The calculation of the out of pocket cost for each mode will be performed based on the cost functions presented earlier.

An analysis of the preferred mode of transport, according to the pure out of pocket costs, will be provided, together with additional elaborations on the hourly, kilometre and ton/km costs.

The research brought the author to the investigation of the main cost items that weight more on the total cost and also the relevance of transhipment costs.

To confirm the results and compare them with other possible scenarios, a sensitivity analysis has been carried out and the main findings are reported later in the text.

After having considered the cost components, the price structure has been investigated, considering the main characteristics of the market structure for each mode of transport and the average values of margin profits for the different transport modes involved. It was also investigated how much the mark up could weight on the shippers or freight forwarders decisions.

A necessary consideration is required before showing the results obtained in the calculations. As it was already specified earlier in the test, an assumption on the volume shipped has been made, considering that the amount of freight would be 1000 tons.

The choice of such volume allowed the author to compare the different modes of transport available on the routes and to have comparable results.

The work has been developed considering only one vehicle type for each mode of transport and the same volume of goods.

Doing so, the results are comparable but an important element is left aside, that is the role of possible economies of scale in the shipments and how these economies of scale could influence the results.

As it is known from transport economics (Blauwens et al., 2008) economies of scale can relate to:

- Infrastructure,
- Vehicle size,
- Vehicle fleet,

If economies of scale in infrastructure are not considerable in this specific case, since the point of view is from a company level, the other two types of economies of scale could play an important role in defining transport modes costs.

As already stated, just a single type of vehicle has been considered for each mode of transport, in order to observe the effect that bigger, smaller or different types of vehicles have on the total costs, additional typologies should have been included in the study, as well as different combination of vehicles employed to provide the service. (Kim, 2010). The inclusion of economies of scale due to different vehicle size or fleet would have required additional technical and cost information; it is nonetheless possible to include these variations in the tool developed, once having the data at disposal.

Also the results concerning the cost per tons are based on the assumption of moving 1000 tons. Although being aware of the limitations that this can impose, it can be argued that the quantity of freight that need to be moved in order to make intermodal transport competitive towards road is generally high. To support this argument, a earlier paper of Bagchus and Kuipers, 1993, develops a similar investigation on the comparison between road and intermodal sea transport, assuming to move the same amount of good, as it is in the present text.

In reading the results obtained, it will be necessary to keep in mind that the values obtained related to a specific amount of freight and the vehicle specifications are the one reported in the text.

This chapter will be structured as follow: in the first part, a description for each cost item for mode of transport will be presented; the second paragraph will deal with the application of the cost functions to the corridors and the analysis of the outcomes, a sensitivity analysis will be presented and the considerations on the final price and market structure will be illustrated before ending with some general considerations.

5.1 Costs items included in the cost function

Before focusing on the selected corridors and on their specifications, it is necessary to describe which the costs items included in the calculations are, what their importance is and some related technical aspects.

The selection process on those cost items started from the literature review on the topic, as presented in Chapter II; bearing in mind which costs to consider, the next step was their application into the costs functions.

A challenging task was the identification of realistic and consistent values to be used for the calculations.

As it is easy to understand, cost figures are sensitive data that companies are reluctant to provide and academic sources are scarce or out of date. The data collection was a long process based on:

- Data collection from existing sources;
- Face to face interviews with transport operators;

- Validation of the figures collected through a comparison of the two above mentioned sources.

For each mode of transport a detailed description of the data collection procedure will be presented, including the sources used, the information gathered from the transport operators and the final values used to perform the calculations.

5.1.1 Road Transport

Among the other modes of transport, road is the one with relatively wider sources set, consisting of reports, academic publications or research projects.

The main sources consulted were the following:

- Cost calculations for road freight transport, NEA consulting group, (2010/2011).
- Technical note for Vlaams Vrachtmodel- Cost Model, Mint and K+P consulting group, (2009).
- Recordit, European Project, (2000).

Those sources allowed a relatively broad-spectrum of the road cost figures. Nonetheless some contacts with road transport operators were taken and the scope of the interviews was to capture some insight from experts. The operators contacted were road independent operators, located in area of the port of Genoa and Antwerp providing services in Europe; their experience and activity is in heavy freight road transport.

The calculations and costs figures refer to a heavy good vehicle, i.e. road tractor + semitrailer of 40 tons, gross vehicle weight, and a loading capacity of 25 tons.

Some technical assumptions are reported in the table below.

Tab. 5.1: Technical characteristics for road transport

Cost Item	***Unit***	***MIN***	***Max***	***Average***
Average speed	km/h	67	70	69

Days of operation	n	230	250	240
Fuel consumption per 100 km	l/100 km	34,30	36,00	35,15
Loading capacity	tons	24	26	25
Loading/unloading	hours	0,10	0,20	0,15
Number of tyres	n	12	14	
Performance per life tyres	km/life	180.000	200.000	190.000
Performance per year truck	km/year	119.800	130.000	124.900
Performance per year tyres	km/year	119.800	130.000	124.900
Working hours	h/year	2.200	2.500	2.350

Source: own elaboration based on different sources

As it can be seen from table 5.1 minimum, maximum and average values are shown. For each cost item the calculation for unit cost has been developed using the average values of the technical characteristics.

For road transport the costs considered for the out of pocket calculation are:

- Personnel and social security,
- Energy and other consumption material,
- Insurance,
- Repair and Maintenance,
- Taxes and charges,
- Tools,
- Overhead costs,
- Depreciation and interest,
- Tyres,
- Other costs,
- Loading/unloading activities.

Personnel costs clearly refers to the costs that a company has for hiring drivers that conduct the trucks and the expenses related to social security and health coverage. This cost can vary according to the legislation on the employment contract. It can be asserted that the working cost in Western Europe does not really change substantially among the member states, while the personnel costs in Eastern Europe are lower. In regard to this, it will be assumed that the truck drivers will be hired under Western Europe rules and legislations.

It is common practise that Eastern European drivers (Polish, Rumanian, etc.) have a lower cost for the companies that decide to work with them. This element should also be considered, since more and more this tendency is growing. Although the effect of having lower costs for personnel will impact on the company cost structure, decreasing the overall figures, still road transport remains very expensive compared with the other modes, as it can be observed in the sensitivity analysis later presented.

Another critical issue is related to the actual working hours and the official ones; although there are more and more sophisticated driving check systems that should not allow for extra working hours, the problem of illegal behaviours is still a current problem. Being anyhow aware of the current practise, in the present calculation it will be assumed that the maximum allowed driving hours is 9 hours; after 9 hours the driver has to stop or a driver replacement has to take place, as declared in the European Regulation 561/2006.

Energy consumption, in the case of road transport, is fuel and namely diesel fuel. The price of diesel can vary from one State to another, but the variations are not meaningful, nonetheless a range of values is considered, and the value can be adjusted according to the country passed through.

Another important technical requirement is the fuel consumption for a heavy good vehicles; also in this case there are minimum, maximum and average indications. The minimum fuel consumption for covering 100 km is 34.30 litres, while the maximum value is 36 litres per 100 km.

The *vehicle insurance* represents the cost that the company has to support in order to cover civil liability for hypothetical damages to people or things that may occur during the use of the vehicle.

As already stated in the methodological part, a calculation of cost in €/hour has been chosen. On the other side good's insurance that covers the good shipped has been omitted; the reason to support this decision is that the cost is normally not covered by the transport operator, but rather from the sender or receiver of the goods.

Repair and maintenance of the vehicle; these costs are supported by the road company to cover ordinary maintenance and to face expenses due to unexpected accidents or problems of the trucks. The cost is calculated in €/Km, according to an average calculated on the basis of the kilometres covered in one year of trucks activity. No particular remarks need to be added for this cost item.

Taxes, charges and tolls are an important cost item in road transport; in particular the taxes refer to the road tax, property tax and Euro Vignette tax. Tolls are mainly the ones that some States impose on their highways. While for the taxes the cost is considered in €/h, the figures for the calculation of tolls are obtained by some route planner tool available on line.

The use of such instruments allowing being more accurate in defining the precise amount of toll, in relation to specific origin/destination route. In this research different route planner have been used and compared, such as ViaMichelin, (http://www.viamichelin.it/), Mappy, (http://it.mappy.com/), Routes Tomtom. (http://www.routes.tomtom.com/)

Overhead costs comprise several costs related to the organization and management of the trip and of the whole company activity; it is difficult to determine a precise amount and all the elements that can enter in this category; nonetheless from the sources consulted and from the results of the interviews, some yearly average figures came out. Those values have been consequently translated in cost per hour.

The costs attributed to *depreciation and interest* for the tractor and semitrailer can be calculated with different methodologies and they can vary upon variations of interest rates. In this thesis the depreciation period for the trailer was assumed to be fixed in 6 years, while for the semitrailer is 10 years. In the case of road transport it is assumed that the vehicle is purchased, and therefore the asset expenses correspond to the yearly payment of interest and depreciation; while for rail and inland navigation it is assumed that the vehicles will be on a leasing contract.

The costs for *tyres* is obviously related just to road transport. From the field analysis it appeared that the average number of tyres for such a type of vehicle are normally twelve, this number can rise up to fourteen in case of an additional axle, or even more for extraordinary shipments. For the current calculation the number of tyres considered was twelve. In the cost per kilometre calculated, the purchasing costs and the maintenance cost are included.

With the name *other costs*, all the other residual expenses that a company has to support are included.

It is unlikely to obtain a precise indication of the yearly expenses attributable to other component or exogenous factors; taking this into account the figures used are based on the previous researches and reports. The count has been done according to Euro spent for each hour of work during the year.

Finally a short description of the costs related to the operations for *loading and unloading* the truck. This cost it is not related to the transport itself, but to the pre-post logistical operations necessary for the realization of the transport operations. The common rules envisage a calculation for loading unit moved. The movement consists of two operations: the loading of the loading unit from the ground or from another mode of transport on the truck and the unloading from the truck to the ground or to a different mode of transport. The average declared time for the operation can vary from 5 to 10 minutes for loading unit.

In this thesis the transhipment cost has been calculated for each movement.

A summary table with all the cost items considered and their equivalent values is reported below.

Tab. 5.2: Cost items and values for road transport

Cost Item	***Unit***	***MIN***	***Max***	***Average***
Depreciation semitrailer and interest	€/year	2.000,00	5.000,00	3.500,00
Depreciation semitrailer per hour	€/hour	0,85	2,12	1,49
Depreciation tractor and interest	€/year	8.000,00	11.000,00	9.500,00
Depreciation tractor per hour	€/hour	3,40	4,68	4,04
Depreciation tractor and trailer per hour	€/hour	4,25	6,80	5,52
Fuel price	€/l	0,87	1,16	1,02

Loading and unloading per hour	€/hour	150,00	350,00	250,00
Loading and unloading per LU	€/LU	30,00	50,00	40,00
Other costs	€/year	8.318,00	10.000,00	9.159,00
Other costs per hour	€/hour	3,00	4,00	3,50
Overhead	€/year	18.520,00	20.000,00	19.260,00
Overhead per hour	€/hour	7,00	9,00	8,00
Repair and maintenance	€/year	8.702,00	10.000,00	9.351,00
Repair and maintenance per km	€/km	0,05	0,10	0,08
Salary	€/year	28.420,55	33.500,00	30.960,28
Salary per hour	€/hour	12,00	16,00	14,00
Social security costs	€/year	13.442,92	15.000,00	14.221,46
Social security costs per hour	€/hour	5,00	7,00	6,00
Taxes	€/year	750,00	2.000,00	1.375,00
Taxes per hours	€/hour	0,30	0,80	0,55
Tyres cost	€/km	0,001	0,002	0,0015
Tyres purchasing price	€	350,00	450,00	400,00
Vehicle Insurance	€/year	3.000,00	5.000,00	4.000,00
Vehicle Insurance per hour	€/hour	1,27	3,00	2,14

Source: own elaboration based on different sources

5.1.2 Rail Transport

The rail data collection and elaboration was relatively more difficult when compared to road transport.

The sources about rail transport are rather scarce and the market is basically divided by the former national companies and relatively small new private companies.

Together with the complexity of the sector, rail transport operators have to deal with a non-homogeneous European network. The differentiations among countries still prevent rail transport to improve its performance; there are infrastructural problems, technical problems, mainly electrical ones, legislation or organizational differences.

All those aspects have to be taken into account, also when making an out of pocket analysis.

The main references in the case of rail transport are the following:

- Technical note for Vlaams Vrachtmodel- Cost Model, Mint and K+P consulting group, (2009).
- Recordit, European Project, (2000).
- Price and costs in the railway sector, Baumgartner, J.P., Litep (2001).

A substantial help, in the gathering information, came from the operator's interviews; more precisely two rail companies have been interviewed, an Italian one and a Swiss one.

The cost data gathered respectively from the production division and from the commercial chief of the two companies were precious and helped in understanding certain sector dynamics or technical requirements that need to take into consideration when making an analysis of the rail transport costs.

The collection of the data focused on a block and combined train, the gross train capacity being 1300 tons, whiles the loading capacity between 600 tons and 800 tons.

Some additional indicators about technical requirements assumed are reported in the table below.

Tab 5.3: Technical characteristics for rail transport

Cost Item	***Unit***	***Min***	***Max***	***Average***
Average speed	km/h	40,00	70,00	55,00
Days of operation	n	250,00	300,00	275,00
Fuel consumption	l/ km	5,00	7,00	6,00
Loading capacity	tons	600,00	800,00	700,00
Loading/unloading	hours	4,00	8,00	6,00
Number of drivers	n	1,00	2,00	1,50
Performance locomotive	km/year	100.000,00	180.000,00	140.000,00
Performance wagons	km/year	50.000,00	150.000,00	100.000,00
Wagons in a train	n	18,00	32,00	25,00
Working hours	h/year	2.200,00	2.500,00	2.350,00

Source: own elaboration based on different sources

Some cost items already described in road transport are present also in the analysis of rail costs, despite this, some comments are required.

Rail transport costs are:

- Personnel and social security,
- Energy and other consumption material,
- Insurance,
- Repair and Maintenance,
- Rail Track,

- Overhead costs,
- Depreciation and interest, leasing/rent,
- Shunting operations,
- Other costs,
- Push locomotive cost,
- Loading/unloading activities.

A brief description is provided for each cost.

For *Personnel costs* some specifications are required. The European legislation defines that a driver should be present for each train, this is commonly applied around the European countries, except for Italy, where it seems that at the current state normally two drivers have to be present on the train. This, of course, causes an increase in personnel and social security costs on the Italian territory.

Energy consumption in rail transport can be either referring to electric power or to diesel fuel. In most of the European main train paths electricity is used, due also to the higher cost of diesel fuel. In the calculations, electricity energy will be preferred, remembering though, that the combinations or only diesel propulsion can be used.

In the case of rail transport the costs for *repair and maintenance* of the vehicle are related both to the locomotive and to the wagons that compose the train. To this regard in table 5.4 a distinction is made between repair and maintenance cost for the locomotive and for the wagons, both expressed in €/km.

The cost of *rail track* refers to the price that the rail operator has to pay to the infrastructure manager in order to be able to use the rail path. All the rail service operators in Europe incur in this cost that varies from country to country, from route to route according to the traffic level of that lane.

The main rail path will have higher costs, while the secondary ones will be less costly. The rail track is assigned by the infrastructure manager normally once a year, but exceptions and extraordinary distributions can happen on-the-spot.

It is well-known that the track cost in Switzerland is higher that in the other Western European Countries.

Shunting operations are the movement of the locomotives and wagons in order to place the train in the right direction, loading/unloading place or in the exact area.

Those operations are normally carried out at the beginning and the end of the trip, but they can also occur at exchanging points.

In most of the cases in Europe the rail company develops the shunting operations by itself. This possibility will be internalized by the company that will try to keep the costs as low as possible; another advantage in this case is that the shunting operations can be carried out without any break, therefore increasing the operational efficiency.

There are, as well, dedicated companies that provide the service for the rail operator; in this case the cost can vary according to different components. In the second case, the rail operator has to wait for the shunting company to move the train. This fact can explain the large difference in time and cost among countries or terminals.

An additional cost that rail operators may have to cope with is the *push locomotive cost.*

Those are the additional locomotives that the wagons may need in case the slope is too high and the one initial locomotive is not sufficient.

This is especially the case on the Swiss territory, where the slope variation, because of the mountains, does not allow the transit with a single locomotive.

It can be assumed that for a gross tons capacity of 1300 tons, an additional locomotive is needed, while for 1600 tons train, two additional locomotives are required.

Taxes and charges are not present in rail transport.

The costs attributed to *leasing or rent* of the locomotive and wagons reflects the yearly expenses for using a locomotive and the wagons. In the calculation it is assumed to insert leasing costs. The purchasing cost of a locomotive it is rather high, and a leasing contract could better represent the current situation on the European scene. This is not in contradiction with the fact that rail companies own locomotives, and therefore the yearly asset cost is the depreciation and the interest rate. Wagons can be either own by the rail company or rented.

The operations, for *loading and unloading* the train, are normally counted in euro per each movement for the loading unit.

Taking in consideration the above technical specifications and the average time for loading and unloading a train, a calculation in €/h has also been applied.

The above mentioned considerations valid for road transport, about the *vehicle insurance, overhead costs, other costs* are valid also for rail transport.

Table 5.4 reports the described cost items and their values.

Tab. 5.4: Cost items and values for rail transport

Cost Item	***Unit***	***Min***	***Max***	***Average***
Energy price electricity	€/km	2,50	3,30	2,90
Fuel price	€/km	0,50	1,00	0,75
Leasing/Rent locomotive and wagons	€/year	270.000,00	480.000,00	375.000,00
Leasing/Rent per hour	€/h	115,00	210,00	162,50
Loading and unloading per hour	€/h	150,00	500,00	325,00
Loading and unloading per LU	€/LU	27,00	40,00	33,50
Other costs	€/year	7.000,00	10.000,00	8.500,00
Other costs per hour	€/h	3,00	4,00	3,50
Overhead	€/year	18.520,00	24.000,00	21.260,00
Overhead per hour	€/h	8,00	10,00	8,50
Push Locomotive	€	500,00	2.000,00	1.250,00
Repair and maintenance loc per km	€/km	0,50	0,70	0,60
Repair and maintenance locomotive	€/year	70.000,00	98.000,00	84.000,00
Repair and maintenance wag per km	€/km	0,03	0,07	0,05
Repair and maintenance wagon	€/year	3.500,00	7.000,00	5.250,00
Salary	€/year	35.000,00	50.000,00	42.500,00
Salary per hour	€/h	15,00	21,00	18,00
Shunting operations (2 operations)	€	700,00	1.000,00	850,00
Social security	€/year	13.442,92	14.000,00	13.721,46

Social security per hour	€/h	5,00	7,00	6,00
Track	€/km	2,50	5,00	3,75
Vehicle Insurance	€/year	30.000,00	40.000,00	35.000,00
Vehicle Insurance per hour	€/hour	10,00	14,00	12,00

Source: own elaboration based on different sources

5.1.3 Inland navigation transport

The literature on cost elements and values about inland navigation is not extended, and also in this case a valuable input for the cost data collection came from the face to face interviews.

Nonetheless some interesting reports exist on the topic and mainly the one produced by NEA consulting group, to this end this report has been included in the reference list reported below.

- Technical note for Vlaams Vrachtmodel- Cost Model, Mint and K+P consulting group, (2009).
- Recordit, European Project, (2000).
- Onderzoek costen per huur in de binnenvaart, NEA Consulting Group, (2003).
- Wasser und Schifffahrtsverwaltung des bundes, PLANCO Consulting GmbH, (2007).

The additional cost data collected were obtained from focused interviews with inland navigation operators in Belgium. The valuable experience of the companies heads, allowed to complete and enrich the cost data set and moreover to have a better understanding of the sector dynamics.

The two companies interviewed provide services in Belgium, France, The Netherlands and Switzerland.

The type of barges used for the calculation is a container barge of 2000 gross tons, and being able to carry up to 1900 tons of goods, some specifications can be found in table 5.5.

Tab. 5.5: Technical characteristics for inland navigation transport

Cost Item	***Unit***	***Min***	***Max***	***Average***
Average speed	km/h	9,00	12,00	10,50
Days of operation	n	280,00	288,00	284,00
Fuel consumption	l/ km	10,00	15,00	12,50
Gross tons	tons	2.000,00	2.000,00	2.000,00
Loading capacity	tons	1.600,00	1.900,00	1.750,00
Loading/unloading	hours	16,00	24,00	20,00
Number of drivers	n	4,00	5,00	4,50
Performance	km/year	70.000,00	80.000,00	75.000,00
Working hours	h/year	3.920,00	6.912,00	4.544,00

Source: own elaboration based on different sources

The cost items used for the elaboration of the indicators are the following:

- Personnel and social security,
- Energy and other consumption material,
- Insurance,
- Repair and Maintenance,
- Taxes and charges,
- Overhead costs,
- Depreciation and interest,
- Other costs,
- Loading/unloading activities.

Concerning the *Personnel and social security* for inland navigation transport it is required that the people on board have different tasks, different level of technical knowledge and diverse experience. Due to this aspect the composition of the crew member changes according to the type of barge and its dimension. For the barge typology considered a minimum of four members is required, while the maximum is normally five, according to their role the wage is different. For the calculation of personnel and social security costs an average of those wages, without differentiations among them has been taken.

The costs for *repair and maintenance* vary from year to year or more precisely from ordinary maintenance to the extraordinary works, that are scheduled normally every five years.

It is clear that the cost rise when having an additional up keeping; in order affording these expenses the common practice is to spare a yearly amount that will be used for that purpose if needed.

In Europe there are some rivers and channels where *taxes or tolls* are due to the national or local authorities; this is though not the case on the main western European river, the Rhine.

This aspect explain why the amount of taxes took into account in the present work is rather low.

Concerning the other costs included in the calculation, no particular remarks need to be added and the comments presented above for the other modes of transport are still valid.

Tab. 5.6: Cost items and values for inland navigation transport

Cost Item	***Unit***	***Min***	***Max***	***Average***
Fuel price	€/l	0,35	0,70	0,53
Leasing/Rent barge	€/year	300.000,00	500.000,00	400.000,00
Leasing/Rent barge	€/hour	66,00	110,00	88,00
Loading and unloading per hour	€/hour	249,00	625,00	437,00
Other costs	€/year	9.000,00	10.000,00	9.500,00
Other costs per hour	€/hour	2,00	6,00	4,00
Overhead	€/year	30.000,00	40.000,00	35.000,00
Overhead per hour	€/hour	7,00	10,00	8,50
Repair and maintenance	€/year	5.000,00	10.000,00	7.500,00
Repair and maintenance per km	€/km	0,06	0,10	0,08
Salary	€/year	35.000,00	40.000,00	37.500,00
Salary per hour	€/hour	14,00	17,50	15,75
Social security costs	€/year	13.000,00	14.000,00	13.500,00
Social security costs per hour	€/hour	5,00	7,00	6,00
Tolls (just some routes)	€/year	200,00	300,00	250,00
Tolls per km	€/km	0,003	0,005	0,004
Vehicle Insurance	€/year	20.000,00	25.000,00	22.500,00
Vehicle Insurance per hour	€/hour	4,00	6,50	5,25

Source: own elaboration based on different sources

5.1.4 Intermodal road/rail transport and intermodal road/inland navigation transport

The characteristics and cost data about the two intermodal solutions are assumed to be similar to the ones already presented for each single mode of transport; therefore the cost values and the technical requirements are the same. Based on this element, it is not necessary to linger on this further more.

5.2 Outcome on the freight corridors calculations

Taking into consideration the previous specifications for each cost item, it is possible to perform the calculation tool in order to obtain some results for each of the freight corridors.

The required elements for the calculations are related to the technical characteristics and to the cost values for each cost item as presented above.

The process for the data elaboration has already been presented in chapter III, and for each corridor, travel’s times and additional specifications will be presented here on.

The following paragraphs will present the results obtained for each corridor in terms of total costs, cost per tons, cost per hour, cost per kilometre and cost per tonkm.

In order to compare the different modes of transport, a typical case with a loading quantity of 1000 tons will be examined. This aspect has to be kept in mind when reading the results; nonetheless the tool can be used for any quantity, according to the specific needs.

In the case of a shipment of 1000 tons an average of 40 trucks need to be employed, 2 trains and 1 barge, these assumptions are valid for all the corridors, therefore the outcomes need to be read keeping in mind these characteristics.

The scenario explains which values have been used for the calculation: MIN defines that the values inserted are the minimum values in the range considered; AVE stands for average and MAX are the maximum values that cost items could have.

Additional information is related to the loading degree that in the calculations is assumed to be 100% and also to the fact that return trips are not taken into considerations in the following applications. The inclusion of return trips could enrich the findings of the present work, nonetheless it could have been rather difficult to have reliable indication on the rate of return trips as well as the loading degrees. A possible expedient to overcome this problem is the use of different assumptions on the calculations, considering several scenarios. This calculation is easily performed with the use of the calculation tool developed, since it is characterized by a good degree of flexibility in its use.

5.2.1 Antwerp-Basel Corridor

The assumptions related to distances and timing per mode of transport are:

- Road transport: 609 km, 7 hours;
- Rail transport: 718 km, 15 hours;
- Inland navigation: 890 km, 105 hours;
- Intermodal transport road + rail: 678 km by rail and 40 km by road, 14 hours by rail, 1 hour by road;
- Intermodal transport road + inland navigation: 850 km by inland navigation, 40 km by road, 104 hours by inland navigation and 1 hour by road.

The first consideration is related to the convenience of rail transport that in each scenario appears to be the cheapest solution, followed by the intermodal transport road-rail.

Road and inland navigation have a higher cost, if compared to rail transport, even though with different order between MIN and AVE-MAX scenarios.

Tab. 5.7: Antwerp-Basel: Total cost

Total cost	**MIN**		**AVE**		**MAX**
Rail	15.055,00	Rail	20.221,00	Rail	25.417,00
Road-rail	17.092,46	Road-rail	22.378,85	Road rail	27.675,56
IWW	19.446,07	Road	24.792,88	Road	28.761,38
Road	20.849,47	IWW	26.188,76	IWW	33.640,95
Road-iww	22.118,01	Road-iww	29.147,50	Road iww	36.796,81

Source: own elaboration

Having in mind that the amount of goods considered for this case are 1000 tons, the following table it is clearly showing the cost for each ton, obtained by the ratio total cost/total tons.

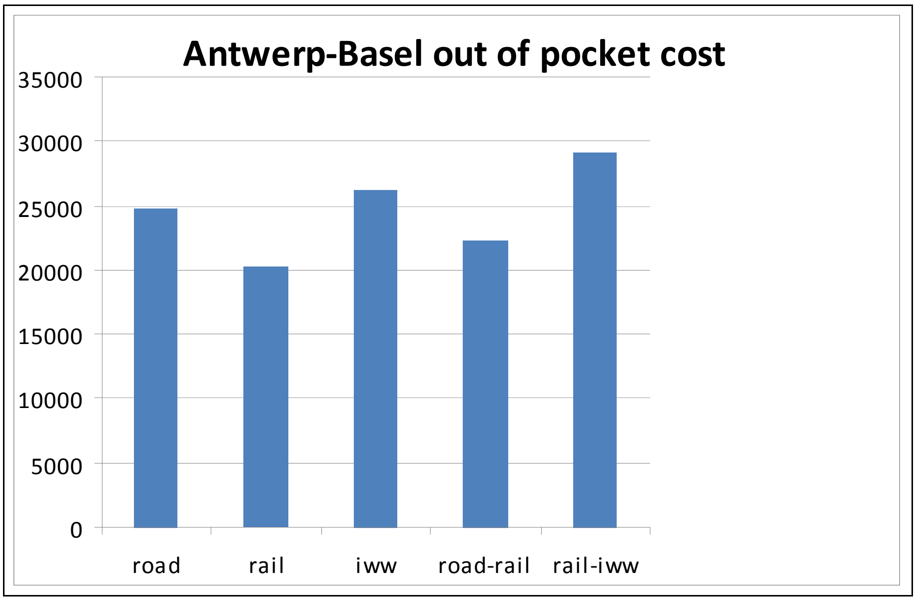


Fig. 5.1: Antwerp-Basel: Total cost

Source: own elaboration

Tab. 5.8: Antwerp-Basel: Cost per ton

Cost per ton	**MIN**		**AVE**		**MAX**
Rail	15,06	Rail	20,22	Rail	25,42
Road-rail	17,09	Road-rail	22,38	Road rail	27,68
IWW	19,44	Road	24,79	Road	28,76
Road	20,85	IWW	26,19	IWW	33,64
Road-iww	22,11	Road-iww	29,15	Road iww	36,80

Source: own elaboration

Also in this case, the same conclusions can be drawn, rail transport is the best solutions €/tons wise, and road-inland navigation transport is the most expensive. The results of this table are quite intuitive.

Of additional interest could be the three following tables showing the cost per tonkm, the cost per kilometre and the cost per hour. These indicators are generally the most used for analysis of transport costs.

Table 5.9 shows, in ascending order, the costs per tonkm of the different modes of transport.

In this case the table is fairly explicit in showing that, regardless the scenario, rail and inland navigation have the cheapest coefficients, while the intermodal solution road-inland navigation is ranking the highest.

The other solutions are listed in the middle of the ranking, road-rail being cheaper that only road transport.

Tab. 5.9: Antwerp-Basel: Cost per ton/kilometre

Cost tonkm	**MIN**		**AVE**		**MAX**
Rail	0,021	Rail	0,028	Rail	0,035
IWW	0,022	IWW	0,029	IWW	0,038
Road-rail	0,024	Road-rail	0,031	Road rail	0,039
Road	0,034	Road	0,041	Road	0,047
Road-iww	0,529	Road-iww	0,684	Road iww	0,850

Source: own elaboration

In the next two tables, the volume of freight is not taken in consideration, since the indicators refer to the distance covered and to the time spent for the travel. Before looking at the results an important premise is needed; as noticed from the description above, the kilometres covered and the driving hours are not the same for all the modes of transport.

To this respect the following tables does not intend to compare €/km or the €/h among modes, rather to present the figures for each single mode.

The figures express the values obtained by the ratio: total cost/total km or total cost/ total hours. In this case there is no differentiation between hourly and kilometre coefficients and their respective cost items, rather the total cost spent for a kilometre or for an hour.

In particularly, table 5.10 reports the results obtained from the calculation of the cost spent for each kilometre covered in this specific route Antwerp-Basel. Road transport has a cost per kilometre, that can vary between 0,85 to 1,18 €/km.

The mode of transport with higher coefficient is inland navigation in all the three scenarios, between 21,85 €/km to 37,8 €/km.

Tab. 5.10: Antwerp-Basel: Cost per kilometre

Cost per km	**MIN**		**AVE**		**MAX**
Road	0,85	Road	1,01	Road	1,18
Road-rail	7,50	Road-rail	9,82	Road rail	12,14
Rail	10,48	Rail	14,08	Rail	17,70
Road-iww	13,23	Road-iww	17,10	Road iww	21,24
IWW	21,85	IWW	29,42	IWW	37,79

Source: own elaboration

To conclude some considerations about the hourly cost in Euro; with regard to this indicator, similar conclusions to the previous ones can be made. As a matter of fact the range of values, from the minimum to the maximum is rather wide; from 74 €/h to 847 €/h. It is notwithstanding understandable that the hourly cost for running a train is notably higher than for a truck.

Tab. 5.11: Antwerp-Basel: Cost per hour

Cost per hour	**MIN**		**AVE**		**MAX**
Road	74,46	Road	88,54	Road	102,71
Road-iww	147,04	Road-iww	190,06	Road iww	236,01
IWW	185,20	IWW	249,41	IWW	320,39
Road-rail	251,36	Road-rail	329,10	Road rail	406,99
Rail	501,83	Rail	674,03	Rail	847,23

Source: own elaboration

As a concluding remark, regarding the comparison of the modes of transport, it can be argued that the cheapest solution from a total cost point of view is rail transport.

Such considerations have to be analysed in light of different distances and moreover different driving hours.

In order to better understand which the relevance of each cost item on the final total cost is, an investigation for each mode and for each scenario will be presented.

The calculation has been done considering the total cost as equal to 100 and looking at the share of each cost item, in percentage.

Starting from road transport, it is observed that for all the scenarios, the cost items that counts more is the fuel price, with a share of 35% on the total cost.

The second cost item, in decreasing order, is personnel cost, having a slightly bigger impact in the minimum scenario. In this route the cost for road tolls seems to impact quite high on the total costs.

Tab. 5.12: Weight of each cost item on the total cost for road transport (percentage of the total cost)

Road	**MIN**	**AVE**	**MAX**
fuel price	35,48	35,27	35,37
salary	16,40	15,83	15,58
social costs	6,83	6,79	6,81
tyres	1,43	1,77	2,03
insurance vehicle	1,74	2,42	2,92
maintenance and repair	5,94	7,87	8,47
taxes	0,41	0,62	0,78
tolls	12,30	10,18	8,76
overhead	9,57	9,05	8,76
depreciation	5,81	6,24	6,62
other costs	4,10	3,96	3,89
	100,00	100,00	100,00

Source: own elaboration

What is reported in table 5.13 shows how the different costs weight in rail transport. It appears that the main part of the costs is due to three elements: the physical assets, namely the locomotives, the rail tracks costs and the cost for the energy's consumption, all of them counting, on average, for 22%.

An important component is the cost for rail track that the operator has to pay to the infrastructure manager for obtaining the train paths. The share of its relevance is higher in the maximum scenario, counting for almost 30%.

Tab. 5.13: Weight of each cost item on the total cost for rail transport

Rail	MIN	AVE	MAX
energy price	22,93	20,59	18,64
salary	5,75	2,67	2,48
social costs	1,92	0,89	0,83
insurance vehicle	1,92	1,78	1,65
maintenance locomotives	4,59	4,26	3,95
maintenance wagons	6,88	8,88	9,89
overhead	1,53	1,26	1,18
average track cost	22,93	26,63	28,25
other costs	0,57	0,52	0,47
leasing or rent	22,04	24,11	24,79
shunting operations	8,94	8,41	7,87
	100,00	100,00	100,00

Source: own elaboration

Considering the composition of inland navigation transport cost, it appears that the most important out of pocket costs, for the company is the renting of the barge or the amortization of it, therefore pure vehicle cost. Actually, according to the scenario this cost can count up to 35%. The other main cost items are personnel costs and fuel consumption.

Fuel cost is becoming more important in the average and maximum scenario.

Tab. 5.14: Weight of each cost item on the total cost for inland navigation transport

IWW	MIN	AVE	MAX
Fuel price	16,02	21,96	27,78
salary	30,24	24,64	21,85
social costs	10,80	9,39	8,74
insurance vehicle	2,16	2,05	2,03
maintenance and repair	0,27	2,65	0,26
tolls	0,01	0,01	0,01
overhead	3,78	3,32	3,12
leasing or rent	35,64	34,41	34,33

other costs	1,08	1,56	1,87
	100,00	100,00	100,00

Source: own elaboration

The comments about the two intermodal solutions are similar to the previous ones; in intermodal road-inland navigations the major costs are related to the main part of the trip, thus inland navigation. The share of barge leasing cost is approximately around 31% in the all the scenarios, followed by the personnel costs, between 19% and 26%, to conclude with fuel costs, from 14% to 24%.

For road-rail intermodal transport, the three main cost items are always related to rail transport and more precisely: energy cost, track cost and the cost to the company assets.

Tab. 5.15: Weight of each cost item on the total cost for intermodal road/inland navigation transport

Road-Iww	**MIN**	**AVE**	**MAX**
fuel price road	2,16	1,97	1,82
salary road	2,17	1,92	1,74
social costs road	0,90	0,82	0,76
tyres	0,09	0,10	0,10
insurance vehicle road	0,23	0,29	0,33
maintenance and repair road	0,36	0,44	0,43
taxes road	0,05	0,08	0,09
tolls road	4,88	3,71	2,94
overhead road	1,27	1,10	0,98
depreciation road	0,77	0,76	0,74
other costs road	0,54	0,48	0,43
fuel price barge	13,45	19,32	24,25
salary barge	26,33	22,48	19,78
social costs barge	9,40	8,56	7,91
insurance vehicle barge	1,88	1,87	1,84
maintenance and repair barge	0,23	0,23	0,23
tolls barge	0,01	0,01	0,01
overhead barge	3,29	3,03	2,83
leasing/rent/amortization barge	31,03	31,40	31,09
other costs barge	0,94	1,43	1,70
	100,00	100,00	100,00

Source: own elaboration

Tab. 5.16: Weight of each cost item on the total cost for intermodal road/rail transport

Road-Rail	MIN	AVE	MAX
Fuel price road	2,62	2,29	2,10
salary road	2,64	2,24	2,01
social costs road	1,10	0,96	0,88
tyres	0,11	0,12	0,12
insurance vehicle road	0,28	0,34	0,38
maintenance and repair road	0,44	0,51	0,50
taxes road	0,07	0,09	0,10
tolls road	5,93	4,32	3,39
overhead road	1,54	1,28	1,13
depreciation road	0,93	0,88	0,85
other costs road	0,66	0,56	0,50
Energy price rail	18,61	15,72	14,06
Push locomotive	5,49	9,99	12,56
salary rail	2,31	2,01	1,85
social costs rail	0,77	0,67	0,62
insurance vehicle rail	1,54	1,34	1,23
maintenance and repair loc rail	3,72	3,25	2,98
maintenance and repair wag rail	5,58	6,77	7,45
overhead rail	1,23	0,95	0,88
average track cost rail	18,61	20,32	21,30
other costs rail	0,46	0,39	0,35
leasing rent rail	17,68	18,19	18,47
shunting operations	7,69	6,79	6,28
	100,00	100,00	100,00

Source: own elaboration

5.2.2 Antwerp-Frankfurt Corridor

The second corridor took into consideration is the one from/to Antwerp-Frankfurt. The distances for each mode of transport are reported below.

- Road transport: 402 km, 6 hours;
- Rail transport: 400 km, 9 hours;
- Inland navigation: 600 km, 84 hours;
- Intermodal transport road + rail: 360 km by rail and 40 km by road, 7 hours by rail, 1 hour by road.
- Intermodal transport road + inland navigation: 560 km by inland navigation, 40 km by road, 83 hours by inland navigation and 1 hour by road.

When comparing the total cost for each mode, rail transport is the one with lower costs in all the scenarios, ranging from 9.200 to almost 15.400 €.

The ranking of the different modalities is stable in the three scenarios, showing that the most expensive solution is represented by the intermodal combination of road and inland navigation transport. In the MAX scenario the intermodal solution road-inland navigation is more than double compared to rail transport.

Tab. 5.17: Antwerp-Frankfurt: Total cost

Total cost	MIN		AVE		MAX
Rail	9.208,00	Rail	12.289,00	Rail	15.388,00
Road-rail	9.853,46	Road-rail	12.945,85	Road rail	16.034,56
Road	13.910,02	Road	16.892,64	Road	19.892,93
IWW	15.157,80	IWW	20.199,60	IWW	25.725,00
Road-iww	16.749,74	Road-iww	22.074,14	Road iww	33.986,49

Source: own elaboration

Similar results are presented in the table 5.18, where the outcome of €/tons are reported.

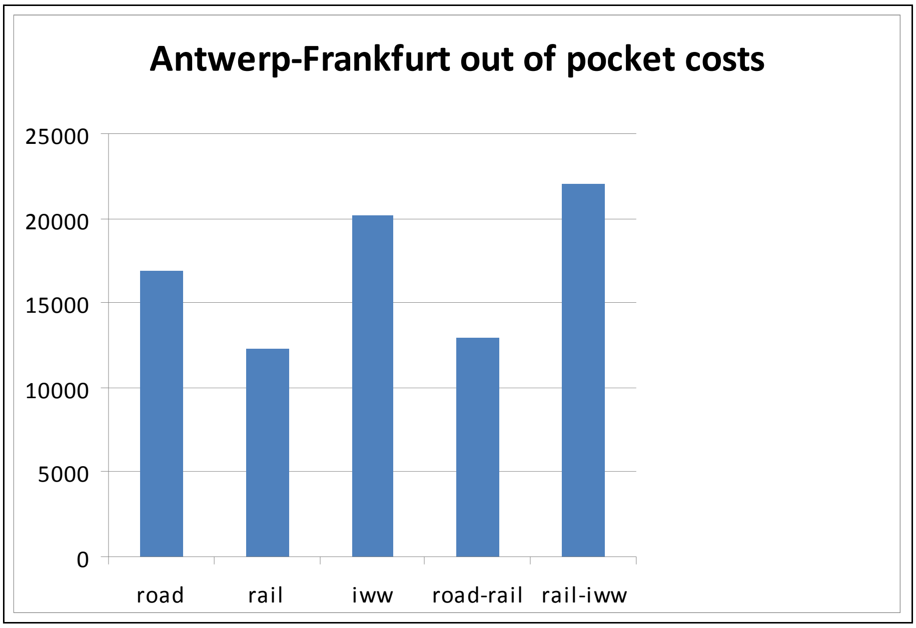


Fig. 5.2: Antwerp-Frankfurt: Total cost

Source: own elaboration

Tab. 5.18: Antwerp-Frankfurt: Cost per ton

Cost per ton	MIN		AVE		MAX
Rail	9,21	Rail	12,29	Rail	15,39
Road-rail	9,85	Road-rail	12,95	Road rail	16,03
Road	13,91	Road	16,89	Road	19,89
IWW	15,16	IWW	20,20	IWW	25,73
Road-iww	16,75	Road-iww	22,07	Road iww	33,99

Source: own elaboration

The values obtained for the costs €/tkm show that rail transport has lower values, ranging from 0,023 to 0,038 €/tkm. For each scenario road-inland navigation confirms to be the mode of transport with higher cost.

Tab. 5.19: Antwerp-Frankfurt: Cost per ton/kilometre

Cost per ton km	MIN		AVE		MAX
Rail	0,023	Rail	0,031	Rail	0,038
road-rail	0,025	road-rail	0,032	road rail	0,040
IWW	0,025	IWW	0,034	IWW	0,043
Road	0,035	Road	0,042	Road	0,049
road-iww	0,419	road-iww	0,552	road iww	0,850

Source: own elaboration

Tables 5.20 and 5.21 illustrate that the kilometres and hourly cost, for this specific route are consistent with the ones obtained for the Antwerp-Basel corridor.

In this case the kilometre cost for road transport goes from 0,86 to 1,24 €/km, rail transport from 11,5 to 21,2 and inland navigation from 25,3 to 42,9 €/km. The two intermodal solutions have a kilometre cost that is higher in both cases than road transport.

If the cost figures reach the maximum level the intermodal solution road-inland navigation has a cost for each kilometre of 21,24 €/km.

Tab. 5.20: Antwerp-Frankfurt: Cost per kilometre

Cost per km	**MIN**		**AVE**		**MAX**
Road	0,865	Road	1,051	Road	1,237
Road-rail	5,027	Road-rail	6,605	Road-rail	8,181
Road-iww	10,469	Road-iww	13,796	Rail	19,235
Rail	11,510	Rail	15,361	Road-iww	21,242
IWW	25,263	IWW	33,666	IWW	42,875

Source: own elaboration

When looking at each hour of work and the related cost per mode of transport, rail is the one with highest values, up to 854 €/h. In the case of this corridor the time spent by rail is 9 hours with the use of two trains.

As it is known road transport has a relatively lower cost, from 58 to 83 €/h, that need to be consider together with the total transport timing and the number of vehicles.

Tab. 5.21: Antwerp-Frankfurt: Cost per hour

Cost per hour	**MIN**		**AVE**		**MAX**
Road	57,96	Road	70,39	Road	82,89
Road-iww	136,18	Road-iww	179,46	Road-iww	236,02
IWW	180,45	Road-rail	239,74	Road-rail	296,94
Road-rail	182,47	IWW	240,47	IWW	306,25
Rail	511,56	Rail	682,72	Rail	854,89

Source: own elaboration

For each mode is now reported the weight that they have on the total cost.

Starting from road transport, it can be observed that the main costs items are personnel costs, fuel costs and overhead costs for the company. Also in this case the results are similar to the previous corridor. The biggest impact is the one of fuel cost, which contributes with more than 1/3 of the total cost.

Tab. 5.22: Weight of each cost item on the total cost for road transport (percentage of the total cost)

Road	MIN	AVE	MAX
fuel price	35,10	34,17	33,76
salary	21,06	19,92	19,30
social costs	8,78	8,54	8,45
tyres	1,41	1,72	1,94
insurance vehicle	2,23	3,04	3,62
maintenance and repair	5,88	7,62	8,08
taxes	0,53	0,78	0,97
overhead	12,29	11,38	10,86
depreciation	7,46	7,85	8,20
other costs	5,27	4,98	4,83
	100,00	100,00	100,00

Source: own elaboration

In the case of rail transport, the influence that track costs have on the total rail costs is varying between 20% up to almost 26%.

The second element is the leasing/renting or amortization of the vehicle and finally the energy price.

Tab. 5.23: Weight of each cost item on the total cost for rail transport

Rail	MIN	AVE	MAX
Energy price	20,90	18,88	17,16
salary	5,64	2,64	2,46
social costs	1,88	0,88	0,82
insurance vehicle	1,88	1,76	1,64
maintenance locomotives	4,18	3,91	3,64
maintenance wagons	6,27	8,14	9,10
overhead	1,51	1,25	1,17
average track cost	20,90	24,41	25,99
other costs	0,56	0,51	0,47
leasing rent	21,63	23,80	24,56
shunting operations	14,63	13,83	13,00
	100,00	100,00	100,00

Source: own elaboration

Similar conclusion can be drown for inland navigation, where the management of the asset and the related costs, the personnel cost and fuel price are the main costs that the operator has to carry out.

Tab. 5.24: Weight of each cost item on the total cost for inland navigation transport

IWW	MIN	AVE	MAX
fuel price	13,85	19,68	24,49
salary	31,03	26,12	22,86
social costs	11,08	9,98	9,14
insurance vehicle	2,22	2,18	2,12
maintenance	0,24	0,24	0,23
tolls	0,01	0,01	0,01
overhead	3,88	3,53	3,27
leasing rent	36,58	36,59	35,92
other costs	1,11	1,66	1,96
	100,00	100,00	100,00

Source: own elaboration

For the two intermodal solutions, it can be observed that the more relevant cost items are the same ones that had a big impact in the previous uni-modal solutions.

In particular personnel costs, energy cost and leasing/rent of the barge for the road-inland navigation solution, and track cost, energy costs and assets costs for road-rail intermodal one.

Tab. 5.25: Weight of each cost item on the total cost for intermodal road/inland navigation transport

Road-IWW	MIN	AVE	MAX
Fuel price road	2,85	2,60	2,40
salary road	2,87	2,54	2,30
social costs road	1,19	1,09	1,01
tyres	0,11	0,13	0,14
insurance vehicle road	0,30	0,39	0,43
maintenance road	0,48	0,58	0,58
taxes road	0,07	0,10	0,12
overhead road	1,67	1,45	1,29
depreciation road	1,01	1,00	0,98

other costs road	0,72	0,63	0,58
fuel price barge	11,70	16,81	21,15
salary barge	27,75	23,69	20,90
social costs barge	9,91	9,02	8,36
insurance vehicle barge	1,98	1,97	1,94
maintenance barge	0,20	0,20	0,20
tolls barge	0,01	0,01	0,01
overhead barge	3,47	3,20	2,99
leasing rent barge	32,70	33,09	32,84
other costs barge	0,99	1,50	1,79
	100,00	100,00	100,00

Source: own elaboration

Tab. 5.26: Weight of each cost item on the total cost for intermodal road/rail transport

Road-Rail	**MIN**	**AVE**	**MAX**
Fuel price road	4,79	4,38	4,13
salary road	4,81	4,28	3,95
social costs road	2,01	1,83	1,73
tyres	0,19	0,22	0,24
insurance vehicle road	0,51	0,65	0,74
maintenance road	0,80	0,98	0,99
taxes road	0,12	0,17	0,20
overhead road	2,81	2,45	2,22
depreciation road	1,70	1,69	1,68
other costs road	1,20	1,07	0,99
Energy price rail	18,05	15,96	14,67
salary rail	2,11	1,93	1,82
social costs rail	0,70	0,64	0,61
insurance vehicle rail	1,40	1,28	1,21
maintenance locomotives rail	3,61	3,30	3,11
maintenance wagons rail	5,41	6,88	7,78
overhead rail	1,12	0,91	0,86
average track cost rail	18,05	20,63	22,23
other costs rail	0,42	0,37	0,35
leasing rent rail	16,14	17,39	18,15
shunting operations	14,04	12,99	12,35
	100,00	100,00	100,00

Source: own elaboration

5.2.3. Antwerp-Strasbourg Corridor

This corridor is the last one considered in relation to the port of Antwerp, some technical information about distances and timing are here on presented.

- Road transport: 472 km, 7 hours;
- Rail transport: 580 km, 13 hours;
- Inland navigation: 775 km, 80 hours;
- Intermodal transport road + rail: 540 km by rail and 40 km by road, 11 hours by rail, 1 hour by road;
- Intermodal transport road + inland navigation: 735 km by inland navigation, 40 km by road, 79 hours by inland navigation and 1 hour by road.

The main conclusions are in line with the ones already obtained for the other two corridors. For a closer analysis the comparison for each total costs can be seen in table 5.27. As illustrated before rail transport is the cheapest mode in all the scenarios. The intermodal solution with rail transport follows with costs that can vary from 13.300,00 € up to 22.000,00 € in the MAX scenario.

The other three modes, road only, inland navigation and the combination of the two, show to be more expensive, in particular in the MIN scenario road transport is the most expensive also compared to the uni-modal and intermodal inland navigation solutions.

In the other two scenarios road-inland navigation is the most expensive mode.

Tab. 5.27: Antwerp-Strasbourg: Total cost

Total cost	**MIN**		**AVE**		**MAX**
Rail	12.706,00	Rail	17.033,00	Rail	21.386,00
Road-rail	13.351,46	Road-rail	17.689,85	Road-rail	22.032,56
IWW	15.161,33	IWW	20.603,48	Road	24.721,41
Road-iww	16.753,26	Road	21.211,04	IWW	26.658,88
Road	17.721,38	Road-iww	22.477,21	Road-iww	28.734,74

Source: own elaboration

Table 5.28 is providing the information on the cost per tons, in case the total amount to be moved is equal to 1000 tons. The ranking of the transport's modes is the same than in table 5.27, as it is easy to understand.

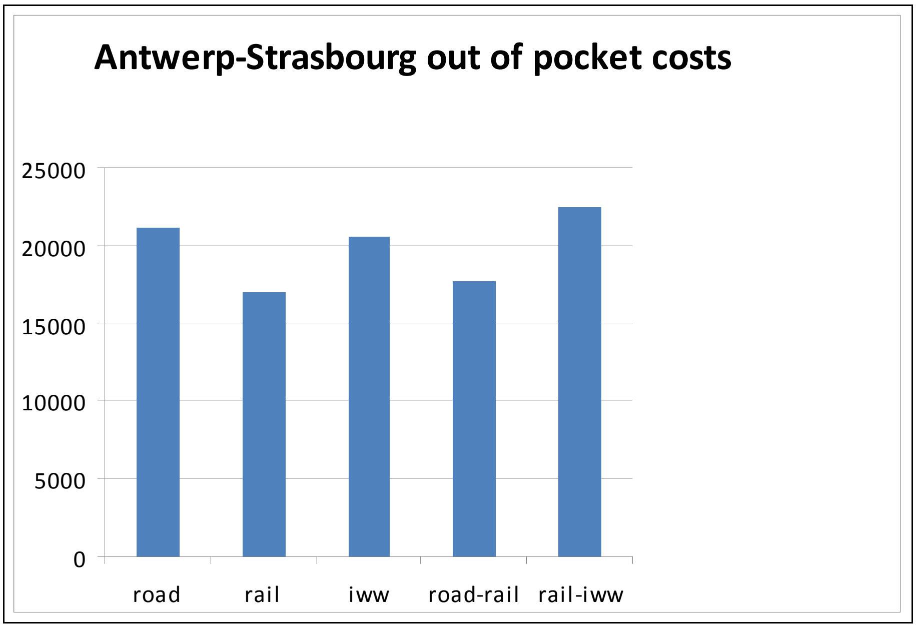


Fig. 5.3: Antwerp-Strasbourg: Total cost

Source: own elaboration

Tab. 5.28: Antwerp-Strasbourg: Cost per ton

Cost per ton	**MIN**		**AVE**		**MAX**
Rail	12,71	Rail	17,03	Rail	21,39
Road-rail	13,35	Road-rail	17,69	Road-rail	22,03
IWW	15,16	IWW	20,60	Road	24,72
Road-iww	16,75	Road	21,21	IWW	26,66
Road	17,72	Road-iww	22,48	Road-iww	28,73

Source: own elaboration

The results of the following table show that, in terms of €/tkm the values of rail and inland navigation are very similar, from 0,020 to 0,037 €/tkm.

Definitely higher are the values for intermodal road-inland navigation.

Tab. 5.29: Antwerp-Strasbourg: Cost per ton/kilometre

Cost per ton km	**MIN**		**AVE**		**MAX**
IWW	0,020	IWW	0,027	Rail	0,037
Rail	0,022	Rail	0,029	IWW	0,034
Road-rail	0,025	Road-rail	0,030	Road-rail	0,038
Road	0,038	Road	0,045	Road	0,052
Road-iww	0,419	Road-iww	0,562	Road-iww	0,718

Source: own elaboration

The costs per kilometres, in this case, show that road-inland navigation and the rail solution are very much alike, since they range from almost 11 €/km in the MIN scenario to 18 €/km in the MAX.

Tab. 5.30: Antwerp-Strasbourg: Cost per kilometre

Cost per km	**MIN**		**AVE**		**MAX**
Road	0,939	Road	1,123	Road	1,309
Road-rail	5,027	Road-iww	8,266	Road-rail	10,296
Road-iww	10,471	Road-rail	14,048	Road-iww	17,959
Rail	10,953	Rail	14,684	Rail	18,436
IWW	19,563	IWW	26,585	IWW	34,399

Source: own elaboration

Similar considerations than above can be done for the costs related to the hours of work, where road-inland navigation and the rail solution are very alike. The hourly cost for road goes from 63 to 88 €/h.

Tab. 5.31: Antwerp-Strasbourg: Cost per hour

Cost per hour	**MIN**		**AVE**		**MAX**
Road	63,291	Road	75,754	Road	88,291
Road-iww	140,784	Road-iww	188,884	Road-iww	241,468
Road-rail	182,471	IWW	257,543	IWW	333,236
IWW	189,517	Road-rail	285,320	Road-rail	355,364
Rail	488,692	Rail	655,115	Rail	822,539

Source: own elaboration

The tables below report the results of the calculation for identifying the cost items that impact most on the total cost. The results are similar to the previous outcome obtained for the other two corridors from Antwerp, therefore energy costs, personnel costs and overhead constitutes the most important cost items for road transport. The final rail transport cost is strongly influenced by the track costs, electricity and costs for the locomotives and wagons.

Tab. 5.32: Weight of each cost item on the total cost for road transport (percentage of the total cost)

Road	MIN	AVE	MAX
fuel price	32,30	31,95	31,89
salary	19,26	18,50	18,12
social costs	8,03	7,93	7,93
tyres	1,30	1,60	1,83
insurance vehicle	2,04	2,83	3,40
maintenance	5,41	7,13	7,64
taxes	0,48	0,73	0,91
tolls	8,30	6,83	5,86
overhead	11,24	10,57	10,19
depreciation	6,82	7,30	7,70
other costs	4,82	4,63	4,53
	100,00	100,00	100,00

Source: own elaboration

Tab. 5.33: Weight of each cost item on the total cost for rail transport

Rail	MIN	AVE	MAX
energy price	21,93	19,75	17,90
salary	5,90	2,75	2,55
social costs	1,97	0,92	0,85
insurance vehicle	1,97	1,83	1,70
maintenance locomotives	4,39	4,09	3,80
maintenance wagons	6,58	8,51	9,49
overhead	1,57	1,30	1,22
average track cost	21,93	25,54	27,12
other costs	0,59	0,53	0,49
leasing rent	22,61	24,80	25,53
shunting operations	10,59	9,98	9,35
	100,00	100,00	100,00

Source: own elaboration

For inland navigation, the main cost items are fuel price, personnel costs and the lease or amortization of the barge.

Tab. 5.34 Weight of each cost item on the total cost for inland navigation transport

IWW	MIN	AVE	MAX
fuel price	17,89	24,90	30,52
salary	29,55	24,44	21,01
social costs	10,55	9,31	8,40
insurance vehicle	2,11	2,04	1,95
maintenance	0,31	0,30	0,29
tolls	0,02	0,02	0,01
overhead	3,69	3,30	3,00
leasing rent	34,83	34,14	33,01
other costs	1,06	1,55	1,80
	100,00	100,00	100,00

Source: own elaboration

The two intermodal solutions show that most of the cost is related to the longest leg of the trip, therefore rail and inland navigation.

Tab. 5.35: Weight of each cost item on the total cost for intermodal road/inland navigation transport

Road iww	MIN	AVE	MAX
Fuel price road	2,85	2,55	2,33
salary road	2,87	2,49	2,23
social costs road	1,19	1,07	0,97
tyres	0,11	0,13	0,13
insurance vehicle road	0,30	0,38	0,42
maintenance road	0,48	0,57	0,56
taxes road	0,07	0,10	0,11
overhead road	1,67	1,42	1,25
depreciation road	1,01	0,98	0,95
loading/unloading road	0,00	0,00	0,00
other costs road	0,72	0,62	0,56
Fuel price barge	15,36	21,66	26,86
salary barge	26,41	22,14	19,25
social costs barge	9,43	8,44	7,70
insurance vehicle barge	1,89	1,85	1,79
maintenance barge	0,26	0,26	0,26
tolls barge	0,01	0,01	0,01
overhead barge	3,30	2,99	2,75
easing rent barge	31,12	30,93	30,24
other costs barge	0,94	1,41	1,65
	100,00	100,00	100,00

Source: own elaboration

Tab.5.36: Weight of each cost item on the total cost for intermodal road/rail transport

Road rail	MIN	AVE	MAX
Fuel price road	3,54	3,22	3,01
salary road	3,56	3,14	2,88
social costs road	1,48	1,35	1,26
tyres	0,14	0,16	0,17
insurance vehicle road	0,38	0,48	0,54
maintenance road	0,59	0,72	0,72
taxes road	0,09	0,12	0,14
overhead road	2,08	1,79	1,62
depreciation road	1,26	1,24	1,23
other costs road	0,89	0,79	0,72
Energy price rail	20,04	17,57	16,06
salary rail	2,45	2,22	2,08
social costs rail	0,82	0,74	0,69

insurance vehicle rail	1,63	1,48	1,39
maintenance locomotives rail	4,01	3,63	3,41
maintenance wagons rail	6,01	7,57	8,52
overhead rail	1,31	1,05	0,99
average track cost rail	20,04	22,71	24,33
other costs rail	0,49	0,43	0,40
leasing rent rail	18,78	20,05	20,82
shunting operations	10,39	9,53	9,01
	100,00	100,00	100,00

Source: own elaboration

5.2.4. Genoa-Basel Corridor

In the following paragraphs the analysis of the results obtained from the elaboration of the corridors leaving from/to Genoa are presented.

In the case of the Ligurian port, the mode choice is limited to three choices: road transport, rail transport and the intermodal combination of the previous two.

The first corridor is the one connecting the Italian port to the Swiss town of Basel; in this case the distances and the time to reach the destination are shown below.

The distances and timing per mode of transport are:

- Road transport: 474 km, 7 hours;
- Rail transport: 456 km, 11 hours;
- Intermodal transport road + rail: 434 km by rail and 40 km by road, 9 hours by rail, 1 hour by road.

Starting from the total costs for each mode, it appears that the cheapest solution, for each scenario is rail transport, varying from almost 12.000 € to 22.000 €. The most expensive way to move 1000 tons from Genoa to Basel and vice versa is road transport; according to the scenario MIN and AVE where the cost is above 21.000 €, while in the MAX scenario the intermodal solution is the most expensive, with more than 25.000 €.

Tab. 5.37: Genoa-Basel: Total cost

Total cost	MIN		AVE		MAX
Rail	11.972,00	Rail	17.111,00	Rail	22.272,00
Road-rail	14.162,46	Road-rail	19.425,85	Road	24.884,74
Road	17.871,39	Road	21.367,68	Road-rail	25.193,56

Source: own elaboration

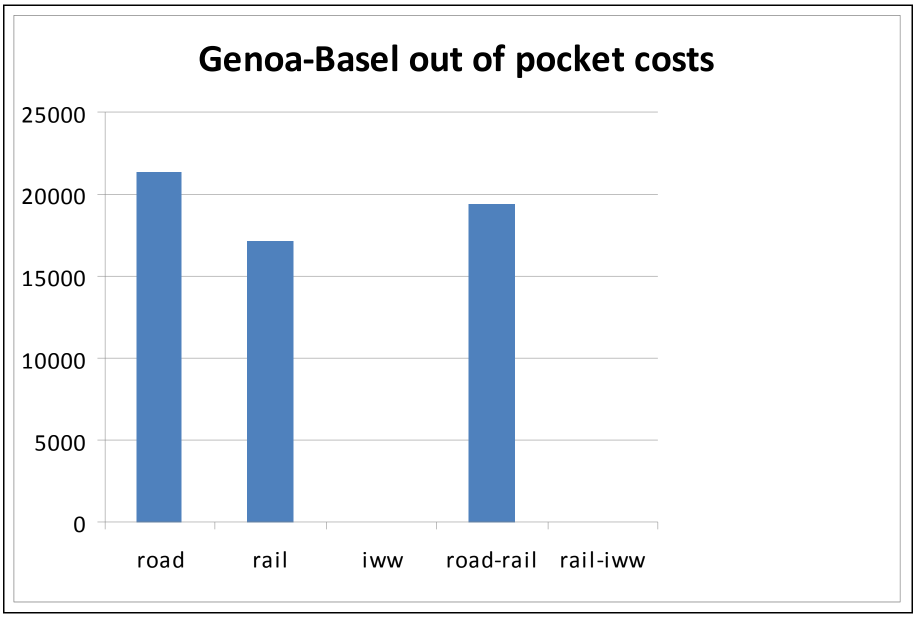


Fig. 5.4: Genoa-Basel: Total cost

Source: own elaboration

The figures reported in table 5.38 are simply the costs for each ton shipped.

Tab. 5.38: Genoa-Basel: Cost per ton

Cost per ton	MIN		AVE		MAX
Rail	11,97	Rail	17,11	Rail	22,27
Road-rail	14,16	Road-rail	19,42	Road	24,88
Road	17,87	Road	21,36	Road-rail	25,19

Source: own elaboration

The figures in the tables below are not suppose to be compared among them, rather to give an indication of the km costs, hourly costs and tons-kilometres costs for this specific route.

The values for €/tkm vary from 0,026, rail transport scenario minimum, up to 0,052 €/tkm in the case of maximum values for road transport.

Tab. 5.39: Genoa-Basel: Cost per ton/kilometre

Cost per ton km	**MIN**		**AVE**		**MAX**
Rail	0,026	Rail	0,037	Rail	0,048
Road-rail	0,029	Road-rail	0,040	Road-rail	0,053
Road	0,037	Road	0,045	Road	0,052

Source: own elaboration

Tables 5.40 and 5.41 give an idea about the km and hourly costs; road transport kilometre costs varies from 0,94 €/km up to 1,31 €/km, intermodal transport between 6,96 to 12,38 and finally rail transport between 13,12 and 24,42 €/km.

Tab. 5.40: Genoa-Basel: Cost per kilometre

Cost per km	**MIN**		**AVE**		**MAX**
Road	0,942	Road	1,126	Road	1,312
Road-rail	6,962	Road-rail	9,550	Road-rail	12,386
Rail	13,127	Rail	18,762	Rail	24,421

Source: own elaboration

The hourly cost per mode of transport are in line with the ranking obtained from the previous tables, indeed road transport has a hourly costs, between 63 €/h and 88 €/h, while rail transport can be performed with an average hourly expenses of 777 €.

Tab. 5.41: Genoa-Basel: Cost per hour comparison

Cost per hour	**MIN**		**AVE**		**MAX**
Road	63,826	Road	76,313	Road	88,874
Road-rail	244,180	Road-rail	334,928	Road-rail	434,371
Rail	544,181	Rail	777,772	Rail	1012,364

Source: own elaboration

In the following tables, some indications of the main cost items for each mode of transport are shown.

For what concerns road transport, the three main cost items are fuel costs, the salary for the employed people and the costs due to overhead of the company.

Fuel price and personnel costs have the bigger share that is around 32% for fuel price and almost 19% for the salaries.

Tab. 5.42: Weight of each cost item on the total cost for road transport (percentage of the total cost)

Road	**MIN**	**AVE**	**MAX**
fuel price	32,16	31,85	31,82
salary	19,10	18,37	18,00
social costs	7,96	7,87	7,88
tyres	1,29	1,60	1,83
insurance vehicle	2,02	2,81	3,38
maintenance	5,39	7,11	7,62
taxes	0,48	0,72	0,90
tolls	8,91	7,35	6,30
overhead	11,14	10,50	10,13
depreciation	6,76	7,24	7,65
other costs	4,78	4,59	4,50
	100,00	100,00	100,00

Source: own elaboration

In the case of rail transport, on this route, the main costs items correspond to the leasing/rent or amortization of the locomotives, to the track costs, and to the electricity used.

In this case a relevant part of the costs is represented by the additional locomotives that need to be added on the Swiss territory.

Tab. 5.43: Weight of each cost item on the total cost for rail transport

Rail	**MIN**	**AVE**	**MAX**
energy price	19,77	15,95	13,90
push locomotive	8,67	15,08	18,47
salary	2,86	2,39	2,13
social costs	0,95	0,80	0,71
insurance vehicle	1,91	1,59	1,42
maintenance locomotives	3,95	3,30	2,95
maintenance wagons	5,93	6,87	7,37
overhead	1,53	1,13	1,02
average track cost	19,77	20,62	21,06
other costs	0,57	0,46	0,41
leasing rent	21,94	21,56	21,33
shunting operations	12,14	10,25	9,24
	100,00	100,00	100,00

Source: own elaboration

To conclude, a brief overview of intermodal solution is provided, where a big impact is given by rail track costs, locomotive and wagons and electricity.

Tab.5.44: Weight of each cost item on the total cost for intermodal road/rail transport

Road-Rail	**MIN**	**AVE**	**MAX**
fuel price road	3,51	3,06	2,79
salary road	3,53	2,98	2,67
social costs road	1,47	1,28	1,17
tyres	0,14	0,15	0,16
insurance vehicle road	0,37	0,46	0,50
maintenance road	0,59	0,68	0,67
taxes road	0,09	0,12	0,13
tolls road	7,94	5,76	4,51
overhead road	2,06	1,71	1,50
depreciation road	1,25	1,18	1,14
other costs road	0,88	0,75	0,67
energy price rail	15,95	13,41	11,97

push locomotive	7,35	13,32	16,72
salary rail	1,98	1,73	1,58
social costs rail	0,66	0,58	0,53
insurance vehicle rail	1,32	1,15	1,05
maintenance locomotives rail	3,19	2,78	2,54
maintenance wagons rail	4,79	5,78	6,35
overhead rail	1,06	0,82	0,75
average track cost rail	15,95	17,35	18,14
other costs rail	0,40	0,34	0,30
leasing rent rail	15,22	15,59	15,80
shunting operations	10,29	9,06	8,36
	100,00	100,00	100,00

Source: own elaboration

5.2.5. Genoa-Frankfurt Corridor

The second corridor analysed is the one connecting Genoa with Frankfurt, the distance between the two points are the ones below.

- Road transport: 800 km, 12 hours;
- Rail transport: 788 km, 18 hours;
- Intermodal transport road + rail: 750 km by rail and 40 km by road, 16 hours by rail, 1 hour by road.

When comparing the total cost to move freight from Genoa to Frankfurt, rail transport shows to be the cheapest solution, followed by the intermodal combination, to conclude with road transport.

Between the less expensive solution, rail transport scenario MIN and the most expensive, road transport scenario MAX, the difference, money wise is more than 20,000 €.

Tab. 5.45: Genoa-Frankfurt: Total cost

Total cost	**MIN**		**AVE**		**MAX**
Rail	14.226,00	Rail	26.038,00	Rail	33.526,00
Road-rail	19.216,46	Road-rail	26.664,85	Road-rail	35.023,56
Road	29.328,00	Road	35.280,00	Road	41.267,20

Source: own elaboration

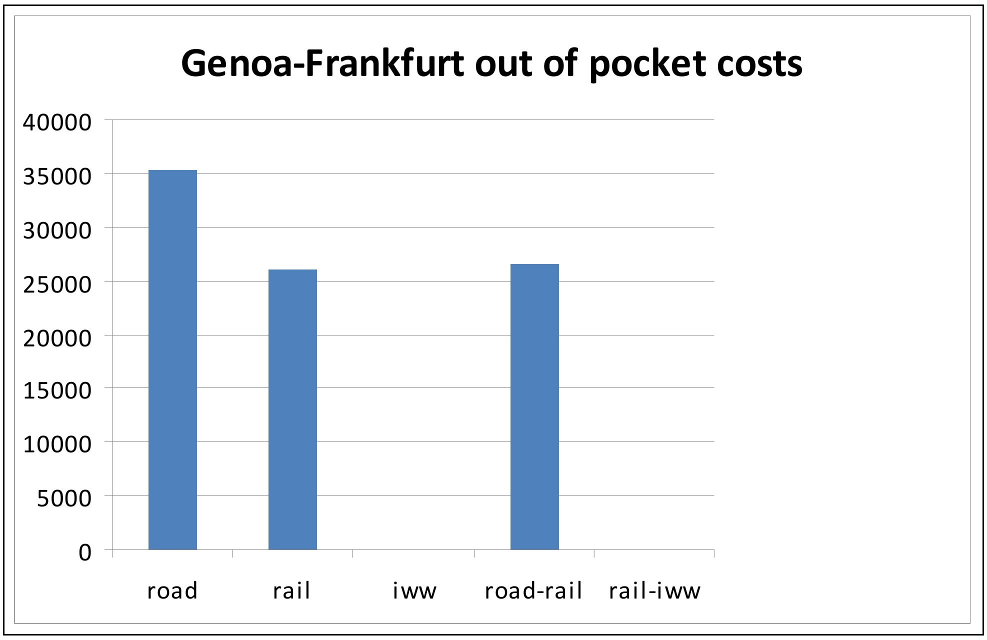


Fig: 5.5: Genoa-Frankfurt: Total cost

Source: own elaboration

Table 5.46 shows the same values than the table before, divided by the total amount of tons.

Tab. 5.46: Genoa-Frankfurt: Cost per ton

Cost per ton	MIN		AVE		MAX
Rail	14,22	Rail	26,03	Rail	33,52
Road-rail	19,21	Road-rail	26,66	Road rail	35,02
Road	29,32	Road	35,28	Road	41,26

Source: own elaboration

The tables below present the values for €/tkm, €/km and €/h.

Rail transport and intermodal transport have an average cost of 0,033 €/tkm, while for road transport the average cost is 0,044 €/tkm.

Tab. 5.47: Genoa-Frankfurt: Cost per ton/kilometre

Cost per tonkm	MIN		AVE		MAX
Road-rail	0,024	Rail	0,033	Rail	0,042
Rail	0,024	Road-rail	0,033	Road rail	0,044
Road	0,036	Road	0,044	Road	0,051

Source: own elaboration

The following two tables report the kilometre costs and hourly costs for the route Genoa-Frankfurt, also in this case as in the previous corridor, road transport has the lowest coefficient, while rail transport has higher values, as it is reasonable to imagine.

Tab. 5.48: Genoa-Frankfurt: Cost per kilometre

Cost per km	MIN		AVE		MAX
Road	0,916	Road	1,102	Road	1,289
Road-rail	8,177	Road-rail	11,346	Road rail	14,903
Rail	12,263	Rail	16,521	Rail	21,272

Source: own elaboration

The hourly cost is clearly different among modes, rail transport being the one with highest values, ranging from around 548 €/h to 931 €/h.

Tab. 5.49: Genoa-Frankfurt: Cost per hour

Cost per hour	MIN		AVE		MAX
Road	61,100	Road	73,500	Road	85,973
Road-rail	266,895	Road-rail	370,345	Road rail	486,438
Rail	547,153	Rail	723,277	Rail	931,277

Source: own elaboration

The last part of the paragraph is dedicated to the weight that each cost item has on the total cost.

As already observed for the other corridors, the main cost components are the same in each case, according to the mode of transport.

Below some general consideration that apply specifically on the Genoa-Frankfurt corridor.

- For road transport the main cost items are: fuel cost, personnel cost and depreciation of the vehicles.
- For rail transport: track costs, leasing/rent of the locomotives and wagons and energy price.
- In the intermodal solution, the more relevant cost items are track costs, leasing/rent of the locomotives and wagons and energy price in the rail segment.

Tab. 5.50: Weight of each cost item on the total cost for road transport (percentage of the total cost)

Road	**MIN**	**AVE**	**MAX**
fuel price	33,09	32,56	32,38
salary	19,96	19,07	18,61
social costs	8,32	8,17	8,14
tyres	1,33	1,63	1,86
insurance vehicle	2,11	2,92	3,49
maintenance	5,55	7,26	7,75
taxes	0,50	0,75	0,93
tolls	5,43	4,45	3,80
overhead	11,64	10,90	10,47
depreciation	7,07	7,52	7,91
other costs	4,99	4,77	4,65
	100,00	100,00	100,00

Source: own elaboration

Tab. 5.51: Weight of each cost item on the total cost for rail transport

Rail	**MIN**	**AVE**	**MAX**
energy price	22,05	18,16	15,99
push locomotive	5,60	9,93	12,30
salary	3,02	2,57	2,32
social costs	1,01	0,86	0,77
insurance vehicle	2,02	1,72	1,55
maintenance locomotive	4,41	3,76	3,39
maintenance wagons	6,62	7,83	8,48
overhead	1,61	1,22	1,11
average track cost	22,05	23,48	24,23
other costs	0,60	0,50	0,44

leasing rent	23,17	23,24	23,25
shunting operations	7,84	6,75	6,15
	100,00	100,00	100,00

Source: own elaboration

Tab. 5.52: Weight of each cost item on the total cost for intermodal road/rail transport

Road-Rail	MIN	AVE	MAX
Fuel price road	2,56	2,21	2,00
salary road	2,57	2,15	1,92
social costs road	1,07	0,92	0,84
tyres	0,10	0,11	0,12
insurance vehicle road	0,27	0,33	0,36
maintenance road	0,43	0,49	0,48
taxes road	0,06	0,08	0,10
overhead road	1,50	1,23	1,08
depreciation road	0,91	0,85	0,82
other costs road	0,64	0,54	0,48
Energy price rail	20,10	16,73	14,83
Push locomotive	5,36	9,61	11,99
salary rail	2,57	2,21	2,01
social costs rail	0,86	0,74	0,67
insurance vehicle rail	1,72	1,48	1,34
maintenance loco rail	4,02	3,46	3,15
maintenance wagons rail	6,03	7,21	7,87
overhead rail	1,37	1,05	0,96
average track cost rail	20,10	21,63	22,48
other costs rail	0,51	0,43	0,38
leasing rent rail	19,73	20,00	20,14
shunting operations	7,50	6,54	5,99
	100,00	100,00	100,00

Source: own elaboration

5.2.6. Genoa-Strasbourg Corridor

The last corridor taken into consideration is the one between Genoa and Strasbourg, in France.

Between the two points those are the distances and the times needed for the shipment.

- Road transport: 612 km, 9 hours;
- Rail transport: 580 km, 13 hours;

- Intermodal transport road + rail: 540 km by rail and 40 km by road, 11 hours by rail, 1 hour by road.

As for the other corridors, the analysis starts from a comparison among the three possible mode of transport in relation to the total costs for each mode. As already seen in the previous two cases, rail transport is the most economic solution, while the less preferable is road transport.

Tab. 5.53: Genoa-Strasbourg: Total cost

Total cost	**MIN**		**AVE**		**MAX**
Rail	14.226,00	Rail	20.157,00	Rail	26.114,00
Road-rail	15.031,46	Road-rail	20.989,85	Road rail	27.568,56
Road	22.568,10	Road	27.071,84	Road	31.602,37

Source: own elaboration

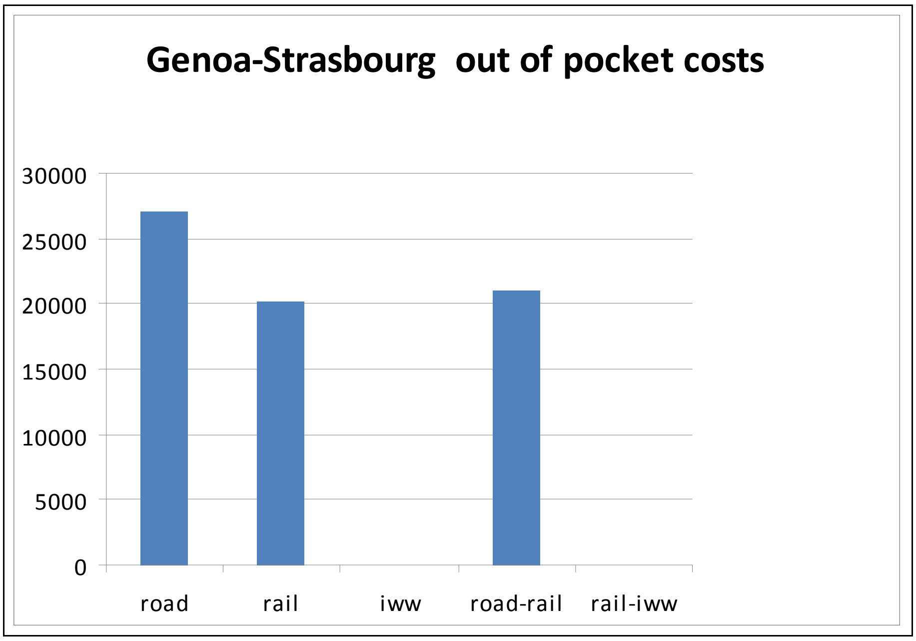


Fig. 5.6: Genoa-Strasbourg: Total cost

Source: own elaboration

The difference between rail transport and the intermodal solution does not seem to be considerable, while a significant difference is present for road transport. In case the cost figures will reach the highest level, the amount of money spent in road transport could be more than 30.000 €.

Tab. 5.54: Genoa-Strasbourg: Cost per ton

Cost per ton	MIN		AVE		MAX
Rail	14,22	Rail	20,15	Rail	26,11
Road-rail	15,03	Road-rail	20,98	Road rail	27,56
Road	22,56	Road	27,07	Road	31,60

Source: own elaboration

The outcome of tables 5.55, 5.56 and 5.57 are related to the €/tkm, €/km and €/h and are in line with the results obtained for the other two corridor leaving from the port of Genoa.

The results have a slight variation that is due to the corridors differences.

Tab. 5.55: Genoa-Strasbourg: Cost per ton/kilometre

Cost per tonkm	MIN		AVE		MAX
Rail	0,024	Rail	0,034	Rail	0,045
Road-rail	0,025	Road-rail	0,036	Road rail	0,047
Road	0,036	Road	0,044	Road	0,051

Source: own elaboration

Tab. 5.56: Genoa-Strasbourg: Cost per kilometre

Cost per km	MIN		AVE		MAX
Road	0,921	Road	1,105	Road	1,290
Road-rail	7,024	Road-rail	9,808	Road rail	12,882
Rail	12,263	Rail	17,376	Rail	22,512

Source: own elaboration

In case one wants to move freight from Genoa to Strasbourg he/she should know that the kilometre road cost is ranging from 0,92 €/km to 1, 29 €/km, while the hourly cost is around 75 €/h in case of average costs.

The hourly cost to move freight with rail transport is definitely higher, bearing in mind that the quantity loaded on a train is higher than the one on a track, therefore to move the same quantity the amount of vehicles is higher for road transport.

Tab. 5.57: Genoa-Strasbourg: Cost per hour

Cost per hour	**MIN**		**AVE**		**MAX**
Road	62,689	Road	75,199	Road	87,784
Road-rail	242,442	Road-rail	338,545	Road rail	444,654
Rail	547,153	Rail	775,269	Rail	1004,385

Source: own elaboration

To conclude some consideration about the relevance of the cost items on the total cost for each mode of transport; for road transport the main cost items are fuel cost, personnel cost and vehicles deprecation.

Tab. 5.58: Weight of each cost item on the total cost for road transport (percentage of the total cost)

Road	**MIN**	**AVE**	**MAX**
fuel price	32,90	32,46	32,35
salary	19,45	18,64	18,23
social costs	8,11	7,99	7,97
tyres	1,32	1,63	1,86
insurance vehicle	2,06	2,85	3,42
maintenance	5,51	7,24	7,75
taxes	0,49	0,73	0,91
tolls	7,06	5,80	4,96
overhead	11,35	10,65	10,25
depreciation	6,89	7,35	7,75
other costs	4,86	4,66	4,56
	100,00	100,00	100,00

Source: own elaboration

The impact that track costs and the leasing or renting of the vehicles have on the total costs can be observed by the share that they have on the total cost.

The share of track cost vary between 20% to 23% on the total cost, lower is the value for leasing/rent, that reaches its maximum in the MAX scenario with 21,5%.

Tab. 5.59: Weight of each cost item on the total cost for rail transport

Rail	MIN	AVE	MAX
energy price	20,39	17,22	15,08
push locomotive	7,03	12,80	15,76
salary	5,48	2,40	2,15
social costs	1,83	0,80	0,72
insurance vehicle	1,83	1,60	1,43
maintenance loco	4,08	3,56	3,20
maintenance wagons	6,12	7,42	8,00
overhead	1,46	1,13	1,02
average track cost	20,39	22,27	22,85
other costs	0,55	0,47	0,41
leasing rent	21,02	21,63	21,51
shunting operations	9,84	8,70	7,88
	100,00	100,00	100,00

Source: own elaboration

The same considerations can be done for intermodal road-rail solution, where the rail components weight more that the road ones, accounting for more than half of the total cost.

Tab. 5.60: Weight of each cost item on the total cost for intermodal road/rail transport

Road Rail	MIN	AVE	MAX
Fuel price road	3,30	2,82	2,55
salary road	3,32	2,75	2,44
social costs road	1,38	1,18	1,07
tyres	0,13	0,14	0,15
insurance vehicle road	0,35	0,42	0,46
maintenance road	0,55	0,63	0,61
taxes road	0,08	0,11	0,12
overhead road	1,93	1,57	1,37
depreciation road	1,17	1,09	1,04
other costs road	0,83	0,69	0,61
Energy price rail	18,66	15,41	13,61
Push locomotive	6,91	12,30	15,27
salary rail	2,28	1,95	1,76
social costs rail	0,76	0,65	0,59

insurance vehicle rail	1,52	1,30	1,18
maintenance loco rail	3,73	3,19	2,89
maintenance wagons rail	5,60	6,64	7,22
overhead rail	1,22	0,92	0,84
average track cost rail	18,66	19,92	20,62
other costs rail	0,46	0,38	0,34
leasing rent rail	17,48	17,58	17,64
shunting operations	9,67	8,36	7,64
	100,00	100,00	100,00

Source: own elaboration

5.2.7 Transhipment costs

The results obtained so far are the ones related to the pure transport cost, without including the expenses for the transhipment activities.

According to the literature review and the outcome of the interviews carried out it appears that the calculation of the transhipment operations is normally calculated on the single movement of the loading unit. This means that, in the case of container transport, a fix amount of money is paid for each container and for its complete loading/unloading operations.

When considering the cost for such operation, the data obtained were witnessing that there is no big difference among the different modes of transport. The reason is explained by the fact that the cost for the movement of a single container does not vary according to the mode of transport from where the loading unit is taken or placed.

The source of such information were few studies dealing also with this topic, but essentially the information obtained by the transport operators, uni-modal and intermodal ones.

According to the interviews, regardless the mode of transport, the cost for moving a container can vary between 30 and 50€/movement. Remarkable information is that the cost does not vary according to the container dimension, therefore the cost is the same for 20 and 40 TEU containers.

Bearing in mind what has been reported above, it is clear that a substantial differentiation is given by the time needed for the complete operations.

In case of a single truck the time spent for the loading/unloading is around 3 minutes, the time is clearly longer when the operation is carried out for a train, where the total time can vary from 3 to 5 hours. The time needed to load and unload a barge, same type considered in this thesis, is ranging from 24 to 48 hours.

The difference, when considering transhipment costs, is made by the time spent for the operation, nonetheless in the cases reported above the amount of freight, assumed equal for each mode, implies that the number of vehicles needed is not one, exception made for inland navigation.

5.3 Sensitivity analysis

After having shown the results of the calculations for each corridor considered, the next step will be the development of a sensitivity analysis. The sensitivity analysis is a method that determines how the model and the results are influenced by parameter's variations. In this case the changes are applied to the cost items present in the cost functions. The aim of the sensitivity analysis is to observe how variations in the cost items' values influence the final results and to see which kind of impacts such changes could have on transport costs and hence on the transport mode ranking based on the total costs.

The standard application of sensitivity analysis is performed taking into account each parameter one by one, so that the consequence of a variation can directly be linked to that element. In the case of this thesis the actual application would consider each cost item for each single mode of transport present on the selected corridors.

This procedure will clearly bring to an unanimous and evident change in the total cost for each mode of transport, attributable to the variations presumed.

One could argue that this type of sensitivity analysis it is not really reassembling the actual situations occurring in real world. The variations in cost components of one mode of transport are not disconnected by other possible events in the remaining modes of transport.

For the sake of argument it is possible to imagine the case of change in fuel cost for road transport; the increase of fuel could come from variation in crude oil, so that a direct effect could be produced on each mode of transport, therefore also inland navigation and rail transport. Assuming that this could be the case, ad additional element should be clarified, that is the impact that a possible crude oil variation could bring to each single mode of transport.

In order to perform this type of sensitivity analysis those elements should be known, nonetheless it is really hard to identify and measure these impacts. A possible solution could be the assumption of certain levels of variations and their combination, but even with this approach the results obtained could just be some of the possible scenarios.

Bearing in mind the limitations of the two approaches, the first one that considers each cost item one by one and for each mode of transport separately has been chosen to perform the present sensitivity analysis that allow to capture the effect that each single variation makes on the total cost.

Some additional explanations are required before presenting the results obtained by the sensitivity analysis. As illustrated earlier in the text, the three main cost item that put strain on the total cost have been detected and for each mode and corridor a precise share on the total cost has been obtained. Considering that those three elements are the most important for the composition of the total cost, the sensitivity analysis has been developed taking into consideration those ones. The reason for such selections is rather straight, since those are the ones that impact most and their variations could lead to bigger impact on the final costs.

For each corridor and each mode of transport, the three cost items have been taken and made them vary within a range that goes from -50% to +50% of the average value assumed for each specific cost item. More precisely the variations of the cost could be: -50%, -30%, -10%, -1%, +1%, +10%, +30%, +50%.

This big range could provide the results in case of structural variations of the costs that could happen in normal market circumstances but also big changes that could occur in more unexpected situations due to particular market events.

Some cost items were modified for the development of the sensitivity analysis, while the remaining ones have been kept at their average value.

The calculations have been performed and the results obtained compared with the previous average total costs. This assessment allowed to confront the ranking of each mode of transport in relation to their total costs, both in "normal" circumstances and when applying a sensitivity analysis.

The conclusions that could be drawn are mainly referring to the possible variations in selecting a mode of transport, based on pure transport costs, in case some important cost component will vary their values.

In order to provide a complete analysis of the results obtained for each corridor, each mode of transport and each variation on the single cost item, the outcomes of the calculations are provided in Annex 5.1.

In this part of the text, the main results are illustrated so that a general understanding of the sensitivity analysis could be grasped, allowing the reader to deepen his/her curiosity with the tables attached.

An important distinction has to be made between the corridors of Antwerp's hinterland and the Genoese ones. In the second case, the only possible mode solution would be road only, rail only and their intermodal combination. This constraint made so that rail transport was always the most convenient in the current circumstances. When applying the sensitivity analysis, the variations on the cost items did not show to be so important to such an extent that could produce a variation in the ranking of the total costs.

The reason is explained by the fact that, in most of the cases, the major consequences of costs variations were observed on the comparison between road and inland navigation transport.

Starting from the corridor Antwerp-Basel the main results obtained are showing that, in case rail transport costs would change, namely energy costs, leasing costs of the vehicles and track costs, the ranking of the modes of transport, based on their transport costs will not change, rail transport remaining always the most convenient. Some exceptions could occur if the variation in rail transport costs would concern only pure rail transport and not intermodal rail transport, this could also be a scenario, although rather difficult to imagine.

Some changes could be observed in case the energy cost in road transport would increase/decrease 50% and 30%. If that will be the case, road transport would become cheaper than rail transport. Similar considerations are valid for inland navigation, and they could be the consequences that a fuel or salaries variations could have on the total costs. A decrease in personnel costs in inland navigation could lead to a shift between road and inland navigation, where using barges to move freight could be cheaper than using trucks. Similar situation in a case of fuel costs drop of 50% or 30%.

In the case of Antwerp-Frankfurt corridor, no big shifts in cost ranking were observed even with high variations.

To conclude the sensitivity analysis of the Antwerp's corridor, the one leading to Strasbourg showed that a consistent increase in energy costs, personnel costs and leasing/amortization costs for inland navigation could make road transport more appealing that the river solution.

On the contrary rail transport will confirm its primacy, being the cheapest, regardless any cost variations of any kind. Road transport could gain opportunity to attract market, according to monetary transport costs, with significant decrease in energy costs, salaries cost and overhead costs.

As already observed before, rail transport showed to remain the most convenient mode of transport in all the routes from the port of Genoa.

It is important to highlight that variation in road transport and rail transport are assumed to happen simultaneously also in intermodal transport, e.g. in case salary of the road sector will decrease, similar situation is assumed for the road part of an intermodal journey.

Some general considerations can be drawn:

- Changes in the ranking of transport modes, based on transport costs, occurred only in case of important variations in each single cost item. The variations that implied consistent cost modifications were the ones of -50%, -30%, +30% and +50%.

- Ranking variations in total costs between uni-modal and intermodal solutions are verified only in the case that cost variations concern only uni-modal or only intermodal transport. These circumstances are hardly believable in real markets.
- In general, it can be asserted that the results are showing how important are the cost items used for the sensitivity analysis. This is explained by the fact that a relatively small variation in their costs' values, does not have a major effect on the general ranking of the transport costs of the transport's modes. On the contrary, if these cost items increase or decrease extremely their market values, those changes can even affect the entire transport sector and have consequence on other transport modes and possibly on the modal shift.

5.4 Market structure, price formation and their link with mode choice

Up to this moment the research carried out the analysis of the cost structure from the transport operator point of view, focusing the attention on the real cost that the company has to bear. It has been already pointed out, though, that the transport company has to obtain a profit out of its activity, therefore a mark up will be put above the operational costs.

This paragraph will try to outline some important information on the final price for each transport mode. The reason of this investigation appears clear when confronting the results obtained from the previous out of pocket analysis and the few found data on modal split, as reported in chapter IV. It is indeed clear that, from an out of pocket point of view, the cheapest mode is in many cases rail transport, nonetheless the indications about modal split report the massive use of road transport, being, according to this thesis, much more expensive than rail transport.

Since cost figures have been considered, it could be argued that the mark up could play a crucial role in defining the final price. This could potentially lead to a different ranking of the transport modes, showing a better positioning of road transport.

In order to clarify this aspect an analysis of the different market structure for the each mode of transport has been carried out complemented with an investigation of the average margin profit for these sectors.

The literature on market structure is showing a plain diversification among road, rail and inland navigation sectors.

In Blauwens et al. (2008) an overview on the different market's structures is illustrated reporting the different elements that characterize each of them. Road transport and inland navigation are rather open markets where the barriers to enter are relatively low, especially in road transport the market is characterized by high competition.

The road sector has been deeply analyzed by the DG TREN European Unit in 2006 (The road transport report n.1); the report is providing useful information on several aspect connected to the road industry, such as flags in international transport, age of the fleet, use of vehicles, use of foreigner drivers and so on.

For the purpose of this study, what it is important to report is the information on the opening of the market to international transport, comprising bilateral transport, cross-trade and cabotage. In Europe five flags, German, Spanish, Dutch, Polish and Italian, represented the 52% the international transport.

An important element is the fact that 50% of the intra EU import and export market in each country is served by domestic hauliers, showing therefore effective competition in the internal markets.

Some indications on the cost structure show that labour and fuel costs are the main costs components.

For what concerns inland navigation, as already said, there is complete freedom to access into the market, a good part of the companies is owned on a family base and on the Rhine river, co-operations, joint ventures and mergers are increasing. A recent tendency for the sector is to develop vertical integrations especially for container services, where a possible complementation with road or rail services could take place. (Notteboom, 2007).

The situation for the rail industry is different from the previous two modes. Although the rail market has been open from 2007 in Europe, still the process for a complete competition in the market is far to be reached.

The European Member States have put in place measures that could contribute to an enlargement of rail market to new entrants, nonetheless the former national companies still detain the majority of the market share in the European scene.

There are some cases where the market liberalization brought to some changes and namely improvement in the rail service and decrease in market price, as in Sweden or in Germany by 20-30%. (Domergue and Quinet, 2001, Makitalo, 2011).

The references above report of different market structure for each mode of transport, a general consideration could be the that road and inland navigation have a more similar market, where there are few barriers to entry and the competition among operators is rather developed. The situation of the rail sector is different showing that the position of the incumbents is still very strong, regardless the liberalization measures, and that the initial asset needed to enter the sector could constitute an obstacle to new entrants.

The analysis of the market structure was also investigated with the support of companies' financial accounts that express the evolution and the current financial state of the companies.

This investigation could give an idea of the company margin profit, in order to make some consideration on the final price of the service, as it comes into the market. It could also be useful for comparing the three modes of transport and observing how the profit can influence the previous finding obtained by the cost analysis.

In order to do so, two databases were used: Belfirst and Aida databases, respectively two national databases containing enterprises' accounting and financial information.

For the two nations data on the overall road and rail sector were collected, moreover from Belfirst information on inland navigation were added.

Among the other data, it was possible to obtain figures on the profit margin (in %) for the last years for the entire road, rail and inland navigation sector.

Based on these sources it was possible to determine that the road sector, both in Belgium and in Italy witnessed a positive trend during the last years, values that were higher of course before the crisis. Even during the years 2008 and 2009 the average values were around 2% of profit margin.

The situation for the inland navigation companies, registered in Belgium, was similar to the road ones during the last years. The values of profit were respectively: 1.21%, 3.32% and 1.17% in 2009, 2008 and 2007.

On the contrary the rail market situation is less positive than the previous two. The values of the last years were negative both for ex-national companies and both for the private ones.

While 2009 was the worst year both for Belgian and Italian companies, during the previous two years the situation were slightly different: in 2008 there was an average increase in profit in Italy, 2.22%, in Belgium the companies were facing a loss of 6,24% on average.

This information is a valuable for elaborating on the relation between costs and prices as mentioned earlier.

The outcome of the cost analysis showed that rail transport is the cheapest mode of transport, nonetheless when looking at the general and few figures about modal split road transport seems to be the preferred ones, although more expensive. A possible reason that could explain this situation could have been related to the difference in mark ups among modes of transport, namely rail transport could have been characterized by high mark ups making the final rail price higher than the road price. Form the analysis just presented, market structures and accounting and financial information, this does not seem to be the case. On the contrary it appears that, above the higher road cost, there is a mark up that could make it even more expensive for the final client. This information is deduct by the fact that road and inland navigation transport have a positive profit margin, while the figures are negative for rail transport.

It is true that the values considered are the average ones, nonetheless they resemble the current situation in the transport sectors.

It is possible to argue that: if also the final price for rail transport is lower than road transport there should be other qualitative reasons that make the shipper or freight forwarder choose road than rail transport for the same destination.

At this stage it important to remember what literature review is reporting on the elements influencing mode choice, that are not just related to the out of pocket costs nor to the price of the service, but also to qualitative attributes, such as frequency, reliability etc.

In order to check if these considerations were correct, before continuing the development of the research, the author looked for some confirmations from the freight forwarders and shippers involved in the study. This further analysis was needed since the data on modal split were, as already said, not available or very poor.

Among the freight forwarders and shippers interviewed, the ones having experienced shipments on the corridors considered were chosen. The information gathered was mainly looking at obtain information on their modal split on the selected corridors, in order to know which were their preferences. The outcomes showed that the preferred mode was road transport, although more expensive than rail transport.

This information confirmed what was already clear from the literature, but enforced the previous finding since they are referring to the specific case studies analyzed in this thesis.

From this confirmation it is possible to proceed forward in the research looking, at this stage, at the other qualitative elements that affect mode choice, as it will be presented in chapter VI.

5.5 Final Considerations

In respect of the analysis of the results some general considerations about modes of transport and their cost functions will be now illustrated. Table 5.61 is summarising the values obtained for each corridor in respect to the final total cost for each mode of transport.

Tab. 5.61: Out of pocket costs, total cost per corridor

Out of pocket cost	**Antwerp-Basel**	**Antwerp-Frankfurt**	**Antwerp-Strasbourg**	**Genoa-Basel**	**Genoa-Frankfurt**	**Genoa-Strasbourg**
road	24.793	16.893	21.211	21.368	35.280	27.072
rail	20.221	12.289	17.033	17.111	26.038	20.157
iww	26.188	20.200	20.603	/	/	/
road-rail	22.379	12.946	17.690	19.425	26.665	20.990
rail-iww	29.147	22.074	22.477	/	/	/

Source: own elaboration

In all the corridors road and inland navigation transport came out to have a comparative disadvantage in relation to the total cost of the entire shipment, while rail transport is performing well being the one with lower costs. It will be reductive to order transport modes just based on the pure cost, it is important to compare them also in relation to the transit time needed to cover the distance from origin to destination. Even if road transport is relatively more expensive, it is also the mode of transport with lower transit time.

Rail transport is performing relatively well if compared to the other modes, and in particularly it is the preferable solution in the corridors connecting Genoa to the destinations in Centre of Europe. Especially in these cases it seems that the cheapest mode of transport is rail, followed by intermodal solution and road transport.

Also in the Antwerp’s cases rail transport is cheaper than the road solution. Time wise rail transport is an in-between solution among the other modes.

When possible, inland navigation, being the slowest solution, can guarantee a good alternative to road transport. It is the case that road transport and inland navigation compete on some routes, also in terms of monetary expenses.

The intermodal solutions, both road-inland navigation and road-rail appear to be intermediate solutions in respect to the total cost of the shipment. In those two cases a relevant component is the loading/unloading part that has to take place twice in the entire door to door trip.

In order to make a comprehensive analysis the transhipment costs can not be omitted. Although it has been reported that the single loading unit cost does not vary consistently among modes, in the intermodal solutions the transhipment activities are more numerous than in a single mode shipment, hence the total costs increase.

Even though the purpose of the thesis is not the direct comparison of the two ports, Antwerp and Genoa, some considerations about their performance in relations to those destinations are reported.

Only rail, road and intermodal rail transport can be compared and the results are different according to the destination selected.

In the case of Basel, a possible choice would prefer the port of Genoa; from the Italian port to Basel the out of pocket costs are less than the ones from Antwerp. This situation is verified for the three possible modes of transport. On contrary, if the freight has to reach Frankfurt or Strasbourg, the most convenient way would be the one form Antwerp, regardless the mean of transport used. The differences, moneywise, are not extreme, however even a small difference in monetary terms can influence the mode and route selection. These last considerations needs to be read keeping in mind that, what has been observed is just the land side of port, non considering the maritime traffic flows.

It is important to underline that the traffic volumes and characteristics of the two ports are very much important and should be take in into account, notwithstanding its relevance, this thesis was focusing on the land side, leaving this additional topic as interesting research for the future.

The figures obtained by the calculation on cost per kilometre covered and cost per hours of work did not have the purpose to compare the different modes among them, since the values are not really comparable, rather to provide an indication on the kilometre cost and hourly cost for each mode of transport.

Below some indications are presented, having in mind that for each corridor the average values have been considered.

In the case of road transport the €/km are ranging from 1,01 to 1,12 Euro for each kilometre, while the hourly cost is varying from 70,39 up to 88,54 €/h.

The values for rail transport are clearly higher, €/km from 14,08 to 18,76, while hourly costs are ranging form 628 to 777 €/h.

To conclude the values reported for inland navigation are showing a kilometre cost around 26 €/km and hourly cost that could range from 239 to 285 €/h.

It is worth to remember that the present outcomes of the calculations are based on a careful data collection on cost figures for each mode, such collection has been supported by expert's opinions and the estimations have been adjusted and re-analysed in light of the transport sector comments.

Furthermore the results obtained are in line with the previous works on the topic.

Interesting, although, not surprising is the pattern about the relevance of the cost items in the total transport cost. Regardless the mode of transport, energy costs, personnel costs and depreciation or leasing are the cost items that influence more the final cost of the operator. A crucial aspect is the cost of railways tracks that constitute a heavy component in rail or intermodal solutions.

In relation to the common cost items, listed above, some conclusions can be elaborated; those three aspects have different nature, while personnel costs and depreciation or leasing are more related to the company business and structure, for the energy cost, both diesel fuel or electric power, the company can not directly intervene in changing or adjusting significantly these costs.

Starting from energy cost, what can be argued is that the transport operator has minimum power in adjusting or deciding the fuel price or the electricity price; some commercial agreements can take place, but the haggling control of the transport operator, regardless its company dimension and power, will be rather negligible.

It is clear that interventions for reducing energy costs will never be taken from electric energy suppliers or oil companies, therefore the only possible interventions could come from National or European governmental authorities.

With regards to personnel costs legislative and social rules enforce the transport operator to conform to, at least, minimum levels of wages and social security contributions. Albeit irregular practises in relation to the actual number of working hours are already rather habitual in the transport sector, reductions in the perceived salary could be unfair from a welfare point of view.

The possible measures, from a business approach, could be to intervene on the personnel management, in order to re-structure the company organizational chart.

To conclude, the depreciation costs and the leasing costs for assets represent a considerable expense for the transport operators. The capital cost is an economic element that belongs to the business activity that the company itself has to control. With respect to this, each company should be well aware of their production factors and intervene, if possible, to optimise it.

Strictly linked to the factors listed above, is their productivity level.

As shown in microeconomics, (Pindyck and Rubinfeld, 2008, Katz et al., 2007) the production of certain goods or services is possible using different production factors that can be combined in order to obtain the final output and minimizing the input used.

Each production factor is therefore characterized by a level of productivity than can change according to several drivers, such as industry structure, market conditions, geographical location. Productivity can influence very much the output produced and have consequences on the final cost and price, hence also the final ranking of different mode of transport can be influenced. As stated earlier the cost figures used in this thesis are assumed to be equal to the whole Western European countries. This does not claim to perfectly represent the current situation in the whole Europe. There could be cases where the same production factor has different level of productivity in different areas or different market conditions. To this respect a good example is labour factor: market conditions, different geographical areas, different legislations and other drivers can influence labour productivity, hence the overall transport service can be influenced. The role of production's factors productivity applies to every transport mode and in general to the transport sector. This element could also help in explaining different port performance, as illustrated in Valleri and Van de Voorde, 1996. In their paper, the authors refer to port competitiveness and productivity's indicators, and the role played by capital and labour factors. A more detailed reference to these concepts will be presented later in the text.

With the information gathered so far it is also possible to elaborate on the relation between outcome of the out of pocket analysis and the current modal split that characterize these corridors.

As it was already observed the information on the modal split are not precise nor really comparable for each corridor, even so can some general considerations be made. In the cases of the corridors connecting Antwerp with Basel, Frankfurt and Strasbourg, rail appears to be most economical solutions; this factor seems to be taken very much into account from the shipper of forwarders that choose this mode of transport. This can be witnessed by the fact that there exist direct rail connections between Antwerp and the destinations considered, as reported in the previous chapter.

According to the data obtained, it seems that inland navigation is not so economic, or at least to the same level than rail transport, according to this information the shippers or freight forwarders should not frequently choose this mode of transport. This statement could be denied by the fact that there are several companies offering inland navigations services on the corridors to Switzerland and Germany, and also by the data of Antwerp Port Authority, reporting that most of the traffic reaching Switzerland is moved by inland navigation.

The case of the modal split to France is presenting a situation where road transport is the mostly used mode of transport, leading the author to assert that there should be other reasons that make freight forwarders or shippers choose for road transport instead of rail transport.

The case of the port of Genoa and its corridors resembles what the supply analysis was already showing.

The cheapest mode of transport seems to be rail transport or the intermodal solution, nonetheless the modal split for this port and corridors are witnessing an intense use of road transport, this is also witnessed by the results of the interviews earlier presented.

This situation is showing that there should be other reasons and elements that prevent the users to choose rail transport. Those elements could be not necessarily linked to monetary costs, but rather to qualitative elements or other exogenous factors that influence choices.

5.6 Chapter’s summary

Chapter V showed the results obtained for the out of pocket cost analysis, where six corridors in Europe were analyzed. The main outcome of the analysis were related to the most convenient mode of transport, that showed to be rail transport and also the costs components that weight more on the final cost.

In order to asses the results and investigate variations from the initial scenario, a sensitivity analysis has been performed, showing that only very important changes in the cost figures could actually modify the current ranking of transport modes.

Together with the cost analysis, the price structure was analyzed for each transport mode, showing that even when dealing with final prices, rail transport appears to be more convenient than road. Nonetheless the few data on modal split and the outcome of the interviews with freight forwards and operators confirm that road transport is preferred to rail transport.

This element constitutes the starting point for analysing qualitative elements that can influence mode choice, as it will be done in the following chapter.

CHAPTER VI

QUALITATIVE ATTRIBUTES THAT INFLUENCE MODE CHOICE AND THEIR ESTIMATION

Mode choice is driven by multiple factors, as already illustrated with the results of the literature appraisal presented in chapter II.

The investigation carried out in the previous chapters was focused on the monetary elements that influence mode choice. From the previous studies it appeared that transit time, reliability, frequency of the service and its possibility to suffer losses or damages would be additional factors that the shippers or freight forwarders consider.

Chapter VI has the aim to report on these qualitative attributes and to capture their relevance. Such enquiry will be put forward with a twofold approach. Firstly the results of qualitative interviews will be presented in order to show which the main elements are that freight forwarders and shippers' sample consider when selecting a mode of transport. The sample selected is constituted by freight forwarders and shippers operating in the two port's areas of Antwerp and Genoa.

The second part of the chapter will deal with the estimation of some qualitative attributes in terms of money. To this matter previous value attributable to transport time in freight transport will be used to the purpose of a real application to the freight corridors considered in this thesis.

The chapter will conclude with some considerations on the general importance of qualitative attributes and possible measures or actions that could be taken to the purpose of enhance their role in transport mode choice.

6.1 Results obtained by qualitative interviews with freight forwarders and shippers

The main purpose of a field analysis was to investigate the research topic with the added value provided by companies directly involved in the transport mode selection in the areas considered in the thesis.

In order to do so, a sample of companies suitable for this purpose was selected in the port of Antwerp and Genoa's areas.

With the purpose of obtaining a representative sample, a first screening of the freight forwarders companies was carried out, according to company size and relevance of the company on an international level. After such first selection, the companies have been firstly contacted in order to present the investigation and to gather their availability in taking part in the interviews, after their acceptance the interviews took place at their premises.

The selection of the shippers was mainly based on the relevance that these two companies cover on a European scale, being one the biggest producer of consumer goods and one of the main logistics companies involved in food distribution in Europe.

To this respect their contributions is of high value and representative of an international involvement into this issue.

6.1.1 Freight forwarders result's description

The description of the results will start from the outcome obtained by the freight forwarders sample.

The interviews have been carried out with the chair of the company or the logistics director of it, in total 45 freight forwarders were interviewed, 25 in Genoa and 20 in Antwerp. The whole sample of field survey took place between April 2009 and April 2010.

In order to obtain a comparison between the two ports, the results will be considered separately; this will allow to identify possible differentiations or to confirm similar answers.

Antwerp's sample results

For what concerns the interviews carried out in the port of Antwerp's area, 20 freight forwarders are counted.

Among these companies, the average number of employees was 70 people and the average annual sales was around 55,5 Million of Euro in 2009.

The first part of the questionnaire (See Annex 3.1), was trying to capture the market share that these companies are covering, divided by export and import flows.

The traffic flows were divided by domestic traffic, (within the country) European traffic, (from/to a European country partners) and overseas traffic, (the land part of an international overseas shipment).

In relation to these market's divisions, the respondents were asked about their modal share between road only transport and intermodal transport. Each company could declare to have domestic, European and overseas traffic. This explains the fact that in tables 6.1 and 6.2 the number of companies belonging to the market areas is different.

Tab. 6.1: Market export flows (Antwerp's sample)

Market export flows	ROAD	INTERMODAL
Domestic (9/20 companies)	80%	20%
European (17/20 companies)	78%	22%
Overseas (13/20 companies)	79%	21%

Source: own elaboration

In table 6.1 it is shown that just 9 companies over 20 are providing domestic services, and for the 80% of the cases, the freight is carried by road transport. Most of the companies have European traffic flows, and also in this case the predominant mode is road transport, the same pattern remains for the overseas traffic flows.

Tab. 6.2: Market import flows (Antwerp's sample)

Market import flows	ROAD	INTERMODAL
Domestic (9/20 companies)	83%	17%
European (17/20 companies)	86%	13%
Overseas (13/20 companies)	76%	24%

Source: own elaboration

For what concerns the import flows, the results are in line with the outcome of the export analysis, and even more in favour of road transport, as it can be seen from the table above.

An additional question was specifically related to the market regions, both for import and export traffic, in which the operators were active. For the Antwerp's sample the main origins/destinations were in Belgium, 43%, followed by Germany, 18% and France, 13%, only the 8% of the total is coming from The Netherlands, and 9% is traffic to/from other destinations.

In relation to typology of loading units used, the main results show that containerized transport is the most popular with a share of 59%, divided by 34% of 40 feet container and 25% of 20 feet.

Most of the remaining freight is general cargo, 22%, followed by dry bulk, 2.5% and liquid bulk, 0.14%.

Once having the information on the cargo typology, it was interesting to investigate how these loading units are moved.

Tab. 6.3: Loading units and modes of transport (Antwerp's sample)

	Rail	Road	IWW	SSS
Container transport	11.50%	72.40%	9.80%	0.10%
General cargo	15%	74%	10%	0.91%

Source: own elaboration

The results show that road transport is mostly used to move both containerized and general cargo.

To investigate the use of intermodal transport it was asked how much of the total traffic was developed by intermodal transport and the type of intermodal transport used. Only the 13% of the shipments was moved by the intermodal solution road-rail transport and 12% by road-inland navigation combination, the remaining transport was moved by road only transport.

Some interesting information is related to the logistics strategy: the inbound and outbound logistics activities were generally equally split by internalization and outsourcing; 60% of the companies outsourced the warehousing activities, and almost all the sample was providing transport services through third parties dealing with the pure transport operations. To confirm this last aspect is the fact that most of the companies did not have physical assets, therefore any means of transport or loading units were not owned by the companies. Only 6 companies out of the 20 declared to have assets like containers, swap bodies, trucks or trailers.

The second part of the questionnaire was more focused on the selection of mode of transport and the evaluation of the criteria that characterize such choice.

The respondents were asked to express their opinion about the decision making process and the actors that take this decision. According to the Antwerp's sample in 11 cases the freight forwarder selects the mode of transport. In 4 cases the choice was taken by the freight forwarder together with the sender and the receiver of the freight. In the remaining cases the decision was taken by the sender or receiver autonomously.

For what concerns the selection of the transport providers, 15 forwarders declared that the selection was made by them, and in 3 cases freight forwarders together with the senders decide on the transport providers. In the other two cases the freight forwarders were excluded from the final decision.

The interesting results about the most important criteria that are considered when selecting a mode of transport are provided by the last two questions. First it was asked which the most relevant criteria are for a generic service, regardless modes of transport; in the second question road transport and intermodal transport were compared, in relation to the same criteria.

The criteria considered are the following:

- Reliability: Certainty of meeting the established time window,
- Flexibility: Minimum notice time for transport order (No. of week/days/hrs before departure or delivery)
- Risk of loss/damage: Probability of Loss/Damage by the shipment
- Frequency: General Frequency of the Transport Service
- Cost: Total costs per shipment
- D2D total transport time: Door to Door for the total transport time, including waiting and transhipment time
- Customer services: Effectiveness and efficiency of Service (Track & Trace/Customer relationship)
- Environmental impact: CO_2 emissions per mode of transport

Tab. 6.4: Service criteria (Antwerp's sample)

	reliability	***flexibility***	***loss/damage***	***frequency***	***cost***	***transport time***	***customer service***	***environment***
Average	4,8	3,95	4,6	3,85	4,1	3,6	4,35	2,5

Source: own elaboration

Table 6.4 shows the average value that each criterion got in a Likert scale from 1 to 5. The score 1 was assigned when the attribute had not relevance at all, while 5 was chosen when the criterion had very high importance. What can be observed is that, the most important aspect is the reliability of the service, namely the certainty to meet the established time window and service level. Just after reliability, the possibility that losses or damages may occur, where the ranking obtained was 4.6. Customer services and costs follow in the ranking, while the less important element is the environmental aspect.

The same exercise was applied to road and intermodal transport supposing that the two modes could be alternatives.

Tab. 6.5: Service criteria comparison (Antwerp's sample)

Average	reliability	flexibility	loss/damage	frequency	cost	transport time	customer service	environment
Road	3,85	4,35	3,75	4,40	3,45	4,10	4,00	2,30
Intermodal	3,80	3,25	4,10	3,40	3,95	3,20	3,65	3,95

Source: own elaboration

In table 6.5 the two modes of transport are compared in terms of criteria considered; what is rather clear for the sample is that road transport is more flexible than intermodal transport, that the frequency in road transport is higher than in intermodal transport, and that road transport can perform better in total transport time. Intermodal transport is perceived better to road transport for what concerns the possibility to have loss or damages during the transport, for the total costs and for the environmental impact. It is important to stress that reliability, earlier indicated as very important criterion, got the same score for the two different modes of transport.

While table 6.4 is showing the relevance that the sample assign to transport attribute, in general, table 6.5 compares the perceptions that the sample has in relation to the same criteria, but applied to the two different modes of transport, when the two modes are comparable on the same route. It is therefore explained why the two tables are slightly different, while the first one is showing the overall relevance given to the attributes, the second is more focused on the actual perceived performances of the two modes.

Some other qualitative considerations emerged during the interviews. It was pointed out that the main objectives that guide their company strategy are the reduction of the total costs and the satisfaction of the client, namely related to the capability to provide reliable services. Although the sample recognised that intermodal transport could provide a better solution in relation to environmental emissions, they stated that this aspect is taken in consideration only if an economic benefit can be obtained together with a lower environmental impact.

It was also observed that the freight forwarders could take into account intermodal transport if the final client was particularly concerned about environment pollution; this was the case in few companies' experience.

Genoa's sample results

The following results are the ones emerged from the interviews carried out in the area of the port of Genoa; in this case the freight forwarders interviewed were 25. The average number of people employed was 47 and the average annual sale, in 2009, equal to 21,5 Million Euro.

Tab. 6.6: Market export flows (Genoa's sample)

Market export flows	**ROAD**	**INTERMODAL**
Domestic (3/25 companies)	93.30%	6.67%
European (10/25 companies)	57.40%	32.80%
Overseas (25/25 companies)	58.08%	37.90%

Source: own elaboration

From table 6.6 it can be observed that road transport is predominant compared to intermodal transport; in particular for domestic transport, it is reaching very high percentage, up to 93% in import traffic. The advantage of road transport is not so marked for European and overseas traffic, nonetheless it is still more used than intermodal transport.

Tab. 6.7: Market import flows (Genoa's sample)

Market import flows	**ROAD**	**INTERMODAL**
Domestic (4/25 companies)	95%	5%
European (6/25 companies)	62%	38%
Overseas (22/25 companies)	72%	28%

Source: own elaboration

The same considerations are valid for import flows, where the situation is even more marked, road transport reaching 95% of the shipment for national traffic.

Also in the case of European and overseas traffic, the share of road transport is higher than intermodal and with higher shares than export flows.

The specification of the market areas served by the freight forwarders operating in Genoa shows that the main market area was limited to the north of Italy, with a percentage of 67%. Another relatively important share of the traffic was reaching the centre of Italy, 9% and a 5% was directed to south of Italy. A minimum part of the traffic reached foreigner countries, Germany and Spain, both 2%; the remaining traffic had different destinations.

In relation to the loading units used, 77% of the cargo was moved with containers, 34.4% of 20 feet and 42.5% of 40 feet. A 6% of the traffic was represented by general cargo typology and 5% was moved with trailers.

Tab. 6.8: Loading units and modes of transport (Genoa's sample)

	Rail	**Road**	**SSS**	**Air**
Container transport	25.80%	71.40%	0.40%	2.40%
General cargo	3%	97%	/	/

Source: own elaboration

The modal division for the specific loading units was showing that, both for general cargo and for containerized transport, road was the most used, just a small percentage was moved by train; in the specific case, 26% of containerised cargo and 3% of general cargo.

The intermodal road-rail combination reaches a 20% of the total shipments, while the big majority of the cargo, 76%, was moved by road. Low quantities were moved by short sea shipping or combined air transport.

All the logistics activities were mainly outsourced, 73% of inbound logistics activities, 77% of outbound activities and 79% of warehousing activities. The physical transport activities were outsourced for the 88% of the cases, therefore few companies had their own means of transport, only 6 companies owned containers, trailers or trucks.

According to answers of the freight forwarders, the selection of the mode of transport and the selection of the transport providers was taken by themselves, 18 times for mode choice and 23 times for choosing the transport operator. If the freight forwarder was not independent in his/her decision, the senders or the receivers cooperate with him/her in the choice. In 2 cases forwarder and sender decide together, in 2 cases receiver and forwarder and in 2 cases the three operators together.

In relation to relevant criteria, for a general service, the main results are reported in the table below.

Tab. 6.9: Service criteria (Genoa's sample)

	reliability	***flexibility***	***loss/damage***	***frequency***	***cost***	***transport time***	***customer service***	***environment***
Average	4,68	3,92	4,28	3,72	4,12	3,92	4,28	2,24

Source: own elaboration

Reliability was considered the most important criteria, equally followed by possibility to have losses or damages and by the importance of having good customer services.

The pure cost of the shipment came after the first three criteria.

In table 6.10 the comparison between road transport and intermodal is presented.

According to the same criteria, road transport was preferred to intermodal transport in relation to reliability, flexibility, frequency, transport time and customer services.

On the other side, intermodal transport was perceived better for its costs and its environmental impact; the two modes were considered almost equal for the possibility to have losses or damages.

The main aspects considered in their company's strategy were the cost of the service and the quality of services offered to the final client.

As it was for the Belgian sample, there were no measures or particular concerns about environment in the companies' strategies.

Tab. 6.10: Service criteria comparison (Genoa's sample)

Average	reliability	flexibility road	loss/damage road	frequency road	cost road	transport time road	customer service road	Environment road
road	4,26	4,47	3,60	4,34	3	4,43	4,21	1,65
intermodal	3,17	2,78	3,56	3,08	4,13	2,86	3,34	4,13

Source: own elaboration

In general, the two groups of freight forwarders expressed similar opinions or experiences in relation to all the topics presented in the questionnaire.

In relation to the market flows, both for exports and imports, the companies interviewed stated that most of the cargo was moved by road transport, and a minor part by intermodal transport. As it could be presumable, the main markets referred to the national extension, both for the Antwerp's sample and the Genoese one, Germany was one of the main origins/destinations of their traffics.

The most used loading unit was the ISO container, followed by general cargo typology. The tendency for these companies was to outsource physical transport operations and therefore they owned very few physical assets.

Another aspect that was common for the two samples was the decision power that the freight forwarders detained when selecting the mode of transport or choosing the transport providers.

When analysing the criteria's relevance expressed by the sample interviewed, the results showed agreement in ranking them from the most relevant to the least ones. The most important elements when selecting a mode of transport were: reliability, possibility to have losses or damages, customer services, costs, flexibility and environment issues; the presented ranking is valid for both the groups' interviewed. The outcome of the field survey is therefore in line with the results of the literature on the topic, as it can be found in chapter II.

Frequency of the service and its transport time were not ranked very high, although important elements, in the case of these two attributes the operators in Antwerp considered more relevant the frequency, while for the Genoese ones transport time was more important.

The comparison of road transport only and intermodal transport brought the freight forwarders to express opinions about their characteristics, and also in this case the results are quite similar.

For both samples, road transport was preferred in terms of flexibility, frequency, transport time and customer services; intermodal transport was performing better in relation to the total cost and the environmental impact.

Some dissimilarity are noticed in relation to reliability, for the Antwerp's case road transport and intermodality were considered equal, while for the Genoese's group road was considered more reliable. Another difference was perceived for what concerns the possibility to have losses or damages, in the case of the forwarders in Antwerp, intermodal transport was considered better. For the Italian group there was no substantial difference between the two modes.

In both cases the environment impacts of different modes of transport were not considered relevant in their company strategy nor in their mode selection.

6.1.2 Shippers result's description

The freight forwarders interviews were complemented by the information provided by a big producing company operating in Europe and located in Belgium, together with a logistics company, located in Italy, providing services for moving food on behalf of European clients. These two operators, in their daily activity, experience the selection of mode of transport for the shipment of goods on their behalf or for third parties.

The reason for investigating shippers' point of view, although only for two cases, is explained by the fact that these interviews could enrich the finding of the previous field study and capture the opinion of a different actor in the logistic chain. Moreover the literature on shippers' perception is more abundant than the one on freight forwarders' perception.

On a general base, the results of the interviews are in line with what has been reported for the freight forwarders cases. Around 90% of the traffic flows, both in export and import, was moved by road transport and the main loading unit was the trailer, counting between 83% and 85% of the total share. The use of intermodal solutions was low, around 7% and it was mainly road-rail-combination or road-short sea shipping-road combination. In both companies the transport activities were fully outsourced and they did not own physical assets. An interesting, although peculiar aspect was related to the actors that select the mode of transport and the transport providers. In the case of the producing company, these decisions were taken by themselves. In the case of the logistics company, they declared to be the one deciding. It could be thought that this answer could be biased by the nature of the respondent. In other words the answer could be influenced by the fact that the respondents wanted to claim to be the ones actually deciding on the two matters. In both cases, the company's strategy was oriented to provide better services to fulfil the client requirements, as well as trying to control the production's costs. The environmental aspects were not the main concerns of these companies, although they reported their interest in focusing on this aspect to improve the company's sustainability approach.

In relation to the main criteria for selecting a mode of transport, the interviewed declared that the most important were: reliability, cost, transport time and customer service. This statement refers to the actual situation, namely providing information on their revealed preferences.

When comparing road and intermodal transport, in hypothetical or real situation when possible, the preferences of the operators indicated road transport as a better mode in relation to its reliability, flexibility, frequency, total transport time and customer services. On the other side, intermodal transport was considered better in relation to costs and to environmental pollution; the two modes seemed to be equivalent for the probability to produce damages or losses to the cargo during the shipment.

The overall most relevant conclusions, for the purpose of this thesis, are that:

- Among the most important elements that influences freight forwarders and shippers in mode choice, reliability is ranking very high, regardless the mean of transport used;
- road transport is perceived better for its flexibility, frequency, transport time and services to the customers;
- Intermodal transport could be preferred for its lower costs and for its greener environmental impact.

6.2 Assessment of qualitative attributes

The findings of the previous interviews showed that qualitative attributes play an important role in mode choice.

Most of the researches on mode choice, after having selected the relevant variables influencing the selection, try to investigate which is the possible monetary value that these qualitative elements could have. The reasons are multiple: going from a detailed analysis of the service demand, to researches on infrastructural cost-benefit analysis. Regardless the final aim of the investigation, it is clear from the literature review that a simple, reliable and unanimous method for the valuation of qualitative attributes has not yet been either defined, nor established values found. The reason of this lack is due to the absence of consensus in defining a single method for the estimation, together with the complexity of defining precise values that can vary according to geographical areas, commodity types and transport modes.

These arguments explain why an extensive literature on reliability, flexibility, frequency, loss or damages values is poor; on the contrary a more extended literature on value of time is present. Therefore in this paragraph the valuation of such criterion will be pursued.

The estimation's approach will be carried out by means of some indications provided by previous values of time applied to the corridors selected in this thesis.

In order to do so, the generalized cost formulation will be used, which is based on the literature presented in chapter II and other works that dealt with generalized costs calculations. (Zhang et al., 2011, Rotaris et al., 2010)

Based on the formulations presented in earlier works, the generalized costs will be calculated according to the following formula.

$$CG(t) = X(t) + VoT*t \tag{6.1}$$

Where: t = travel time

X(t) = out-of-pocket-cost for the total cargo,

VoT = value of time per hour for the total cargo

6.2.1 Applications of value of time on the selected corridors

Starting from the previous assumptions, the analysis will focus on values of time found in previous researches and applied to the present cases.

The calculation will be based on the generalized cost function, where out of pocket costs and value of time are added together.

Previous researches have already presented similar calculations, applied to different case studies, as such urban rural areas (Kumar, 2004), CO_2 pricing on container transport, (Zhang, 2011) and urban road pricing scheme in Milan, (Rotaris, 2010).

The exercise that will be presented is based on the assumption of moving 1000 tons, as it was supposed earlier in the text. Although it can be argued that the price component should be put in the generalized cost function, it has been observed that the final price's ranking does not differ very much from the ranking of the modes obtained by their cost analysis.

Moreover the final price is driven by the underneath costs.

The estimation of value of time has been deeply analysed in the European Project on: Developing of Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO), a project developed in the Sixth Framework Programme and terminated in 2006. The aim of the project was to propose harmonised guidelines for project assessment for trans-national projects in Europe. Among several costs elements, the value of time was tackled.

This source allows for a general applicability of the values obtained and the methodology applied in the European project. Numerous sources were reviewed and the final values came out of a profound analysis with possible application all around Europe.

The definition of *Value of Travel Time Saving* provided by the HEATCO project is the following:

"The VTTS for commercial goods traffic is the marginal benefit arising from a unit reduction in travel time".

According to the European project, the methodologies for values appraisal used in the European countries are mainly of two types:

- Willingness to pay for freight time saving using Revealed Preference or Stated Preference techniques;
- Cost saving approach, meaning the change in freight operators' costs structure.

The limit of this study is represented by the lack of information for all the modes of transport, presenting harmonized values only for road and rail transport. The lack of values for inland navigation, maritime and air transport is explained by the shortage of studies and researches on these transport's modes by each European country.

For the purpose of the present work, it was therefore excluded to use this relevant reference.

An interesting contribution to this matter has been provided in several studies by De Jong, (2004a, 2009, 2010) that treated this issue applied on the mode choice situation in The Netherlands.

This author represents one of the more quoted and expert researchers for the specific topic of values of time, and his studies represent the most recent researches developed in Europe.

Although the values obtained for The Netherlands are not directly applicable to any area in Europe, due to the reasons explained earlier, for the sake of a pure academic exercise the values presented in his research will be used for some calculations applied to the present cases. Regardless their fame, the researches conducted by De Jong and his colleagues are particularly suitable for this thesis, since precise values are identified for each mode of transport.

The values proposed by De Jong, €/th in 2002 have been update to 2011 figures, adjusted to the Central Bank inflation index, and are reported in the following table.

Tab. 6.11: Values of time per tons per hour (2011)

Values of time, €th	
Road €/th	6,23
Rail €/th	1,13
Iww €/th	0,054

Source: Own elaboration based on De Jong, 2004

In order to investigate the value of time attributable to intermodal solutions, an assumption on the value of time for these combinations has been considered.

The necessity to define values of time for intermodal transport is explained by the fact that there are no available figures in De Jong's study.

The assumptions on the values of time for intermodal road-rail combination and road-inland navigation combination can be various. For the purpose of this exercise it has been assumed that the value of time in road-rail intermodal solution will be equal to 1,13 €/th as much as the value of rail transport. For the intermodal solution road-inland navigation, the value used will be 0,054 €/th. These values are actually based on the longest mode of transport present on the intermodal combination.

Additional values could be also used, for instance averages figures between the two values of time, the results will therefore be different, based on the assumptions taken.

It is important to bear this in mind, since the results that will be shown later in the text have to be read according to these assumptions, especially for what concerns the values of time assigned to the intermodal solutions.

An additional clarification is required: the values presented do not refer to a specific commodity type, but are rather general. This is a crucial aspect, since it could be argued that there exist precise values according to different commodities and this could influence the final result. This observation is correct, nonetheless in this thesis the focus is on containerized cargo, and no available data on the contained commodities were available.

The results obtained are the sum of the out of pocket money, already presented in Chapter V, and the value of time for each mode; this will provide the generalized costs.

As first step it was necessary to calculate the value of time for each corridor and for each transport mode, this was done taking the value of time for each mode and then multiplied for the travel time and for the total amount of tons to be moved.

The results of this calculation are shown in table 6.12.

The element that appears immediately is the high value of time of road transport in all the corridors considered.

Tab. 6.12: Value of time, total cost per corridor

VOT	Antwerp-Basel	Antwerp-Frankfurt	Antwerp-Strasbourg	Genoa-Basel	Genoa-Frankfurt	Genoa-Strasbourg
road	43.610	37.380	43.610	43.610	74.760	56.070
rail	16.950	10.170	14.690	12.430	20.340	14.690
iww	5.670	4.536	4.320	/	/	/
road-rail	16.950	9.040	13.560	11.300	19.210	13.560
rail-iww	5.670	4.536	4.320	/	/	/

Source: Own elaborations based on (De Jong, 2004a)

The following elaboration was the calculation of the generalized cost composed by out of pocket cost and value of time, as illustrated in table 6.13.

The results obtained are confirming that road transport reaches the highest level of generalized cost, compared to the other modes of transport. This is clearly showed in the following figures where for each corridor a graphical diagram of the generalized cost ranking is presented.

Tab. 6.13: Generalized cost per corridor

Generalized cost	Antwerp-Basel	Antwerp-Frankfurt	Antwerp-Strasbourg	Genoa-Basel	Genoa-Frankfurt	Genoa-Strasbourg
road	68.403	54.273	64.821	64.978	110.040	83.142
rail	37.171	22.459	31.723	29.541	46.378	34.847
iww	31.858	24.736	24.923	/	/	/
road-rail	39.329	21.986	31.250	30.725	45.875	34.550
rail-iww	34.817	26.610	26.797	/	/	/

Source: Own elaborations based on (De Jong, 2004a) based on previous results

The first corridor was the one from Antwerp to Basel, the previous results on out of pocket costs were showing a situation of relative advantage of rail transport. The most expensive modes of transports were road, inland navigation and their intermodal combination.

When looking at the generalized costs, it appears that road transport will become the most expensive compared to the other possibilities.

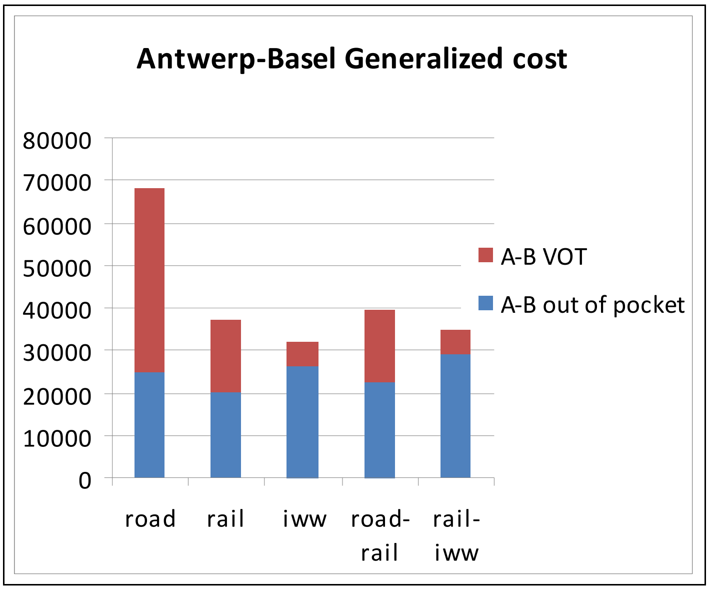


Fig. 6.1: Antwerp-Basel: Generalized cost

Source: own elaboration

Similar considerations can be argued for what concerns the corridor Antwerp-Frankfurt, the impact of value of time in road transport is very much important compared to the other modes.

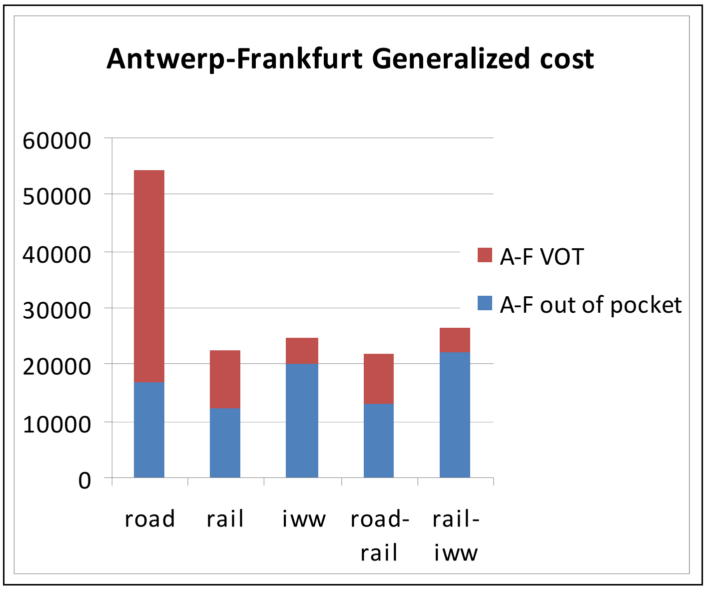


Fig. 6.2: Antwerp-Frankfurt: Generalized cost

Source: own elaboration

In case considering the generalized cost in the Antwerp-Strasbourg corridor, road transport will be the most expensive, followed by rail and intermodal road-rail combinations.

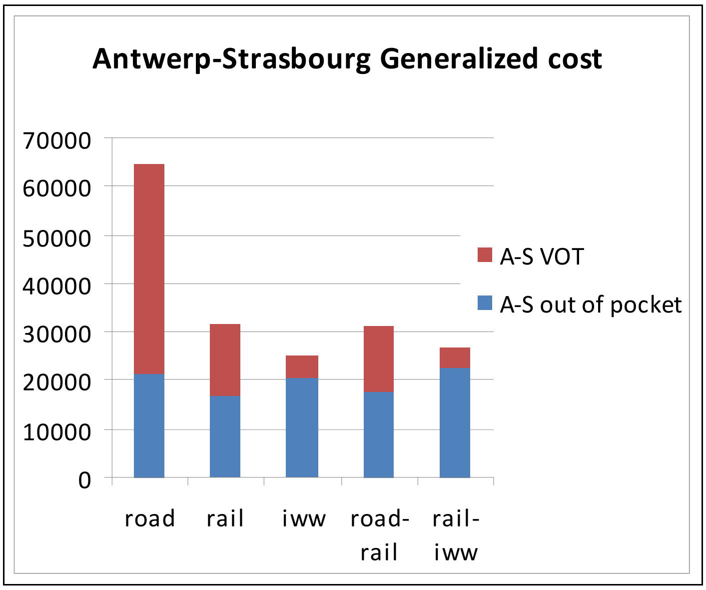


Fig. 6.3: Antwerp-Strasbourg: Generalized cost

Source: own elaboration

The results illustrated in the following figures present the estimation of generalized costs in the three cases of corridors with Genoa as starting point.

The previous results obtained by the out of pocket costs were consistent in presenting road transport as the most expensive mode of transport. As it can be observed form figures 6.4, 6.5 and 6.6 the same stands in case of generalized costs.

Rail transport will be the cheapest solution followed by the road-rail combination.

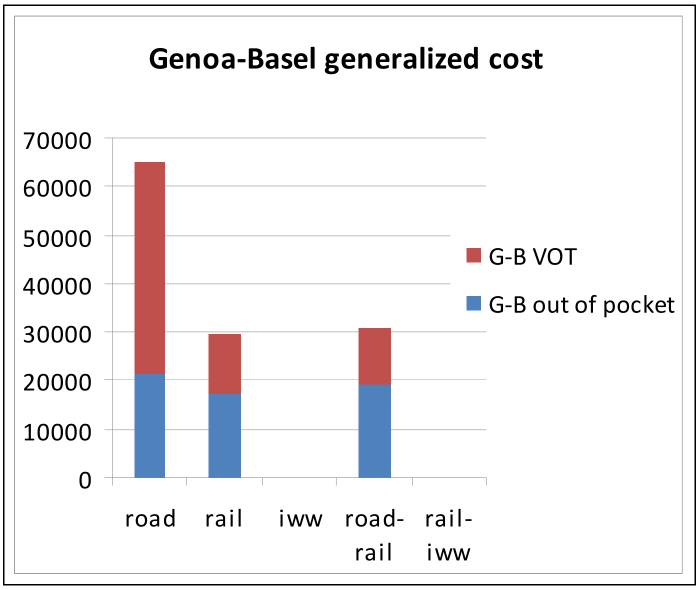


Fig. 6.4: Genoa-Basel: Generalized cost

Source: own elaboration

The following two images present the possible amount of money that could be paid in case the value of time component will be include in the cost function for the Genoa-Frankfurt and Genoa-Strasbourg corridors.

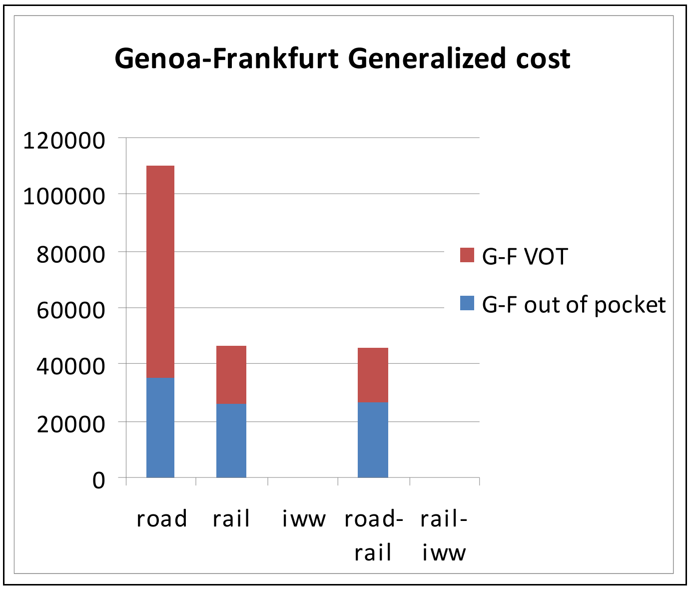


Fig. 6.5: Genoa-Frankfurt: Generalized cost

Source: own elaboration

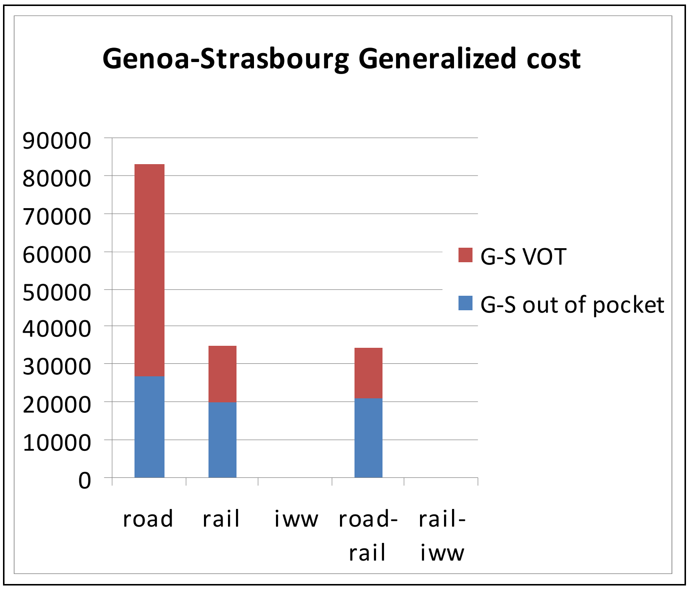


Fig. 6.6: Genoa-Strasbourg: Generalized cost

Source: own elaboration

Out of the previous calculations it is possible to elaborate on their implications.

From the previous chapter it was possible to observe that in general road transport is more expensive than the intermodal combinations, but still it is chosen very often and more than intermodal transport.

In order to investigate other elements that affect mode choice, this chapter looked at the value of time assigned to each mode, so that indications on the generalized cost could be provided.

General evidence is that, when calculating the generalized cost, still road transport is the most expensive. If road transport is selected even when including the value of time, as it is observed by the information collected in the interviews, there should be additional components that make this happen.

At this stage, the value of time is very much relevant but does not explain on its own the preferences of the freight forwarders or shippers. This conclusion is in line with previous studies and also with the outcome of the presented interviews that showed how the role of flexibility and frequency was particularly appreciated in road transport.

This conclusion is very much relevant for intermodal operators, showing that the factors were intermodal transport should invest are rather qualitative than related to the cost/price of the service. To support this argument, there is evidence of the lower cost/price that intermodal transport is already providing on the market.

If intermodal transport wants to become more competitive towards road transport, interventions are needed in order to increase its flexibility and frequency, above the transport time and the reliability.

The remarks that can emerge form the previous analysis are rather evident, showing how qualitative elements are important and how much they influence mode choices.

The qualitative element considered so far, value of time, seems to detain a crucial role and already attracted very much interest from the academic world. Nonetheless the amount of studies and researches on this issue, it remains difficult to define unique values that could be applied univocally, due the reasons already explained.

The consequences of calculating the generalized costs are different for each mode of transport and can vary very much according to the data and the methodology used. From the results obtained earlier, the impact on road transport is much higher than the consequence on rail, inland navigation and intermodal transport.

The conclusion reached so far consider that pure transport costs and travel time influence mode choice, but also other qualitative factors are crucial and not been treated in detail.

Some considerations are therefore required, in relation to the role played by reliability, frequency, flexibility, possibility to have losses or damages.

These variables are quite difficult to measure; this could be the reason why the literature that concentrates on the value attributable to these factors is not so extended as the one for travel time.

Some authors nonetheless took a stab at their measurement applied to different cases or geographical locations. Starting for example by reliability, the same author De Jong, (2004b) established some values for The Netherlands. The studies have been updated by the author together with his collaborators: Hamer (2005) and Kouwenhoven (2005).

Bergantino and Bolis (2005) tried to find out values for reliability that could be applied to the ro-ro segment in maritime transport, measuring the value as increase of 1% of reliability, defined as expected number of shipment arrive on time in one year, in %. The authors used SP as methodological technique.

Value of reliability was also investigated for the Swiss territory, respectively by Bolis and Maggi, (1999) and Rudel (2005); similar study the one of Maier and Bergaman that investigates these aspect in Austria, 2002.

Some of these authors considered as well other criteria, such as frequency, Bergantino and Bolis (2005), Maier and Bergaman (2002), Bolis and Maggi, (1999), where the common measurement was calculated as increase of number of shipments in a range of period.

Few studies considered value of flexibility, Bolis and Maggi, (1999), where it was measured as 1 h less for advance notice, and values for losses or damages are considered in Rudel (2005) as increase/decrease of 1% in avoidance of losses or damages.

As already stated earlier the measurement of these elements could be very complicated, although the SP technique seems to be confirmed as the most popular one.

The values obtained are very different from each other and it would also very complicate to compare these figures, since they are measured according to different approaches and scales. An estimation of these aspects would have been not possible in this work, since data on actual reliability, flexibility or frequency were not available.

What it is possible to conclude is that also these additional criteria need to be taken into consideration, since they influence very much the mode choice; if out of pocket cost and value of time are not sufficient to explain a certain modal split, the remaining leverage is played by these factors, that should be further investigated on a national level, so that harmonized values could be also proposed.

6.3 Chapter's summary

Chapter VI had the purpose to investigate the role of qualitative attributes in mode choice.

The first part presented the results obtained by qualitative interviews with freight forwarders and shippers in Europe, namely on the port of Antwerp and Genoa.

The following section considered the estimation of qualitative attributes in terms of money, taking some previous estimations of value of time.

Out of the first part the following main evidences can be reported.

- Reliability is a very important criterion;
- In the case of the Belgian corridors road transport is the main mode of transport, nonetheless there is a use of the other two modes, rail and inland navigation; while in the Genoese corridors the majority of the cargo is moved by road, 80% on average.
- According to the outcome of the interviews, road transport is considered as reliable as rail transport from the Belgians' sample, while for the freight forwarders and shippers in Genoa road transport is more reliable than rail transport.

The exercise on the calculation of generalized costs brought the author to conclude that the value assign to time in transport is very much important, nonetheless it is not the only factor considered. When comparing road and intermodal solutions a key role is played by flexibility and frequency of road transport, criteria were the performance of road transport is better than in intermodal transport.

Investigations on other qualitative criteria and their estimation are required in order to obtain harmonized values applicable on a European scale.

As already shown through the text, out of pocket cost and qualitative variables are very much relevant for mode choice. In this chapter emerged that the preferences of the clients go very often to road transport that regardless its possible higher cost, seems to be more appreciated for other qualitative aspects.

Among the elements that guide the freight forwarders or shippers to select a transport mode, environmental concerns seem not to influence very much final decision. On the contrary, on a policy level, problems such as congestion, air and noise pollution, green house emissions are highly considered.

It is therefore interesting to investigate the effects that internalization of external costs could have on the transport users, and how these possible measures of internalization could help in re-balancing modal split and in reducing emissions. This topic will be addressed in the next chapter.

CHAPTER VII

EXTERNAL COSTS' INTERNALIZATION

Among the variables that could influence mode choice, environmental aspects, congestion, accidents and other types of pollutant elements were selected for a further investigation. This topic is not recognised as the most important for the decision maker; nonetheless it is a priority on the European policy agenda in relation to transport.

As shown in the literature review freight forwarders and shippers do not really take into consideration these elements when selecting a mode of transport. The reasons of deepening the analysis on this specific topic is thus explained by the fact that more and more external costs internalization is becoming a central topic in the European policy level. The reason is easily explained by the fact that the level of negative externalities is not sustainable for the society and, in particular in the transport sector, the modal split needs to be adjusted so that a more equilibrated situation could be reached.

If the normal market conditions are not sufficient for obtaining a reduction of externalities or a re-balancing in the modal shift, a measure of internalization of external costs could be an appropriate policy measure.

In the previous chapters a review of earlier studies and methodologies has been considered, in this chapter an application of external costs internalization will be presented, taking as case studies the same European corridors studied earlier in the thesis.

The following calculations could be taken as examples of internalization, in order to obtain monetary costs that each transport operator would have to pay if an enforcement of European laws will take place.

The approach undertaken in this work, as already stated earlier, started out from the values contained in the Handbook for the internalization of external costs and from these values a tool has been created that could provide total figures for certain distances.

The purpose of this chapter is to get a better view on the relevance, in monetary terms, that external costs have and also to assess the impact that this hypothetical measures could produce on transport economics. Among the other possible effects, a shift in the modal split or the impact in the overall transport demand.

The chapter will be articulated as follow: the first part will focus on the corridors' applications and their results in terms of total costs to be paid.

The second part of the chapter will concentrate on road transport, namely the effects that road pricing scheme could have on the road transport sector with a specific analysis applied on the Belgian territory.

7.1 External costs internalization applied to the European corridors

Before looking at the results obtained, some methodological remarks are needed.

A calculation tool has been developed in such a way that the user can choose some technical or organizational parameters, as input, in order to obtain results for a specific corridor or length.

The elements that need to be chosen are:

- Total amount of cargo transported, expressed in tons,
- Period in which the transport will take place, (night or day),
- Moment of rush or normal traffic hours,
- Area where the transport will take place (urban or inter-urban)
- Distance to cover, expressed in kilometres,
- Loading factor, expressed in percentage,
- Type of energy used for rail transport (diesel or electric).

As output it is possible to obtain the cost for vehicle and the cost for the entire journey, loading quantity assumed.

For what concerns the quantity of goods moved, in the following calculations, an amount of 1000 tons has been assumed, and it will be considered that the trips will take place at rush hours during days. Considering that the work is dealing with European corridors of medium-long distances, the calculations of external costs will be performed on highways.

The specifications about transport modes and distances are equal to the ones illustrated in the earlier chapters; nonetheless it is worth to remember the use of electrified locomotives in rail transport.

The estimations will be produced for three scenarios based on different loading factors: 100%, 50% and 80% of the possible maximum loading capacity.

Given these assumptions, the results will be presented illustrating first the corridor of the Antwerp's hinterland and consequently the ones of Genoa. The procedure undertook was the following: the calculations for the external costs internalization were performed and consequently the results obtained added to the out of pocket costs found in the previous part of the work. The sum of the two constitutes the total costs that one should pay: internal costs and external costs.

Some considerations on the incidence that external costs have on the total costs will be reported and possible changes in the results due to parameters variations will be provided.

7.1.1 Antwerp-Basel Corridor

On the corridor Antwerp-Basel the out of pocket costs calculations showed that the preferred mode of transport could be the railways and the most expensive inland navigation. When applying the calculation of external costs, the situation is slightly different; while railways remains the cheapest solution for all the loading factors scenarios, the most expensive mode becomes road transport.

The reason can easily be read in table 7.1, the external costs that 40 trucks produce is almost 14.000,00 €, and even doubled if the load factor drops to 50%. The uni-modal modes, rail and inland navigation, are cheaper as well as the intermodal solutions.

In this case an internalization of external costs could influence the selection of transport mode in favour of railways, inland navigation or intermodal transports.

Tab. 7.1: External costs for the Antwerp-Basel Corridor

Antwerp-Basel							
Mode	**Out of pocket cost (AVE)**	**E.C per L.F. 100%**	**Sum**	**E.C per L.F. 50%**	**Sum**	**E.C per L.F. 80%**	**Sum**
Rail	20.221,00	1.241,11	21.462,11	2.482,23	22.703,23	1.551,39	21.772,39
Road-Rail	22.378,85	2.548,76	24.927,61	5.097,52	27.476,37	3.596,14	25.974,99
IWW	24.792,88	1.774,07	26.566,95	3.548,13	28.341,01	2.217,58	27.010,46
Road	26.188,76	13.824,30	40.013,06	27.648,60	53.837,36	17.280,38	43.469,14
Road-Iww	29.147,50	3.449,50	32.597,00	6.899,00	36.046,50	6.218,00	35.365,50

Source: own elaborations

The figure below clearly shows the comparison among modes on the 100% loading factor (L.F.) scenario.

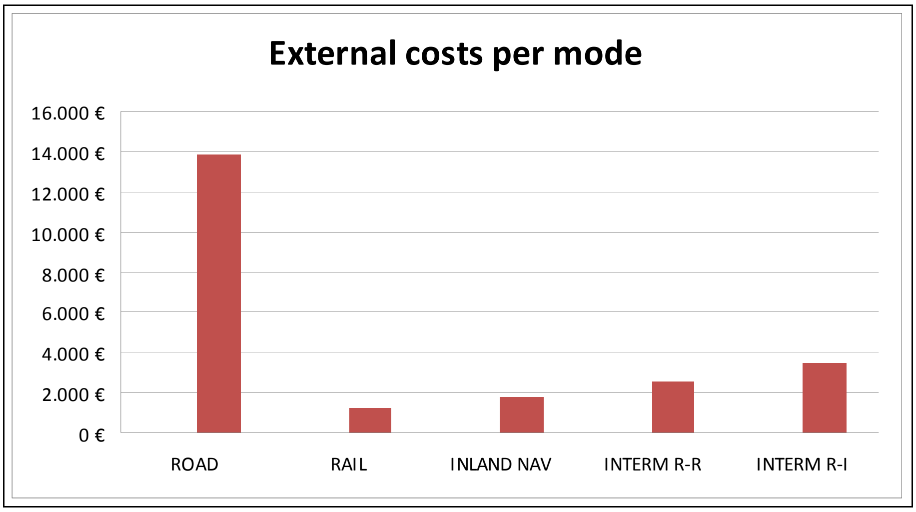


Fig. 7.1: External costs per mode for the Antwerp-Basel Corridor (100% L.F.)

Source: own elaborations

7.1.2 Antwerp-Frankfurt Corridor

The second corridor considered, Antwerp-Frankfurt, the shortest one from Antwerp, resembles the same situation than before. In fact the most expensive mode of transport was intermodal Road-Iww, after internalizing the external costs, this solution becomes cheaper than road only. In the scenario, with a loading factor of 100%, that it is not the most frequent, the total cost would be 26.000,00 €, in the case with 50% of loading factor up to 35.000,00 €.

The detailed description of out of pocket costs, external costs and total ones is summarized in table 7.2.

Tab. 7.2: External costs for the Antwerp-Frankfurt Corridor

Antwerp-Frankfurt							
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**L.F. 50%**	**Sum**	**L.F. 80%**	**Sum**
Rail	12.289,00	691,42	12.980,42	1.382,86	13.671,86	864,28	13.153,28
Road-Rail	12.945,85	1.779,20	14.725,05	3.558,40	16.504,25	2.441,80	15.387,65
Road	16.892,64	9.125,40	26.018,04	18.250,80	35.143,44	11.406,75	28.299,39
IWW	20.199,60	1.196,00	21.395,60	2.392,00	22.591,60	1.495,00	21.694,60
Road-Iww	22.074,14	2.582,40	24.656,54	5.164,80	27.238,94	4.483,80	26.557,94

Source: own elaborations

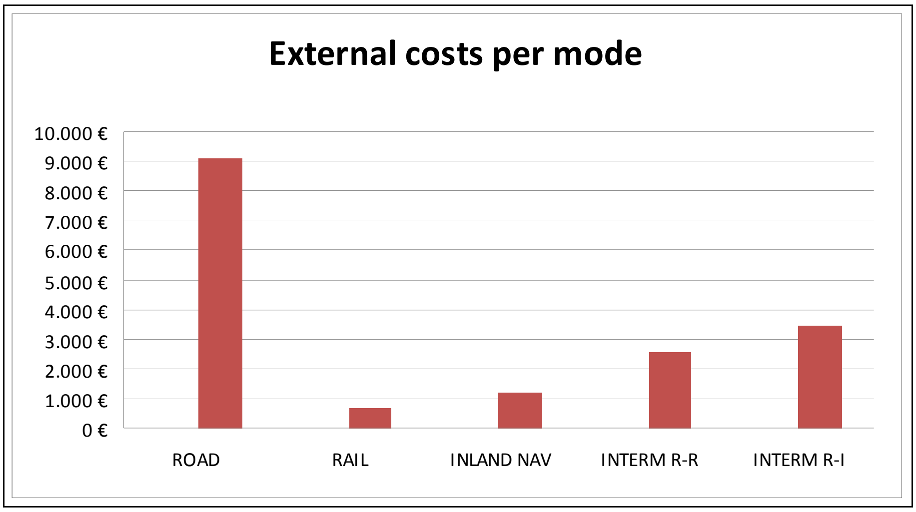


Fig. 7.2: External costs per mode for the Antwerp- Frankfurt Corridor (100% L.F.)

Source: own elaborations

7.1.3 Antwerp-Strasbourg Corridor

In the case of Antwerp-Strasbourg, the lesson that could be learned from the outcome of the calculations on internal costs was already indicating that the best solution, money wise, could be proved by rail transport and the most expensive by road transport.

Considering that road transport is the most polluting one, compared to the other two modes of transport, the outcome of the internalization of external costs is not surprising.

In the scenario with full loading factor, the additional external costs were respectively: € 1.000,00 for rail, € 1.544,00 for inland navigation and € 10.700,00 for road transport. It is clear that the total costs will follow this order confirming that the best solution is provided by rail transport.

What reported for 100% loading factor is valid also for the other two scenarios, being notably higher for 50% loading factor.

Tab. 7.3: External costs for the Antwerp-Strasbourg Corridor

Antwerp-Strasbourg							
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**L.F. 50%**	**Sum**	**L.F. 80%**	**Sum**
Rail	17.033,00	1.002,57	18.035,57	2.005,14	19.038,14	1253,21	18.286,21
Road-Rail	17.689,85	2.214,80	19.904,65	4.429,60	22.119,45	3.095,20	20.785,05
IWW	20.603,48	1.544,83	22.148,31	3.089,67	23.693,14	1.931,04	22.534,52
Road-Iww	21.211,04	3.105,65	24.316,69	6.211,30	27.422,34	5.530,30	26.741,34
Road	22.477,21	10.714,40	33.191,61	21.428,80	43.906,01	13.393,00	35.870,21

Source: own elaborations

It appears clear from figure 7.3 that road transport is considerably above the other modes of transport, while the difference among the others is still present but without such a big proportion.

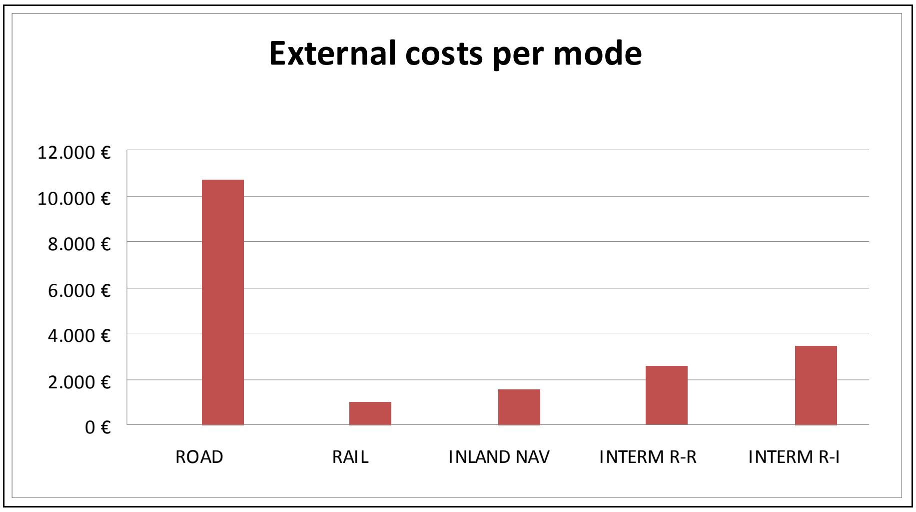


Fig. 7.3: External costs per mode for the Antwerp- Strasbourg Corridor (100% L.F.)

Source: own elaborations

7.1.4 *Genoa-Basel Corridor*

In the case of the corridors from Genoa, the modal possibilities are reduced to the uni-modal solutions: road and rail, and the intermodal road-rail combination.

The first one to be considered is the corridor Genoa-Basel, where it is possible to observe that the preference was given to rail transport and the most expensive mode was road transport. The internalization of external costs confirms the current status. The amount of money that would be paid to move 1000 tons by trucks will be almost 11.000,00 €, while the external costs produced by rail are a bit more than 1/14 of external road costs; this would be the situation in case the transport means will be completely loaded. The costs produced will be clearly higher in case of not complete capacity utilization.

Tab. 7.4: External costs for the Genoa-Basel Corridor

Genoa-Basel							
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**L.F. 50%**	**Sum**	**L.F. 80%**	**Sum**
Rail	17.111,00	788,22	17.899,22	1.576,46	18.687,46	985,28	18.096,28
Road-	19.425,85	1.958,28	21.384,13	3.916,56	23.342,41	2.710,42	22.136,27

Rail							
Road	21.367,68	10.759,80	32.127,48	21.519,60	42.887,28	13.449,75	34.817,43

Source: own elaborations

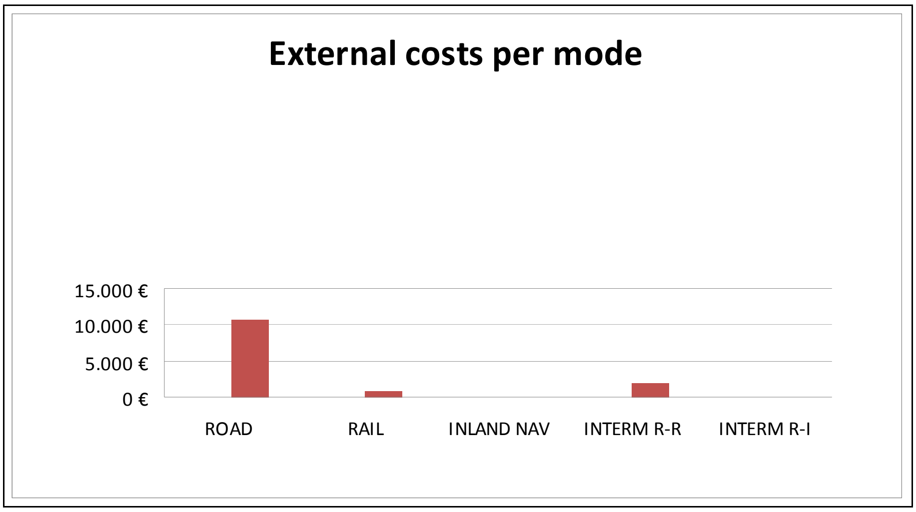


Fig. 7.4: External costs per mode for the Genoa- Basel Corridor (100% L.F.)

Source: own elaborations

7.1.5 Genoa-Frankfurt Corridor

The second corridor, Genoa-Frankfurt represents the corridor with highest external costs from the Genoese side, although the general considerations are valid also for this corridor.

Even with the addition of external costs the cheapest mode is rail transport, followed by intermodal solution with a relatively small difference, around 1.400,00 to 3.000,00 €.

Tab. 7.5: External costs for the Genoa-Frankfurt Corridor

Genoa-Frankfurt							
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**L.F. 50%**	**Sum**	**L.F. 80%**	**Sum**
Rail	26.038,00	1.362,11	27.400,11	2.724,23	28.762,23	1.702,64	27.740,64
Road-Rail	26.664,85	2.723,00	29.387,85	5.446,00	32.110,85	3.857,50	30.522,35
Road	35.280,00	18.160,00	53.440,00	36.320,00	71.600,00	22.700,00	57.980,00

Source: own elaborations

Intermodal road-rail transport is slightly above rail only transport, but definitely lower that road external cost.

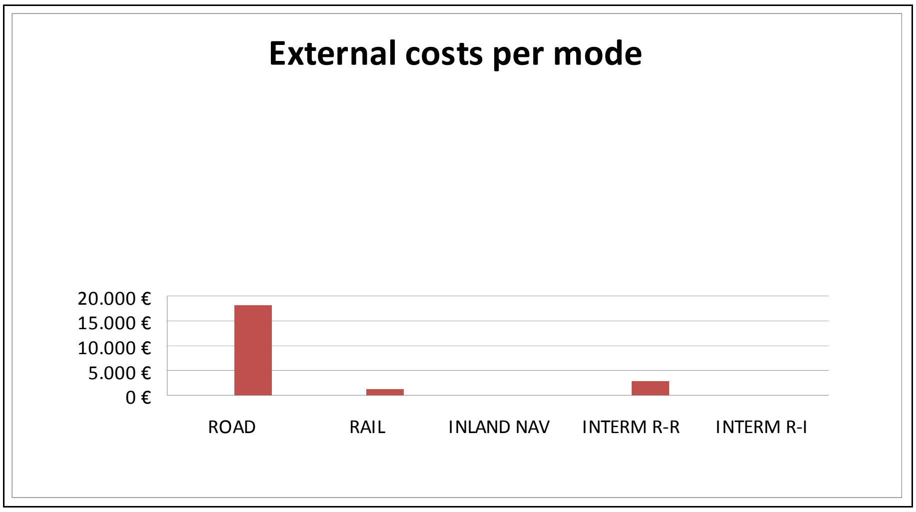


Fig. 7.5: External costs per mode for the Genoa- Frankfurt Corridor (100% L.F.)

Source: own elaborations

7.1.6 Genoa-Strasbourg Corridor

The last corridor is the one from Genoa to Strasbourg where the most convenient mode of transport is rail transport. This situation is verified in both cases, with or without internalization of external costs. The amount of external costs produced by road transport is ranging from 13.892,00 to 27.784,00 respectively in case of 100% and 50% loading factor.

Tab. 7.6: External costs for the Genoa-Strasbourg Corridor

Genoa-Strasbourg							
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**L.F. 50%**	**Sum**	**L.F. 80%**	**Sum**
Rail	20.157,00	1.002,57	21.159,57	2.005,14	22.162,14	1.253,21	21.410,21
Road-Rail	20.989,85	2.214,80	23.204,65	4.429,60	25.419,45	3.095,20	24.085,05
Road	27.071,84	13.892,40	40.964,24	27.784,80	54.856,64	17.365,50	44.437,34

Source: own elaborations

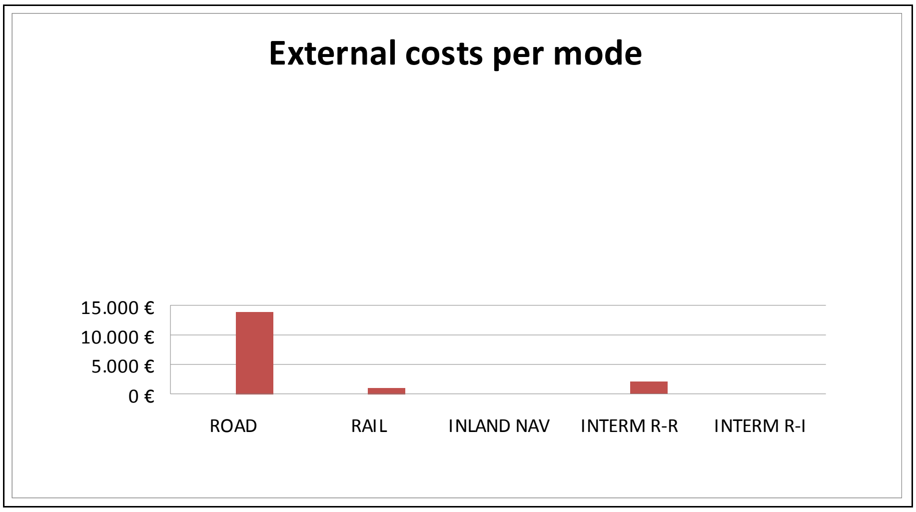


Fig. 7.6: External costs per mode for the Genoa- Strasbourg Corridor (100% L.F.)

Source: own elaborations

7.1.7 Share of out of pocket and external costs on the total costs and additional cases

After having investigated the costs that could be paid in case of external cost internalization, it will be interesting to observe how this measure will affect the generalized cost.

In order to do so, the tables below illustrate the share of external cost and out of pocket cost on the generalized cost; the figures below provide a graphical representation of the comparison among modes, considering both components, out of pocket and external costs.

Table 7.7 is summarising the amount of external cost in case of a loading factor of 80% for all the corridors and for each transport mode; while the following tables and figures illustrates case by case, each single corridor.

Tab. 7.7: Summary of External costs (L.D. 80%)

External costs	Antwerp-Basel	Antwerp-Frankfurt	Antwerp-Strasbourg	Genoa-Basel	Genoa-Frankfurt	Genoa-Strasbourg
road	17.280	11.406	13.393	13.449	22.700	17.365
rail	1.551	864	1.253	985	1.702	1.253
iww	2.217	1.495	1.931	/	/	/
road-rail	3.596	2.442	3.095	2.710	3.857	3.095
rail-iww	6.218	4.483	5.530	/	/	/

Source: own elaborations

The amount of money that should be paid for road transport is extremely high if compared with the other modes of transport, while a much lower impact will be observed in rail and inland navigation.

Tab. 7.8: Share of out of pocket and external costs on the total cost, Antwerp-Basel Corridor

Mode	Out of pocket cost (AVE)	L.F. 100%	Sum	Out of pocket cost (AVE)	L.F. 50%	Sum	Out of pocket cost (AVE)	L.F. 80%	Sum
Rail	94%	6%	100%	89%	11%	100%	93%	7%	100%
Road-Rail	90%	10%	100%	81%	19%	100%	86%	14%	100%
IWW	93%	7%	100%	87%	13%	100%	92%	8%	100%
Road	65%	35%	100%	49%	51%	100%	60%	40%	100%
Road-Iww	89%	11%	100%	81%	19%	100%	82%	18%	100%

Source: own elaborations

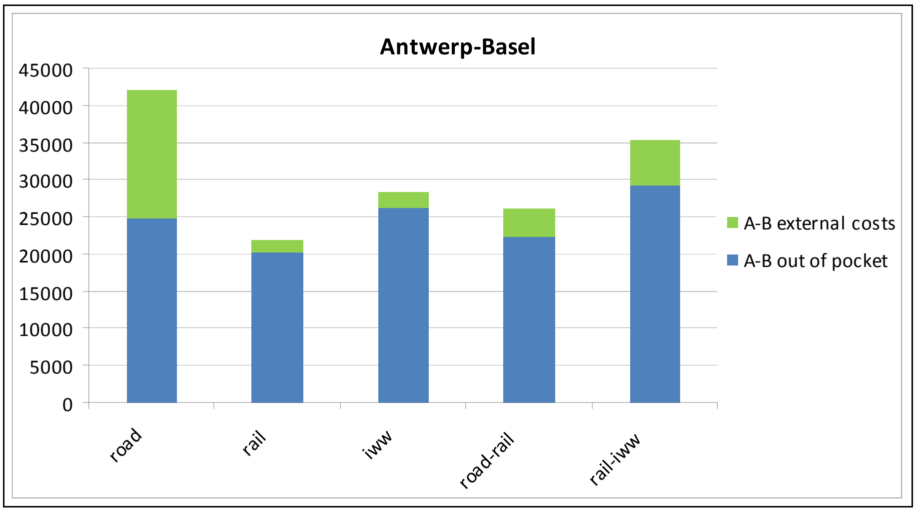


Fig. 7.7: Total cost: out of pocket + external costs on Antwerp-Basel Corridor (80% L.F.)

Source: own elaborations

Figure 7.7 shows that the share of external cost in case of road is much higher than in rail or inland navigation transport.

The situation is similar in all the corridors, the generally speking, in the full loading factor scenario, the weight of external costs is residual compared to the out of pocket costs.

External costs are more relevant in the scenario with 50% of loading factor, although some differences among modes are noticed.

Tab. 7.9: Share of out of pocket and external costs on the total cost, Antwerp-Frankfurt Corridor

Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**Out of pocket cost (AVE)**	**L.F. 50%**	**Sum**	**Out of pocket cost (AVE)**	**L.F. 80%**	**Sum**
Rail	95%	5%	100%	90%	10%	100%	93%	7%	100%
Road-Rail	88%	12%	100%	78%	22%	100%	84%	16%	100%
Road	65%	35%	100%	48%	52%	100%	60%	40%	100%
IWW	94%	6%	100%	89%	11%	100%	93%	7%	100%
Road-Iww	90%	10%	100%	81%	19%	100%	83%	17%	100%

Source: own elaborations

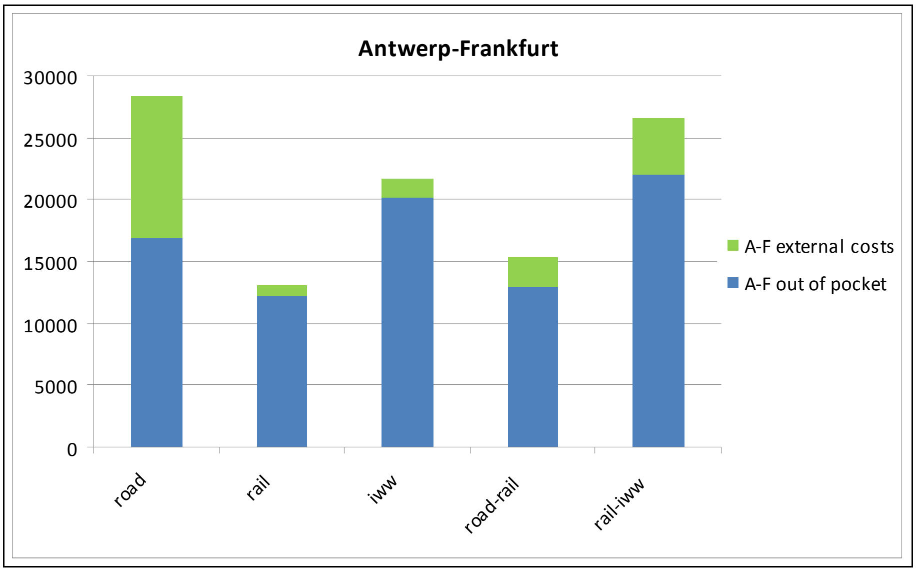


Fig. 7.8: Total cost: out of pocket + external costs on Antwerp-Frankfurt Corridor (80% L.F.)

Source: own elaborations

For rail transport and inland navigation the share of external costs, in all the scenarios is not reaching high values and never overcoming the out of pocket costs. This is not the case for road transport. The conclusions are easily reached: the share of external costs on road transport is much higher than in the other modes.

Tab. 7.10: Share of out of pocket and external costs on the total cost, Antwerp-Strasbourg Corridor

Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**	**Out of pocket cost (AVE)**	**L.F. 50%**	**Sum**	**Out of pocket cost (AVE)**	**L.F. 80%**	**Sum**
Rail	94%	6%	100%	89%	11%	100%	93%	7%	100%
Road-Rail	89%	11%	100%	80%	20%	100%	85%	15%	100%
IWW	93%	7%	100%	87%	13%	100%	91%	9%	100%
Road-Iww	87%	13%	100%	77%	23%	100%	79%	21%	100%
Road	68%	32%	100%	51%	49%	100%	63%	37%	100%

Source: own elaborations

The same pattern is valid also for the corridor Antwerp-Strasbourg.

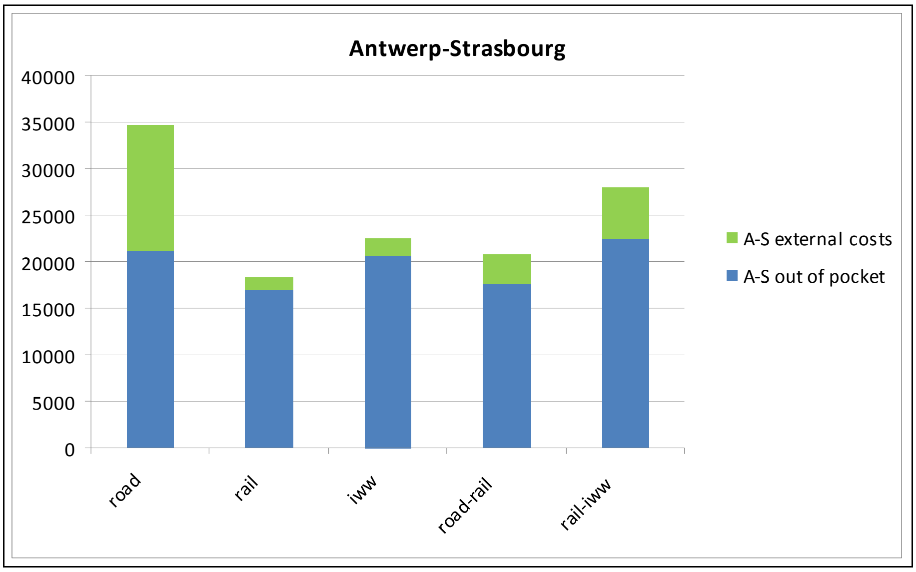


Fig. 7.9: Total cost: out of pocket + external costs on Antwerp-Strasbourg Corridor (80% L.F.)

Source: own elaborations

Tables 7.11, 7.12 and 7.13 and figures 7.10, 7.11, 7.12 represent the share compositions in the three corridors from Genoa.

In these three cases rail transport is the one with less pollutant's costs and indeed the internalization of external costs does not influence tremendously the final total costs, its share of it can vary from a minimum of 4%, Genoa-Basel, to a maximum of 9% in the corridors to Frankfurt and Strasbourg, 50% loading factor scenarios.

Tab. 7.11: Share of out of pocket and external costs on the total cost, Genoa-Basel Corridor

Mode	Out of pocket cost (AVE)	L.F. 100%	Sum	Out of pocket cost (AVE)	L.F. 50%	Sum	Out of pocket cost (AVE)	L.F. 80%	Sum
Rail	96%	4%	100%	92%	8%	100%	95%	5%	100%
Road-Rail	91%	9%	100%	83%	17%	100%	88%	12%	100%
Road	67%	33%	100%	50%	50%	100%	61%	39%	100%

Source: own elaborations

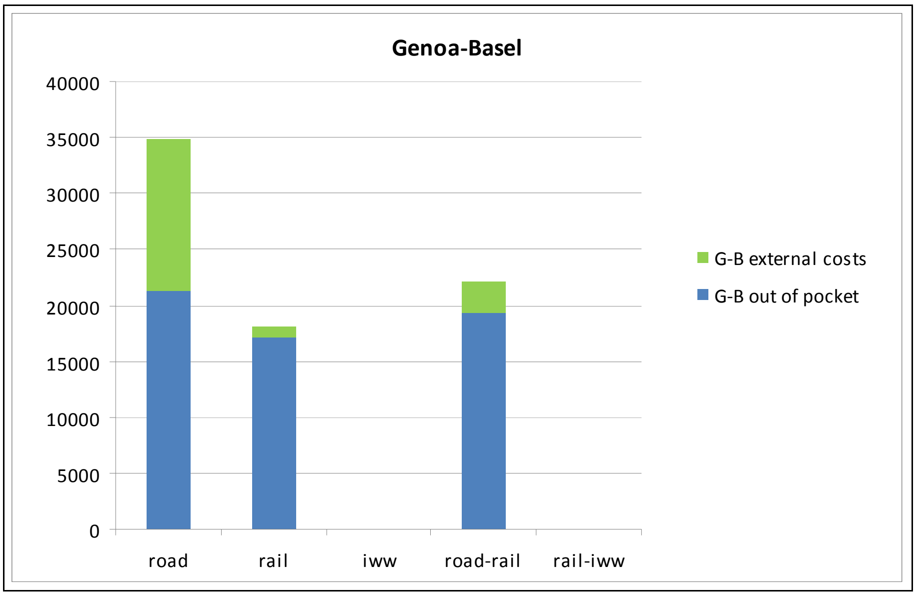


Fig. 7.10: Total cost: out of pocket + external costs on Genoa-Basel Corridor (80% L.F.)

Source: own elaborations

For this corridor the importance of external costs on the overall cost is reaching 39% of the total, as illustrated in fig. 7.12.

Tab. 7.12: Share of out of pocket and external costs on the total cost, Genoa-Frankfurt Corridor

Mode	Out of pocket cost (AVE)	L.F. 100%	Sum	Out of pocket cost (AVE)	L.F. 50%	Sum	Out of pocket cost (AVE)	L.F. 80%	Sum
Rail	95%	5%	100%	91%	9%	100%	94%	6%	100%
Road-Rail	91%	9%	100%	83%	17%	100%	87%	13%	100%
Road	66%	34%	100%	49%	51%	100%	61%	39%	100%

Source: own elaborations

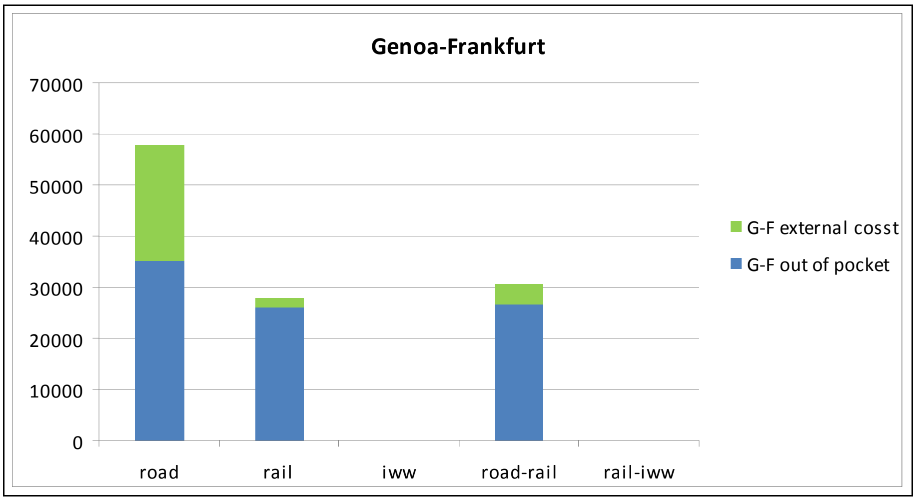


Fig. 7.11: Total cost: out of pocket + external costs on Genoa-Frankfurt Corridor (80% L.F.)

Source: own elaborations

Tab. 7.13: Share of out of pocket and external costs on the total cost, Genoa-Strasbourg Corridor

Mode	Out of pocket cost (AVE)	L.F. 100%	Sum	Out of pocket cost (AVE)	L.F. 50%	Sum	Out of pocket cost (AVE)	L.F. 80%	Sum
Rail	95%	5%	100%	91%	9%	100%	94%	6%	100%
Road-Rail	90%	10%	100%	83%	17%	100%	87%	13%	100%
Road	66%	34%	100%	49%	51%	100%	61%	39%	100%

Source: own elaborations

In the corridor from Genoa to Strasbourg the total cost reaches almost 45.000,00 €, while the intermodal solution is providing a solution that would costs almost half of the rail costs.

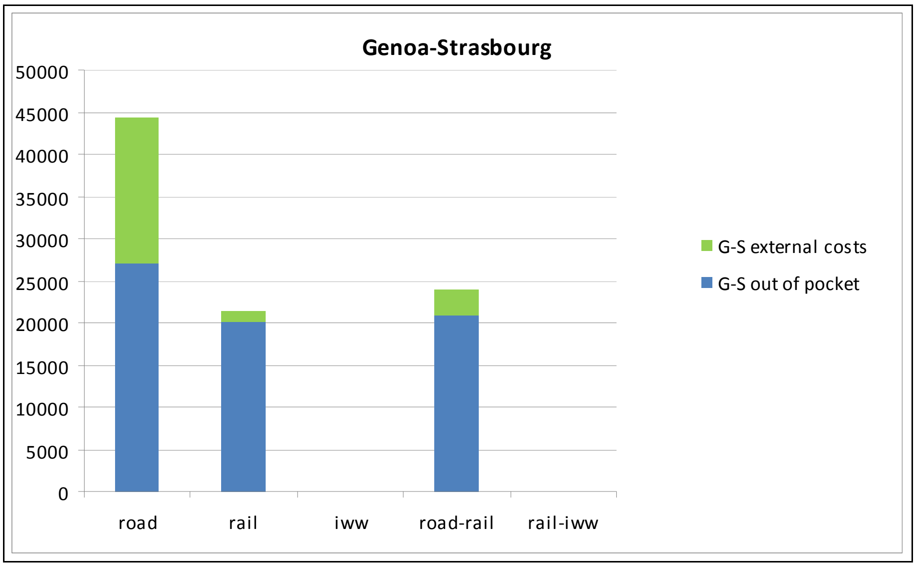


Fig. 7.12: Total cost: out of pocket + external costs on Genoa-Strasbourg Corridor (80% L.F.)

Source: own elaborations

Based on the results presented earlier, a summary table with an averages of the share of external costs for each mode and for each scenario has been produced. This gives a short and clear overview on the relevance that internalization of external costs can have on the total monetary costs.

Tab. 7.14: Average share external costs on the total cost for mode of transport

	Average External cost Share L.F. 100%	**Average External cost Share L.F. 50%**	**Average External cost Share L.F. 80%**
Rail	5,1	9,6	6,3
Road-rail	10,1	18,6	13,8
IWW	6,6	12,3	8
Road	33,8	50,6	39
Road-iww	11,3	20,3	18,6

Source: own elaborations

The external costs produced by rail transport are not extremely high, this is gleaned by the fact that its share varies from 5% to 9.6% in case of 50% loading factor. Rather similar considerations can be made for inland navigation, with a slightly high impact. The major impact is the one of the external costs produced by road transport, where the impact that those can have could reach half of the total costs of transport, as reported in table 7.14.

The cases illustrated so far were based on the assumptions presented at the beginning of this section, comprehending, among the others, the use of electrified trains.

Additional calculations have been produced in order to asses the results in case of a diesel locomotive will be used. This assumption is rather strong, since most of the lines in Europe are electrified and also considering that the diesel part of the journey would never cover the complete length of the corridor.

The results reported below are therefore purely illustrative and do not resemble a realistic situation; they have been performed in order to observe what could change in case of diesel locomotive and the effects on the other modes of transport.

The results reported are the ones that could occur in a scenario with full loading capacity utilization.

Diesel used for rail propulsion is more polluting than electric energy, this fact can be observed by the pure external costs that come out of the tables.

Nonetheless the increase in the external costs, railways transport remains always the cheapest mode of transport, followed by inland navigation for the Antwerp-Basel corridor, as shown in table 7.15 and figure 7.7.

Tab. 7.15: External costs for the Antwerp-Basel Corridor (Diesel train)

Antwerp-Basel			
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**
Rail	20.221,00	4.575,71	24.796,71
Road-Rail	22.378,85	6.955,00	29.333,85
IWW	24.792,88	1.774,07	26.566,95
Road	26.188,76	13.824,30	40.013,06
Road-Iww	29.147,50	3.449,50	32.597,00

Source: own elaborations

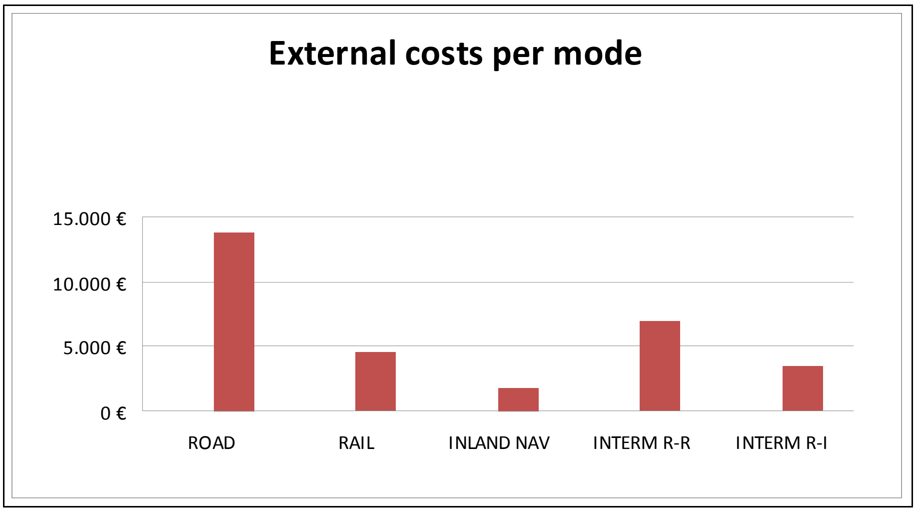


Fig. 7.13: External costs per mode for the Antwerp-Basel Corridor (Diesel train)

Source: own elaborations

For the case of Antwerp-Frankfurt, also with the use of diesel fuel, rail is the cheapest mode, followed in this case by the intermodal solution road-rail transport. When using road transport, the costs to be added to the pure transport costs is above 9.000,00 €, much higher than rail transport, with a bit more than 2.500,00 €. The competitive advantage of rail transport is represented by its lower cost both in the internal and external part of the costs.

Tab. 7.16: External costs for the Antwerp-Frankfurt Corridor (Diesel train)

Antwerp-Frankfurt			
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**
Rail	12.289,00	2.549,14	14.838,14
Road-Rail	12.945,85	4.119,00	17.064,85
Road	16.892,64	9.125,40	26.018,04
IWW	20.199,60	1.196,00	21.395,60
Road-Iww	22.074,14	2.582,40	24.656,54

Source: own elaborations

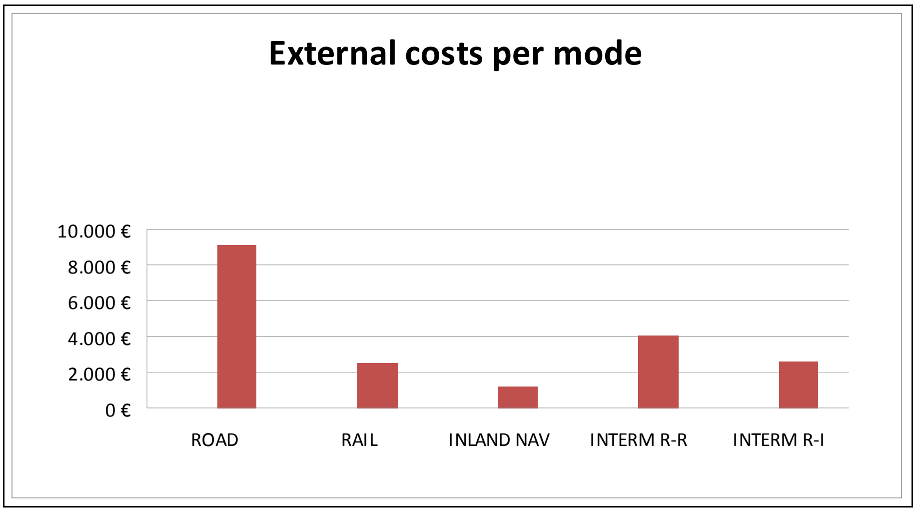


Fig. 7.14: External costs per mode for the Antwerp-Frankfurt Corridor (Diesel train)

Source: own elaborations

In the corridor from Antwerp to Strasbourg it is more convenient to choose rail transport, or alternatively inland navigation; among the two the difference is less than 2.000,00 €.

Tab. 7.17: External costs for the Antwerp-Strasbourg Corridor (Diesel train)

Antwerp-Strasbourg			
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**
Rail	17.033,00	3.696,26	20.729,26
Road-Rail	17.689,85	5.724,80	23.414,65
IWW	20.603,48	1.544,83	22.148,31
Road-Iww	21.211,04	3.105,65	24.316,69
Road	22.477,21	10.714,40	33.191,61

Source: own elaborations

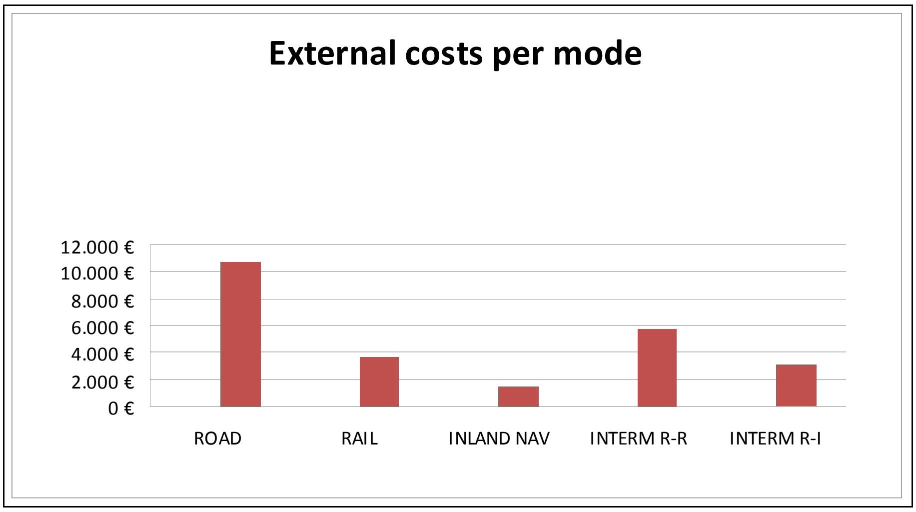


Fig. 7.15: External costs per mode for the Antwerp-Strasbourg Corridor (Diesel train)

Source: own elaborations

The results obtained in the corridors from Genoa, are the same in all the cases and confirm what already emerged in the previous pages, rail transport is still the most convenient mode of transport even in the hypothetical situation of using diesel fuel for the entire length of the journey.

Tab. 7.18: External costs for the Genoa-Basel Corridor (Diesel train)

Genoa-Basel			
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**
Rail	17111	2.906,02	20.017,02
Road-Rail	19425,85	4.779,28	24.205,13
Road	21367,68	10.759,80	32.127,48

Source: own elaborations

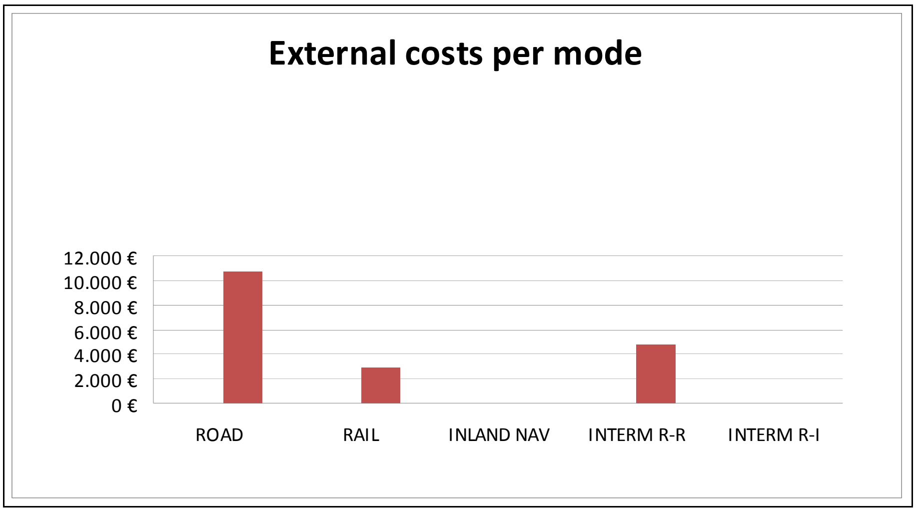


Fig. 7.16: External costs per mode for the Genoa-Basel Corridor (Diesel train)

Source: own elaborations

Tab. 7.19: External costs for the Genoa-Frankfurt Corridor (Diesel train)

Genoa-Frankfurt			
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**
Rail	26038	5.021,81	31.059,81
Road-Rail	26664,85	7.598,00	34.262,85
Road	35280	18.160,00	53.440,00

Source: own elaborations

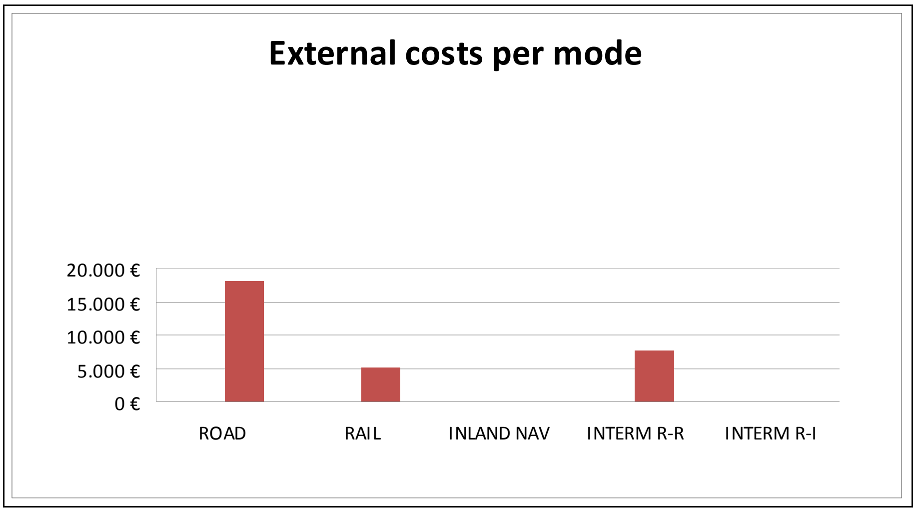


Fig. 7.17: External costs per mode for the Genoa-Frankfurt Corridor (Diesel train)

Source: own elaborations

Tab. 7.20: External costs for the Genoa-Strasbourg Corridor (Diesel train)

Genoa-Strasbourg			
Mode	**Out of pocket cost (AVE)**	**L.F. 100%**	**Sum**
Rail	20157	3.696,26	23.853,26
Road-Rail	20989,85	5.724,80	26.714,65
Road	27071,84	13.892,40	40.964,24

Source: own elaborations

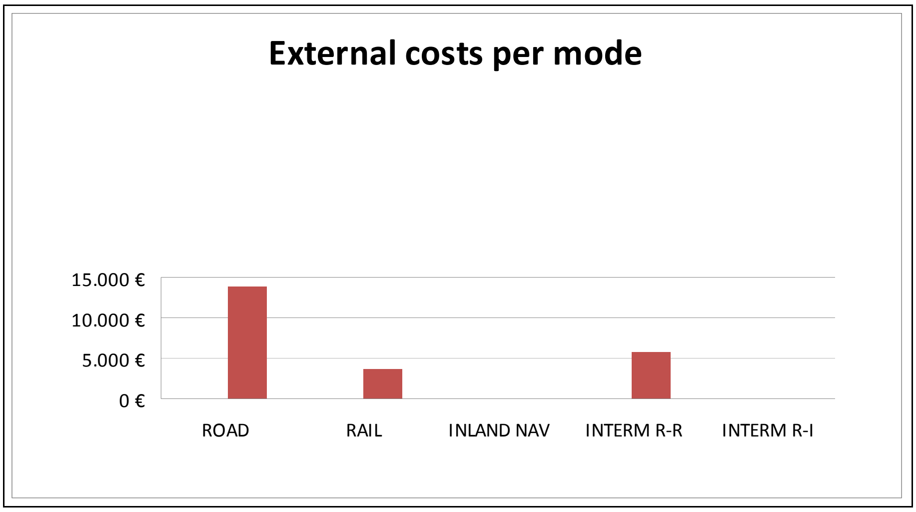


Fig. 7.18: External costs per mode for the Genoa-Strasbourg Corridor (Diesel train)

Source: own elaborations

Some additional cases have been performed and reported in Annex 7.1, in the present chapter the main results will be reported.

Assuming to cover the corridors with electrical trains and same specifications reported above, but during nights, the outcome of the maths do not differ considerably from the previous results. In all the corridors form Antwerp to Basel, Frankfurt and Strasbourg the cheapest mode of transport remains rail transport, followed by the intermodal solution road-rail.

Although the external costs are always higher for road transport, the final comparison, including also out of pocket costs, suggest that the intermodal solution road-inland navigation is the less preferred both on the corridors to Basel and to Frankfurt.

The considerations for the Genoese port and its inland corridors are similar, confirming that rail is the less pollutant and also less costly solution, moreover during night's trips.

7.1.8 General considerations

From the analysis above reported, some general conclusions can be presented.

The calculations brought to the clear results that for road transport the external costs are higher, in all the cases. In case there will be an application of these calculations, therefore the internalization of external costs will be considered, road transport will be the one with major penalizations.

On the contrary rail transport and inland navigation appear to be less polluting and the external costs are impacting less on the total costs.

It is important to bear in mind that the estimations done are based on the distance covered and do not take into consideration technical or structural differentiation that may exist on the corridors. There could be some differences in the pollutants present in different areas that may modify the values considered for the internalization. For the scope of this thesis, an assumption on the same conditions applied for all the corridors has been followed. The reason of such choice is explained by the level of details that would be required in order to capture differentiations for each pollutant for each selected corridor. Moreover it is not plain that these values could be easily found or calculated; the values provided by the

Handbook of internalization of external costs are general ones, applicable to the whole Europe that fit very well in the purpose of this work.

The tool developed for this purpose, showed in chapter III, allows for a great flexibility. The different external costs' parameters can be modified according to the specific areas of applications. The values can change country by country, and also among different areas in the same country, in relation to different parameters used for the calculation of each pollutant.

For these costs calculations the average values provided in the Handbook have been used.

An interesting comparison is the one between corridors reaching the same destination, but leaving from the two ports, e.g. Antwerp-Basel and Genoa-Basel.

In this first case, the external costs calculation shows that the external costs are higher in the Antwerp-Basel corridor than on the Genoese one, these considerations are applicable to all the modes, excluding inland navigation and intermodal road- inland navigation that are not present on the Mediterranean side.

Completely opposite is the situation for the two corridors to Frankfurt, where it seems more convenient to use the Port of Antwerp instead of Genoa, since the difference in external costs are rather different. It is shown that from Genoa to Frankfurt the rail external costs are almost doubled compared to Antwerp-Frankfurt. The same occurs for road transport and intermodal transport.

The last case, to Strasbourg, is particularly interesting since the external costs for rail transport and intermodal transport are the same from both origins, while for road transport is more convenient to choose the route from Antwerp.

The considerations just illustrated are presenting results that are not surprising in transport economics and are in line with the European vision that follow the principle of "pollute-pay". The supplementary value that is offered in this thesis is the possibility to obtain reliable results, in terms of money, using a simple tool.

If such measures and internalizations will actually be applied the consequence for freight transport economics could be diverse with different impact's level.

Based on the work presented earlier in the text, some general considerations can be developed in relation to the modal split on the modes of transport on the considered corridors.

Even though precise data on the modal split for the specific destinations were not available, some indications for the modal split about the area of destination can be taken as a good reference.

The data from the port of Antwerp were suggesting that most of the traffic going to South of Germany and Switzerland was moved with inland navigation, followed by rail and just 7-8% by road transport. For the Alsace area, inland navigation was used, 42% followed by road transport, 33%.

Considering these data and the outcome of the previous estimations, it seems that the operators are already aware of the benefits that they obtain in choosing inland navigation or rail transport. This situation would become even more evident in case external costs will be taken into consideration. These considerations can be made assuming that the modal split will actually remain the same for the specific destinations considered in the mentioned areas.

Different case is the one concerning the port of Genoa and its hinterland, since the few available data were witnessing an almost complete use of road transport for any destinations from the port.

Although already the first results of the out of pocket cost were showing that road transport was relatively more costly than rail, the results of the internalization calculations enforce these findings.

For these corridors, the real implementation of the internalization measure could possibly lead to a re-organization of the modal split, due to the high costs that the road sector will have to support.

7.2 Road pricing applied to freight corridors, special focus on the Belgian case

The second part of this chapter will delve into a specific case of external cost's internalization that is the road pricing one.

So far each transport mode has been considered for the possible implementation of this measure, assuming that the same principle could apply to each mode. It is on record that road transport is the one mode that produces most pollutants.

This concept has been already accepted from some European States that introduced road pricing tool on their national roads. There are some European countries, such as Italy, France, Austria, Switzerland, Spain were a toll is paid for cargo vehicles above a certain tonnage level, 3,5 tons or 12 tons, according to the country legislation. Among these tools introduced by the mentioned States, there are some differences due to final purpose of the legislator in introducing such measure. In some cases, such as Italy, the road tax to be paid is varying according to the type of vehicle and the distance covered, without considering pollutant emissions. The tolls paid in Switzerland and Austria are based on different elements, among the others a differentiation according to the pollution's levels.

Different from any road taxes or vignette, is the Eurovignette system that is based on a charge that heavy goods vehicles with a gross vehicle weight of minimum 12 tons have to pay.

The amount of the Eurovignette is based on the emission's level and the number of axles of the truck. The Eurovignette toll is used on motorways and toll highways in some Eurovignette countries, which are Belgium, Denmark, Luxembourg, The Netherlands and Sweden.

In June 2011, the European Parliament officially adopted the text on heavy goods vehicles, according to this directive the Member States can adopt the toll on their motorways for vehicle above 3,5 tons with an additional cost that could vary from 3 to 4 €ct/vkm.

There is no unanimity on the toll's application among the different States or on the methodology for defining the appropriate cost for each vehicle type or geographical differences.

Some countries do not have any kind of road taxes, while others differ for the different applications that could be based on financial reasons or, in some cases, also on environmental issues.

The purpose of this section is to look in detail at the Belgian situation and the possible outcome of a road pricing toll introduction on the Belgian territory.

On the contrary from the paragraph 7.1, the mode of transport involved is only road transport and the corridors selected imply a segment or all the part of the journey on Belgian territory.

The aim is to observe the impact of road pricing on the total transport cost and to capture the consequences of such measure for the overall transport sector.

The first purpose is to observe how the current cost structure of road transport could be modified by the introduction of an additional toll, and to measure the impact, according to the different implementation schemes.

The introduction of an additional cost for the road sector could lead to changes in the entire transport sector, such as decrease in transport demand or changes in the use of alternative modes of transport, possibly with an increase of demand for rail or inland navigation.

7.2.1. Methodological approach

The development of this exercise implies the definition of the methodology followed, as well as the assumptions taken.

As first step, the out of pocket cost was defined using the calculation tool presented earlier in the text, such estimation allow to obtain a cost figure resembling the current situation, where no external costs are required to be paid.

The following part consisted in the calculation of the road pricing toll, using as well the calculation tool, integrated by the costs for the trucks' pollutions.

To conclude the exercise, the two mentioned costs were summed up and an analysis of external costs' impact was carried out.

The calculations were performed on national and international corridors. The reason of this choice is explained by the fact that possible differences in the scenarios could be captured.

Among the corridors analyzed, some were chosen as case studies to be reported in this thesis.

The national corridors are:

- Antwerp-Ghent (59,3 km)
- Antwerp-Charleroi (96,7 km)

The international ones are:

- Antwerp-Basel (609 km)
- Antwerp-Wien (1272,4 km)
- Antwerp-Lille (124,6 km)
- Rotterdam-Lyon (868,4 km)
- Zeebrugge-Lyon(764,4 km) .

Some necessary premises on the assumptions adopted in the calculations are illustrated here on.

At the current stage (2011), the taxes and tolls due in Belgium are: excise taxes on fuel, road taxes and Eurovignette, for the purpose of the road pricing exercise it is assumed that excises on fuel and Eurovignette will remain as they are at the present. The amount of road taxes will be decreased to the minimum level allowed in case of road pricing introduction. The reason of leaving unchanged the other two factors allows obtaining rather "important" results in monetary terms. The results that could be obtained in case of Eurovignette exclusion could have a lighter impact on the overall cost.

The principle of the road pricing introduction is based on the kilometres covered on the Belgium territory for the total distance.

The cost's data used for the estimations were collected through two main data source:

- Cost calculations for road freight transport, NEA consulting group, (2010/2011).
- Technical note for Vlaams Vrachtmodel- Cost Model, Mint and K+P consulting group, (2009).

It is assumed that the transport costs are in line with the ones supported by a Belgian road company.

The definition of the road pricing tolling assumptions was based on previous literature on the topic, based on the European Commission rules.

The distances, timing and current tools among the origins and destinations were calculated with the support of TLN planner (version 2010). This route planner is credited by different transport organizations such as: Transport and Logistics Nederland, FENEX, KNV, Association of maritime transport operators, the Flemish Transport and Logistics organization Febetra, and UPTR.

Given the previous assumptions the scenarios were defined based on the following criteria:

- Type of vehicle, according to the commodity present on board. The trucks considered are the following: non specialized cargo trucks, container truck, reefer truck, bulk and tank trucks.
- Type of vehicle based on the emissions standards, namely Euro 5 and Euro 4.
- Time of the day, distinguished among: peak, off-peak during day, off-peak during night. The values for the road pricing tolls were clearly varying between Euro 5 and Euro 4 vehicles and the time of the day, as illustrated in table 7.20.

Tab. 7.21: Road Pricing tolling assumptions

EURO type/time of day	Off peak night	Peak	Off-peak day
EURO 1	€0,16	€0,20	€0,18
EURO 2	€0,15	€0,18	€0,17
EURO 3	€0,13	€0,16	€0,15
EURO 4	€0,12	€0,14	€0,13
EURO 5	€0,11	€0,13	€0,12
EUR0 6	€0,10	€0,12	€0,11

Source: Literature reviews and EU rules

The results that will be presented here on, illustrate the impact of road pricing on the total cost for the selected corridors. As already stated the road pricing toll is applied on the Belgian part of the journey for international trips, and on the whole route for the national ones. The results need to be read carefully, considering that the Eurovignette will be maintained in Belgium and also that the situation in the other European countries it is assumed. These calculations can provide general results that could be better adjusted once enforced to be put in place, according to the specification of the route, loading factors, addition or reduction of road tolls.

7.2.2. Outcome for the selected corridors

The first results presented are the ones obtained from the international corridors considered.

Tab. 7.22: Increase share in the total costs with the road pricing introduction, on international routes, Euro Vehicles 5

Euro 5 Vehicle	Antwerp-Basel	Antwerp-Wien	Antwerp-Lille	Rotterdam-Lyon	Zeebrugge-Lyon
Non specialized transport (Nea Values)					
Night off-peak (0,11 €)	2,35%	0,54%	6,93%	1,80%	0,48%
Day off-peak (0,12 €)	2,63%	0,59%	7,62%	1,97%	0,53%

Day peak (0,13 €)	2,91%	0,64%	8,31%	2,13%	0,57%
Sea container (Grosso's thesis)					
Night off-peak (0,11 €)	3,99%	0,65%	10,24%	2,18%	0,57%
Day off-peak (0,12 €)	4,35%	0,71%	11,17%	2,38%	0,62%
Day peak (0,13 €)	4,71%	0,77%	12,10%	2,58%	0,68%
Sea Container (Nea Values)					
Night off-peak (0,11 €)	3,27%	0,58%	8,14%	1,94%	0,51%
Day off-peak (0,12 €)	3,57%	0,63%	8,88%	2,12%	0,56%
Day peak (0,13 €)	3,87%	0,68%	9,61%	2,29%	0,61%
Refer transport (Nea Values)					
Night off-peak (0,11 €)	3,00%	0,53%	7,46%	1,77%	0,47%
Day off-peak (0,12 €)	3,28%	0,58%	8,13%	1,93%	0,51%
Day peak (0,13 €)	3,55%	0,63%	8,81%	2,09%	0,55%
Tank transport (Nea Values)					
Night off-peak (0,11 €)	2,79%	0,49%	6,91%	1,64%	0,44%
Day off-peak (0,12 €)	3,05%	0,54%	7,54%	1,79%	0,48%
Day peak (0,13 €)	3,30%	0,58%	8,17%	1,94%	0,52%
Bulk transport (Nea Values)					
Night off-peak (0,11 €)	2,80%	0,50%	6,93%	1,66%	0,44%
Day off-peak (0,12 €)	3,06%	0,54%	7,56%	1,81%	0,48%
Day peak (0,13 €)	3,31%	0,59%	8,19%	1,96%	0,52%
Average	3,32%	0,60%	8,48%	2,00%	0,53%

Source: own elaborations

Table 7.22 illustrates the increase in the total monetary cost for road transport in case of Euro 5 vehicles, for the different corridors and for the moments of the day, in each of the road transport sectors. In all the corridors the major impact of road pricing introduction is observed in the container sector, both with the costs data presented in this thesis and with the NEA figures. On the contrary the road transport sector that will be affected less by road pricing is the tanker sector. This is also observed in the major part of the corridors.

In order to give a general indication of the road pricing impact, an average value for each corridor has been estimated, and it is summarized in the last row of table 7.21. While on the routes from Antwerp to Wien and from Zeebrugge to Lyon, the introduction of this new toll will not change dramatically the current cost structure, of higher importance is the introduction of this measure on the corridor from Antwerp to Lille, for an average increase of 8.48% on the current pure transport cost.

Table 7.23 is showing the results obtained by the calculations with the assumption of using Euro 4 vehicles, therefore with a higher level of tolls, since these types of vehicles are more pollutant than the previous ones. The focus is on container transport, with the two different cost databases. A clear pattern is present, in line with the previous observations, showing that on the Antwerp-Lille corridor the impact will be more evident than in the others, with an average increase of almost 11%.

As already illustrated earlier in the text, possible changes in the cost structure can be noticed in the case of having a truck driver of Eastern Nationality, since the hourly wage will considerably be lower in comparison with the average Western European wages as also confirmed in Blauwens et al. 2010.

Tab. 7.23: Increase share in the total costs with the road pricing introduction for container transport, on international routes, Euro Vehicles 4

Euro 4 Vehicle	**Antwerp-Basel**	**Antwerp-Wien**	**Antwerp-Lille**	**Rotterdam-Lion**	**Zeebrugge-Lion**
Sea container (Grosso's thesis)					
Night off-peak (0,11 €)	4,35%	0,71%	11,17%	2,38%	0,62%
Day off-peak (0,12 €)	4,71%	0,77%	12,10%	2,58%	0,68%
Day peak (0,13 €)	5,07%	0,83%	13,03%	2,78%	0,73%
Sea Container (Nea Values)					
Night off-peak (0,11 €)	3,57%	0,63%	8,88%	2,12%	0,56%
Day off-peak (0,12 €)	3,87%	0,68%	9,61%	2,29%	0,61%
Day peak (0,13 €)	4,16%	0,74%	10,35%	2,47%	0,65%
Average	**4,29%**	**0,73%**	**10,86%**	**2,44%**	**0,64%**

Source: own elaborations

The following two tables present the outcome for the two corridors considered in the Belgium territory, the Antwerp-Charleroi and the Antwerp-Ghent.

Tab. 7.24: Increase share in the total costs with the road pricing introduction for container transport, on national routes, Euro Vehicles 5

Euro 5 vehicle	Antwerp-Charleroi	Antwerp-Ghent
Non specialized transport (Nea Values)		
Night off-peak (0,11 €)	7,82%	9,42%
Day off-peak (0,12 €)	8,60%	10,33%
Day peak (0,13 €)	9,38%	11,24%
Sea container (Grosso's thesis)		
Night off-peak (0,11 €)	11,44%	14,02%
Day off-peak (0,12 €)	12,48%	15,29%
Day peak (0,13 €)	13,52%	16,57%
Sea Container (Nea Values)		
Night off-peak (0,11 €)	8,91%	10,43%
Day off-peak (0,12 €)	9,72%	11,38%
Day peak (0,13 €)	10,54%	12,33%
Refer transport (Nea Values)		
Night off-peak (0,11 €)	8,42%	9,83%
Day off-peak (0,12 €)	9,19%	10,72%
Day peak (0,13 €)	9,95%	11,62%
Tank transport (Nea Values)		
Night off-peak (0,11 €)	7,81%	9,13%
Day off-peak (0,12 €)	8,52%	9,95%
Day peak (0,13 €)	9,23%	10,78%
Bulk transport (Nea Values)		
Night off-peak (0,11 €)	7,84%	9,12%
Day off-peak (0,12 €)	8,55%	9,94%
Day peak (0,13 €)	9,26%	10,77%
Average	**9,51%**	**11,27%**

Source: own elaborations

Table 7.24 presents the increase in total costs with the road pricing component for all the transport types, also for the national corridors the biggest impacts are for container vehicles; while slightly lower is the increase in transport cost for tanker transport.

The impact of this measure on Euro 4 vehicles is clearly bigger, as it is possible to notice in table 7.25, where the average values for container transport in the two corridors is respectively of 12% and 14,4% on Antwerp-Charleroi and Antwerp-Ghent.

Tab. 7.25: Increase share in the total costs with the road pricing introduction for container transport, on national routes, Euro Vehicles 4

Euro 4 vehicle	**Antwerp-Charleroi**	**Antwerp-Ghent**
Sea container (Grosso's thesis)		
Night off-peak	12,48%	15,29%
Day off-peak	13,52%	16,57%
Day peak	14,56%	17,84%
Sea Container (Nea Values)		
Night off-peak	9,72%	11,38%
Day off-peak	10,54%	12,33%
Day peak	11,35%	13,28%
Average	**12,03%**	**14,45%**

Source: own elaborations

7.2.3. Concluding remarks on the results obtained

The final considerations on the application of road pricing on the Belgian territory came out of the previous results and some additional economic observations on transport economics.

The first element to be considered is the difference between national and international corridors. While for the first ones the effect of introducing road pricing is felt only or mostly on the Belgian territory, for the international trips there could be other exogenous factors that could distort the road pricing application in Belgium. This is due to the fact that some countries where the goods are shipped have already similar measures, some others have different policies, some others none of them. The final result is therefore influenced by different elements and not all of them under control of the Belgian policies. This consideration can explain that the exercises carried out in the present chapter have a descriptive purpose and do not pretend to precisely illustrate the real situation.

It is clear that the road pricing application will allow having a more realistic scenario where all the users pay for the consequences that their actions produce. The externalities will be paid according to the “who pollutes pays” principle and covering the marginal social cost.

The costs is based on the kilometres covered on the Belgian territory, therefore the national corridors or the ones close to borders are disadvantaged if compared with the international ones, especially the long international trips.

This can be explained by the fact that on long distances, the effect of a road pricing introduction weight less than in shorter routes. To this respect the overall cost structure of a long distance journey, including a Belgian segment, will not vary considerably.

Different is the case when the distances are relatively short and the final destination can be reached with alternative roads, both normal Belgian roads and international roads that lead to the same destination. In this case the introduction of road pricing could make the difference money wise and pull the transport operator to alternative solutions.

In the previous applications the values used for the road pricing tolling system were relatively similar, according to the time of the day. Some minor differences could still be observed, having a clear higher impact if the trip was performed in peak hours during the day.

These considerations are consistent if no compensation measures are assumed. As a matter of fact, it could be the case that a road pricing policy could be introduced together with additional compensation measures that could stimulate the use of road transport or cleaner vehicles. These measures will intervene in the overall scenario, modifying the effect that a single road pricing measure could have produced. Although it is impossible to foresee the precise consequences of possible compensation measures, it is rather simple to hypothesize a minor impact of the road pricing toll.

It is therefore predicable to expect a raise in transport costs that will vary also in relation to the goods transported, for high values goods the perception of the cost increase could be lower than low values goods. On the contrary the introduction of a road pricing scheme could possibly reduce the road congestion and be accepted positively by operators.

Together with a measure affecting freight transport, additional provisions for the passengers sector should be established, so that the advantage in road congestion produced by the road pricing toll could not be cancelled by an increase in passenger transport.

The effects that road pricing could produce can be observed also in the overall transport sector, affecting the road sector as well as the other modes on the transport demand.

The reaction from the transport sector can be different according to the time frame: short, medium and long term.

In the short time the reactions from the transport operators could be the switch from motorways to normal roads, where road pricing toll is not applied, or not to choose Belgian routes.

An additional road operator's strategy could be a better cost structure organization, trying to reduce others company' costs. To this respect it has been already observed which the cost items that count more on the total costs are, as described in Chapter V. The focus will therefore be on fuel costs, personnel costs, amortization costs or company's overhead costs.

The road company will try to increase and improve the loading factor on truck's board. This will imply that in the same trip more cargo is loaded or that the company fleet will be better restructured in order to perform less empty trips as possible. At the first stage of road pricing introduction, the expenses for asset investments would be postponed.

In the medium term, when the company will be already acquainted with the policy measure, a possible structural reaction could be put in place, with a fleet reorganization and acquisition of greener vehicles. This strategy will be seen as an investment since the costs for new investments will be covered in the long run by lower expenses for road pricing tolls.

According to the company size and asset availability, possible cooperation's or mergers could be put in place by the road companies in order to obtain synergies and to reduce operational costs.

When looking at the long term, the effects of such policy measure could have influences on other transport modes, namely shifting some of the road transport traffic to rail or inland navigation modes.

The effect of price variations on mode choice has been studied by several authors, in a recent study De Jong (2010), reviewed major studies on price sensitivity of road freight transport. Out of his research the author was able to pinpoint that the price elasticity related to mode change, in tonkm, for long distance road transport in Europe is ranging from -0.2 to -1.3. A single common value for all the European countries could not be acceptable since geographical differences among regions could already have an important influence on the price elasticity value.

A possible consequence could be a general decrease in transport demand, also in this case it would be rather hard to predict a precise price variations on the overall transport demand.

The underneath reasons of such difficulty are explained by the reactions that different types of commodity could have on road transport cost increase. De Jong (2010) reports that, in this case, an average European value for transport demand elasticity could be around -0.4.

An additional effect of road pricing on the long term could be a general re-organization of the transport and logistic distribution aimed at obtaining costs cut both for transport operations and also for the logistics activities. To this respect the distributions centres could be re-located closer to the consumer market or shipment size could be increased in order to reach scale economies.

7.3 Chapter's summary

Chapter VII has been developed to the purpose of presenting the results of several applications in external costs internalization on a European scale.

Firstly the results obtained by the internalization of a comprehensive set of pollutants on six corridors in Europe for all modes of transport have been reported, showing that rail transport is the less affected by the introduction of this policy measure.

On the contrary, road transport will be one the one with higher penalization in terms of cost for its pollutant emissions.

Such considerations are applicable to the entire sample of corridors considered.

The second part of the chapter considers the application of road pricing on the Belgian territory. Different scenarios have been presented taking into consideration national corridors and international segments, with a wide range of variations according to vehicle types and moment of the day for the road pricing application.

Out of the results obtained, some general considerations have been presented both concerning the impact of road pricing on the road sector and also on the entire transport sector.

This chapter aimed at showing which consequence could be obtained by a policy measure on external costs internalization. If the current problems that characterize intermodal transport hamper its development and increase in competitiveness, such initiative could help in promoting its use.

The next chapter will review what has been treated in the whole thesis and draw some conclusion and recommendations for the private and public sector.

CHAPTER VIII

CONCLUSIONS

This last chapter will try to summarize the main findings emerged from the development of the present thesis, with the final aim to answer the research questions posed at the beginning of the text and to propose possible solutions or recommendations for interventions heading at improving the competitiveness of intermodal transport in Europe.

This chapter will therefore be structured in the following manner: a first part of the text will report on the work developed providing a summary of the findings that was possible to achieve in each of the previous chapters, the next paragraph will try to answer the research questions and to provide possible recommendations for interventions on a European scale on the specific topic of intermodal transport, the following paragraph will put evidence on the added value of my thesis, as well as the limitations of the work. The text will conclude with advices for future researches and possible investigation on the same topic or related ones.

8.1 Summary of the research development and main findings

The review of the outcomes of the research will be presented according to the chapter's order.

The first chapter of the thesis had the aim of presenting to the reader what intermodal transport is, its technical and organizational characteristics, and some indications about the development of intermodal transport in Europe with the support of few statistical data. The analysis touched also the responsibility issue of the intermodal operator and the European policies and researches carried out so far for the investigation of this topic.

It was expressed the difficulty in providing a single definition of the concept, due the presence of different meanings indicating similar notions of it, nonetheless the main elements that characterize intermodal transport were outlined:

- The use of several modes of transport that are identified under a unique transport contract. There is the tendency to use rail, inland waterways or short sea shipping transport as alternative to road only transport. Road transport tends to remain the initial and final part of the transport chain.
- The use of a loading unit, from the initial point of departure until the final place of consignment. Such loading unit can be an ISO-container, a swap body, a trailer, a semi-trailer.
- The loading unit is shipped from one mode to another without any handling of the goods, for the entire door-to-door transport chain.

An important indication on the use of intermodal transport was provided stating that: it is used when demand requirements and supply dimension match each other in a way that there could be economies of scale, reduction of the costs, improvement in the speed of the transports, such as the diseconomies due to the transhipment of the freight could be reduced. Moreover the general management of an intermodal business requires advanced organizational skills due to the intrinsic complexity of this mode of transport.

For each intermodal solution and single mode of transport a description of the technical requirements was presented, together with some descriptive statistics on the use and spread of it around European countries. What emerged from this part is the general lack of reliable and recent data on intermodal transport.

The report on European policies and projects showed high interest in the topic and its economical and environmental potentials in respect to a possible re-balancing in the European modal shift.

The main purpose of Chapter II was to present the main literature review that constituted the methodological and reference base for the development of the work.

In the first part the main researches that dealt with the concept of intermodal transport, especially in respect to its competitiveness toward other modes of transport, were presented.

Among the others a paper written by Bontekoning et al. (2004), stated which the common problem of intermodal transport is: “The general problem of intermodal transport is its competitiveness in relation to other modes…for which markets intermodal transport is attractive, how intermodal performs compared to other modes, how market share can be increased, and which pricing strategy to follow”. This statement perfectly fitted in the purpose of the present work, and it could be considered as a reference point when proceeding in the research activity. After reviewing and learning from previous work it was decided to focus on the topic from an economic point of view, analysing the costs related to intermodal and uni-modal transport and driving the attention to the costs elements that compromise the effective competiveness of it.

In the second part of the chapter the literature examined was based on the elements affecting mode choice, that can be mainly split in three major veins: the literature on the out of pocket costs and each cost item considered, as well as the methodological approach for its estimation, the literature on qualitative attributes, their selection and monetary valuation, to conclude the review of existing works that deals with external costs.

After an attentive examination of the previous works, in chapter III, the methodological framework undertook in the thesis was presented, that is based on the generalized cost concept, namely:

Generalized costs are the sum of monetary costs and non-monetary costs of a journey.

The expression of the generalized costs is in a monetary unit and comes out of monetary costs and non-monetary attributes of the trip.

In order to examine each of the generalized cost components, it was necessary to decompose the total cost in: out of pocket costs and the values attributable to qualitative variables.

What has been reported in chapter III shows that the procedure has been threefold: the first part of the work considers the out of pocket cost that a transport provider has, the tangible costs that he/she has to face on an everyday base, moreover an analysis of the relation between cost and price has been undertaken.

The additional variables considered in the generalized cost functions are the qualitative elements that influence mode choice.

This part has been investigated with the support of personal interviews with shippers and freight forwarders. To complete the analysis, a qualitative approach, based on previous results on values of time, has been followed.

Among the aspects influencing mode choice, the thesis took into consideration and put particular attention on environmental concerns, with the development of external cost internalization's.

Chapter IV was expedient for obtaining a clear view on the areas and corridors that were going to be analyzed. The purpose of this chapter was to present some economic and transport indications on traffic flows in Europe, mainly focused on the Port of Antwerp and Genoa and their hinterland, so that some freight corridors could be identified.

These two areas were investigated, especially looking at the port's characteristics and at their modal split. The two ports are rather different in terms of traffic flows and also for their sector specializations. Although these differentiations are not negligible, the role of container traffic is a crucial sector in both ports, moreover they both represent two of the main ports in their own port ranges: the Hamburg-Le Havre and the Mediterranean one. In this chapter the reason of comparing these two ports is also explained, mostly on the base of a continuous process of port competition to capture market share, especially in their hinterland.

Few available data on modal split were presented, showing that road transport is the most used mode, nonetheless inland navigation has an important share of the modal split in the case of the Port of Antwerp, on the other side in Genoa the 80% of the cargo to/from the port is using road transport.

On the basis of the available data and some qualitative considerations three destinations in the centre of Europe were selected: Basel, Frankfurt and Strasbourg.

For each corridor connecting the three destinations and the port of origin, a general description was provided and an overview on the rail and inland navigation services was presented.

The following chapters presented the results obtained by the elaborations carried out in the research process: out of pocket analysis, estimation of qualitative attributes, internalization of external costs.

The first part, chapter V, was based on the estimation of the pure transport costs for each mode of transport on each of the corridors considered. After a general presentation about the costs items considered, the calculations were performed with the support of an excel tool developed ad hoc. Several indications were provided by the outcome of the calculations, in relation to the comparison among modes, but also on each single transport cost attributable at a single mode of transport.

The results were compared for each corridor, out lightening the ranking of the modes of transport, from the most convenient to the most expensive. These considerations were purely based on the pure transport cost and showed that rail transport was the better solution in most of the cases; in the corridors from Antwerp and Genoa road and inland navigation were competing very often, while the intermodal solutions were in-between solutions. Consequently, an analysis on the cost items that weighted most on the total cost was carried out, showing that, in general, energy costs, personnel costs and asset cost, leasing or depreciation costs, were the most important.

An analysis of the different market structures for each transport sector was provided, showing that road transport and inland navigation have similar market structure, while rail transport differs from the previous two.

Moreover an investigation with the sample of freight forwarders was carried out in order to obtain information of their actual mode choice on the selected corridors. Some of the companies interviewed were actually involved in traffic on these routes and confirmed to use road transport, although more expensive.

The next step was the estimation of transhipment costs that are of high relevance in intermodal transport. The chapter dedicated the final part to the comparison between the results obtained and the actual supply of services present on the examined routes and the data on modal split.

While Chapter V looked at the monetary elements that influence mode choice, the following one was based on the study of qualitative attributes. The author presented the results obtained by the interviews carried out with freight forwarders and shippers in the two ports' areas. The overall most relevant conclusions that came out are:

- Among the most important elements that influences operators in mode choice, reliability is very important, regardless the mean of transport used;
- road transport is perceived better for its flexibility, frequency, transport time and services to the customers;
- Intermodal transport could be preferred for its lower costs and for its greener environmental impact.

The chapter was complemented by an additional qualitative analysis on the value of time, where previous values have been applied to the corridors selected in this thesis.

The calculations were carried out considering the values of time for each transport's mode and for each corridor, by means of the values proposed by De Jong, (2004a), which treated this issue applied on The Netherlands. The outcome of the mentioned paper was that the value of time for road transport is much higher than the other modes.

As such, in this Phd thesis it is not considered directly the values of time per freight category since information on freight categories is not available.

The values proposed by De Jong were applied to each corridor, so that an indication of the value of time could be presented.

The next step was the calculation of the generalized cost, composed by the results of the out of pocket analysis, chapter V and the outcome of the value of time calculations.

The main conclusion was that the generalized cost for road transport was higher than other uni-modal and intermodal solutions.

This is showing that, if road transport is still chosen also when including the value of time, the possible explanation is the role that other qualitative elements play in the mode choice, namely flexibility, frequency, etc.

This means that road transport can provide better services than intermodal solutions, in respect to these factors.

Besides the value of time, other qualitative elements play a key role in mode choice. These factors: reliability, flexibility, frequency, probability to have losses or damages or environmental impact need to be further investigated.

Especially on this last aspect, external costs and environmental impact, was based the last chapter, where their importance in case of internalization was estimated.

After having selected the values attributable to congestion and scarcity costs, accidents costs, air pollution costs, noise costs, climate change, costs for nature and landscape, costs for soil and water pollution and costs of up-down stream processes, according to the Handbook on estimation of external costs in the transport sector, IMPACT, the estimations for the selected corridors were performed. To the purpose of these calculations, an excel tool was developed ad hoc, providing indications on external costs for each mode of transport, based on defined assumptions.

The main results of an internalization of external costs would be an additional advantage to rail transport that would confirm to be the cheapest mode of transport even when including external costs, on the contrary the most affected by this measure would be road transport, being the most polluting.

The remaining part of the chapter considered a particular case of internalization of external costs, applied only on road transport, which is road pricing measure. The exercise was applied to road corridors on the Belgian territory, national ones and international ones with a part of the journey on the Belgian territory.

The analysis considered the road pricing introduction and the impact that this measure could produce on the road sector and, in general, on the transport sector.

8.2 Main conclusions and recommendations

Approaching now the conclusion of this PhD thesis, I would like to put forward what has been possible to learn from my research and how my work will in some way contribute to enrich the academic field on the intermodal transport's competitiveness.

Whit this concluding part of the work I will also tried to answer the main question research posed at the beginning of the text.

1. *Which are the factors that hamper intermodal competitiveness on European level and how it is possible to intervene to improve it?*

2. *What are the role of external costs and the consequence of their internalization on the competitiveness of intermodal transport?*

3. *Which could be additional barriers that hamper a real competitiveness of intermodal transport in Europe?*

The purpose of the thesis was mainly to try capturing which are the factors that nowadays hamper the development of intermodality and also its competitiveness towards other modes of transport, namely road transport.

The conclusions reached have been acquired by means of the work developed during the last years and presented mainly in chapters V, VI and VII.

The work was especially addressing the role that costs component play in selecting transports modes and especially intermodal transport, using the generalized cost approach.

The first part of the work looked at the out of pocket costs, with a particular focus on the ones that weight more on the overall transport cost. The lesson learned was that road transport was the most expensive mode of transport in almost all the cases considered, while rail transport and the intermodal solution road-rail were less costly.

Notwithstanding this outcome, road transport is still preferred and, according to the general data on modal split, chosen more than the intermodal solutions.

In order to be confident, an investigation on the relation between cost and prices was carried on, confirming what already obtained with the cost analysis.

It was therefore possible to expand the analysis on other qualitative factors that could have a role in mode choice, namely the value of time was investigated for the selected corridors and for each mode of transport, using values already available in literature.

Through this analysis it was possible to obtain the generalized cost function for each mode of transport in each corridor so that the importance of the time could be investigated.

The results obtained showed that road transport was still confirming its higher generalized cost; from this I could conclude that not just travel time is very much important when selecting a mode of transport, but also other qualitative factors are definitely not negligible, as already confirmed by previous literature and by the results of the interviews carried out. In particularly road transport was preferred to intermodal transport for its flexibility and frequency, hence on these qualities intermodal operators should focus to increase intermodal competitiveness.

Chapter V and VI were more focused on representing the actual situation within intermodal transport is acting nowadays. This situation nonetheless does not really portray a situation of equilibrium among modes of transport, as National and International Institutions are seeking.

In order to reduce the impact that transport's pollutants create and to facilitate a better modal split, Chapter VII tackles the problem of internalization of external costs which could be a valuable measure so as to reach the mentioned objectives.

The outcomes of Chapter VII are actually supporting the idea that the internalization of external costs, applied to each mode of transport, will particularly affect road transport. Therefore the tool presented in the chapter, for this purpose, could constitute a valuable instrument for the implementation of such measure.

Some detailed consideration for each of the parts analysed in this thesis are required.

Within of the out of pocket analysis, it was possible to establish which the main cost components that weight more on the total cost are.

The cost items that need be considered more carefully are: energy cost, personnel costs, and depreciation or leasing costs.

These costs belong to energy, capital and labour factors that are employed in the production function, in order to obtain a certain output.

When deciding to produce a certain good or service, these production factors are considered, by the company, in such a way that a maximum output should be reached with the minimum input. The combinations of production factors result in different isoquants, which allow obtaining the same level of output. (Pindyck and Rubinfeld, 2008).

In respect to this matter, it is important to mention the productivity linked to these factors and how this could influence the final output of the previous calculations.

In the present text it was assumed to have the same cost figures for each cost item, since the calculations were performed in Western Europe, moreover it can always be possible to adjust cost figures to the specific circumstances.

I could conclude, based on this assumption, that the three factors mentioned above are the most important on the total cost, and it is important to act up on these elements.

This conclusion can be generally accepted and confirmed by previous studies on the topic, as confirmed earlier in the text, nonetheless different combinations in the production system can be put in place and different forces can influence the final productivity of a company.

Referring to labour productivity is important to put attention on the role that personnel has on company structure, especially in the transport sector.

The cost that companies have hiring drivers has a high impact on the overall cost, nonetheless it is a cost that can not be completely replaced by capital cost, and the same occurs for capital costs that are the main asset in transport firms.

There could be differences in labour and capital productivity according to each transport sector; this is due to different business structure, as well as different market conditions.

An additional difference can be observed according to the production area, local and regional aspects can influence as well the level of productivity.

The different level of productivities can clearly affect the total cost, hence the final ranking among transport modes can be influenced too.

The level of productivity for each production factor is a key element in comparing transport modes.

It is worth to mention the difference in labour productivity according to different work conditions, legislations and characteristics of the workforce.

In the previous chapters a reference was made on the different wage level of trucks drivers, according to their nationality. Namely a difference was found in relation to Easter and Western European drivers, the former being more convenient in terms of hourly salary. This element could already represent an increase in labour productivity, moreover the road company could obtain additional benefits in hiring Easter European drivers, as such as their willingness to adapt to longer working hours or their skills in communicating in several languages. These aspects increase their productivity, if compared, as an example to the Italian drivers.

This example illustrates that labour and capital productivity can influence the final cost of each transport mode and therefore their performance, therefore the productivity of the entire transport sector can have consequent effects on the general productivity of a certain area, in the specific case of this thesis, the ports area considered. This could be one of the crucial elements in port competitiveness and port competition among the two ports considered. As already indicated in Valleri and Van de Voorde, 1996, port productivity can be influenced, among other factors, also by labour flexibility.

Some possible measures for interventions are now suggested to the **private sector** so that a rationalization of these costs could be obtained.

From a company point of view these costs need to be put in perspective with interventions on the company management, clearly the measures than can be taken will vary according to the time frame.

The actual costs for *fuel* can not be changed, since imposed by the market; nonetheless it would be possible to intervene on the consumption. Some measures could be: the speed's reduction, the increase of loading factor, or the decrease of empty trips.

An internal reorganization of the fleet could also be a manner to tackle the problem, so that fewer vehicles could cover the actual demand minimising overcapacity.

Some suggestions reported are clearly more appropriate for inland navigation or road transport, while for rail transport, where electricity is mainly used, the optimization of the services and therefore the fleet management could help saving money.

In medium and long term, technologies development aiming at reduction of fuel consumption and, in general, improvement in propulsion systems could provide a substantial help in facing this problem. The possible investments in new fleet could be counterbalanced by long time saving in energy costs. A clear example in this direction is represented by the numerous improvements in road transport. Among the others transport sectors, road is the one than can adapt more easily to technological changes, as it is possible to observe in the constant evolution and improvement in trucks' types.

Some considerations on the role of *personnel costs* have been presented earlier, showing how the productivity level can constitute a key element in cost rationalization.

Also *depreciation or leasing costs* represent a very important cost item in all the modes of transport. A possible help in reducing assets costs is represented by their maximum utilization, namely the capacity to provide services that could cover to the maximum extent the vehicles capacity, the effective employment of the vehicle so that the dead times could be minimized and the vehicle could be employed as much as possible for the transport operation.

Investments in advanced technologies fleet could also be a measure that in the long run could show to be beneficial, due to new and more resistant materials and technical equipment that could require less maintaining and repairs costs.

From the out of pocket point of view, since the costs are mainly operational, the main interventions could come from the private sector, while public interventions can be barely bring any benefit, moreover the elements previously considered are dependent by market dynamics, within public intervention is not allowed in normal circumstances.

Chapter VI considered the importance of value of time on the generalized cost function. From the analysis it appeared that road transport confirms its position in being more expensive than the other transport solutions. Based on this I could argue that the value of time is only one of the factors that guide the freight forwarders and shippers in mode choice.

The relatively lower flexibility and frequency of intermodal transport explains why road transport is preferred, besides being faster.

In respect to these factors, the involvement of the private sector could be limited to the improvement of the quality's service, trying to minimize any inefficiency that they can control with their company's power. It was, already expressed in the interviews and in general it is reasonable to presume that the main purpose of the company is the satisfaction of the client. It is therefore possible to state that the quality of the service, in the cases analyzed and especially for the Genoese hinterland, is not only related to the company power but also to the market structure and to the public sector.

According to my understanding and to the results of my work it is possible to focus the attention on some **public interventions** that could help in improving intermodal service qualities, such as its flexibility and its frequency.

It is necessary to *streamline bureaucratic and documentary process*; at the current stage the time spent in order to fulfil these procedures is still very high, especially in the case of intermodal transport that it is characterized by a complex structure. On an international level these procedures are still not homogeneous, if measures in this direction will be enforced, a faster and more reliable service will be available. Most of the documentary process is "paper based" and produced in each country with different format but containing the same information.

A main issue in intermodal transport is represented by the *lack of sufficient infrastructures* that can support its full development. This aspect is crucial, since restrictions or lack of capacity on the rail network compromise the spread of intermodal transport, as well as its frequency.

Looking back at the two ports considered in the work, and the corridors heading at the different destinations in Europe, it appeared clear that there was a difference between two ports hinterland. The nature of this difference is multiple; nonetheless the infrastructural aspect is as much important. The problems related to the lack of sufficient rail tracks, as well as different technical characteristics that compromise a full interoperability among countries. The public intervention to this respect is necessary. Especially for intermodal rail transport a major problem that was encountered is the inadequacy of the rail infrastructure, that in some cases are missing or with low capacity. This could be the case of the rail connections from the Port of Genoa towards its hinterland, an historic example is the third rail connection between Genoa and Milan, (Terzo Valico) which is on the agenda since years and seems to represent a turning point for the rail traffic between the port and the hinterland.

The infrastructural problem affecting the port of Genoa is a real element that is hampering an enlargement of rail and intermodal transport spread. The rail path between Genoa and Milan is actually imposing several restrictions on the rail operators, connected to speed, weight and tunnel profile. The rail connections between Antwerp and the final destinations show clearly a much easier management, without major infrastructural problems.

The different infrastructure network among the two ports is ad additional element that can influence the port productivity, hence their competitive power, as illustrated in Meersman et al., 2002 and in Ferrari et al., 2011.

This element can help in understanding the underneath reasons for the different spread of intermodal transport in the Antwerp's hinterland and in the Genoese one. Another aspect that is crucial in intermodal transport is the volume of goods that needs to be moved; in normal circumstances the volume should be big enough so that intermodal rail or inland navigation solutions could be possible alternative to road transport. To this respect the two ports considered can stand on different positions, namely Antwerp has higher maritime volumes handled at its docks than Genoa. The development of intermodality, related to port hinterland, is very much linked to maritime flows. This could also represent a difference between the two ports, showing that intermodal development, hinterland connections and maritime traffic are strictly linked and together contribute to define port competitiveness.

An additional intervention that could help in improving intermodal competitiveness is related to *legislative regulations* that do not currently provide a clear and unique transport responsibility. As stated at the begging of the thesis, there is an important lack in the discipline that regulates transport operator's responsibility when dealing with intermodal transport. If this issue could not be directly linked to the decision maker, hence to the selection of intermodal transport, it is nonetheless an important deterrent for its promotion.

Different legislations are applied among European countries for what concerns operational procedures, this aspect slows down the transport and reduces intermodal flexibility.

In relation to the *market structure*, especially in the intermodal rail sector, the service competition is limited to the presence of a low number of rail operators around Europe.

Moreover the role of ex-stated owned companies is still relevant on the European scene, impeding a real competition on the market, although the privatization process is putting on the market new private entrants.

Measures that could actually promote the entrance of new companies in the rail and intermodal sector, with a real competition among the transport actors, will lead to an increase of the transport services, as well as more competition on a price level.

From the public point of view, important expedients could be put in place, opting at a minimization of infrastructural, operational and bureaucratic problems that have been presented as crucial bottlenecks.

To tackle this need of intervention the European Commission already took different measures aiming at enforcing the role of intermodal transport.

As already mentioned previously in the text, the indication given in the last White Paper (2011), within the EC was prone to stimulate the use of intermodal solutions also with the internalization of external cost. The Marco Polo program financed initiatives and interventions undertook by the private operators aiming at increasing the use of intermodal transport, as well as numerous European project investigated different aspect connected to this transport mode.

These directives and indications seem to be adopted by the member states in a fragmented way, so that a clear disparity is present on a European level, especially with reference to single documentation process, bureaucratic procedures and investments in infrastructures.

An additional consideration about the allocation of subsidies or founds is required; the help that the EC provides to the private sector could actually represent a worrying signal if the profitability of the beneficiaries is only liked to such measures. If this would be the case, it could be confirmed that not only monetary costs are taken into account, but qualitative elements related to the service are more important.

Together with the measures aimed at supporting the investments in intermodal transport, it would be strategic to *disseminate information on the concept of intermodality and on its potentiality*, making references to best practices, to applied case where it showed to be successful and applicable.

It is very often the case that freight forwarders or shippers are not completely aware of the solutions that intermodal transport can offer in comparison to road transport.

To this matter it will be expedient to develop a *tool or a platform* where the potential users could actually have the possibility to know which intermodal services are available, on which routes and the price of the service. Such services already exist for passenger transport, and although with different characteristics, could be applied also to freight transport, so that the final user could have a better view on the supply of the services.

A more general consideration that emerged out of my work is related to the importance of *available data on intermodal transport*. There is a clear lack of official, updated and comparable data, this constitute a main issue when analysing intermodal transport, not just for academic reasons but for any market analysis. From my point of view, it is necessary to create a methodological framework for the collection and elaboration of such data and apply the same regulation to every national institution dealing with the intermodal transport.

The lack of data was one of the main problems when I started to deepen my analysis; I could obtain relatively more information from the port of Antwerp, while very few information were available from the Genoese side.

All the considerations reported so far did not consider yet an important finding emerged in my work, the crucial role that externalities play in transport economics and the potentiality of an ***external cost's internalization measure***.

It has been observed that intermodal transport would take advantage of such a measure, possibly increasing its competitive position towards road transport.

The introduction of such policy measure will help in decreasing environmental pollution and will introduce the equity principle: who pollutes pays. It can be a strategic action, although taking into consideration technical specifications and local applicability.

Moreover it should be taken into consideration that the road sector, although being the one more affected by the internalization of external costs, is as well the more flexible in terms of technological adaptation, as it is witnessed by the increasing technological improvements present on the new generations of trucks.

This observations wants to underline that, also including external costs in the total road price, it can still compete with the intermodal solutions and maintain its relative advantages.

This consideration take me to conclude that the qualitative aspects on which intermodal transport should act upon, flexibility and frequency, are the key elements in order to increase intermodal competitiveness.

Road transport will always maintain its relevance within the transport chain, opting thought to obtain a re-equilibrium in the modal split that could ensure a maximization of the benefits with decease in terms of social costs.

I can therefore conclude that intermodal transport is a valuable alternative to road transport in relation to its lower generalized cost, to its environmental emissions and more in general to the negative external costs produced.

From a theoretical point of view there should be no reasons for not selecting intermodal transport, nonetheless the evidence is showing that this mode of transport is still not often preferred to the road solution.

It came evident, in the text, that the cost/price is already a strong point for intermodal transport, therefore the elements that should be improved for increasing its competitiveness are more related to the qualitative attributes, reduction of travel time, increase of flexibility and frequency and enhancement of reliability.

As already stated, very much can be done in this direction by public authorities, since most of the measures heading to these results are legislative, infrastructural or bureaucratic.

It is equally important to promote intermodal transport on a company level showing how efficient and competitive it could be.

When wanting to intervene on a general level, the introduction of policy measures aiming at reduction of external costs and re-equilibrium in modal split is representing a strategic approach.

In my understanding and in light of what I was able to discover in my work, intermodal transport can actually be an alternative to road transport, as far as certain conditions are fulfilled.

There should be enough volume to be transported, the intermodal service should be economically convenient, and the quality of the service should be at list comparable to the road one. If these conditions are not present intermodal transport will suffer in order to impose itself on the market, as a valuable alternative.

I would also like to put emphasis on the importance of road transport that will always remain essential in the transport chain and have fundamental role in reaching the desired equilibrium in modal split.

Based on the finding already presented earlier, it is possible to state that the hypotheses posed at the beginning of the work are verified and supported by the results obtained during the elaboration of the thesis.

8.3 Added value and limitations of the present work

One of the main purposes of a PhD thesis should be the development of a research that could, in some way, add some value to the scientific and academic investigations on that specific topic.

Also in my case, I tried to reach this objective being able to:

- Provide a focus on the critical elements that can constitute barriers for the success of intermodal transport and some possible approaches to tackle the problems. Both quantitative cost factors and qualitative attributes have been considered.
- Produce two tools: the first for the calculation of out of pocket costs, that could help the users of intermodal transport when selecting a mode of transport, and the second one, that provides values in case of external costs estimation, being a possible tool for policy makers. These tools are flexible ones that can be applied to any geographical area or with different technical specifications, allowing for any variations in the inputs required.
- Present a detailed analysis of some case studies dealing with some freight corridors in Europe.
- Suggest possible recommendations on possible measures that could help in modal shift re-balancing and decrease in transport external costs.

Together with the added value that it was possible to obtain in my work, also some limitations need to be reported.

- The calculations performed were based on the assumption that the volume to move was 1000 tons, this allowed to compare the different transport modes. On the other side, as already stressed earlier in the text, this assumption limited the work in investigating the possible effects that economies of scale could have on the generalized cost's results.
- The analysis carried out was applied on some specific corridors in Europe. This can be considered a limitation, since the results obtained can be related to these specific case studies. It is nonetheless valid that the tools are flexible ones and suitable for every application. Moreover it is possible to generalize the finding of the study, at least for the Italian corridors, where similar situations on the scarce role of intermodal transport are witnessed. It is worth to remember that some general considerations on the limited development and competitiveness of intermodal transport can also be extended to the Italian side of some important European TEN-T corridors, such as the Rotterdam-Genoa corridor or the Berlin-Palermo one.

8.4 Future researches

The research progress is a never ending story, especially when the topic is able to capture interest and new questions rise while working. Although the development of the present thesis is foreseeing its ending, some arguments remain to be deeply analyzed and other new ones attract the author's attention.

In this last part of the work some references to matters, already considered, that would be nice to investigate further will be illustrated and some considerations on new future researches will be hypothesized.

- In the text the study was focused on intermodal transport and uni-modal transport only applicable to land transport and rivers. The reason is explained by the fact that the corridors considered were European land ones. It is nonetheless clear that alternative solutions to the land ones can be proposed as such as short sea shipping or air transport. Both these two alternative modes could be as well alternatives to road transport. The choice of selecting short sea shipping is clearly bind with the presence of coast's areas; the use of intermodal air transport could mostly be related to the commodity type, knowing that air transport for goods is mainly associated with high value goods.

- Another element that has not been considered is the impact that return trip have on the overall out of pocket costs and the role that they play in relation to the quality perception. It needs to be outlined that the difficulty in gathering reliable data on traffic flows was a main issue in deepening this topic. Since data was missing, considerations on actual situation on balanced/imbalanced flows were not possible. It would nonetheless be interesting to measure the impact of return trip on the total costs, assuming different levels of loading degrees.

- As already stated before an element that should be taken into consideration is the impact that economies of scale will have on the results previously obtained. An interesting exercise would be to modify the total volume, as well as introduce different vehicles types, and check if substantial differences can be found in terms of monetary expenses, as well as estimations of values of time and internalization of external costs.
- It will be very much interesting to investigate further if possible available data on intermodal transport could be found. As already expressed earlier this is one of the main issues in investigating this topic, and during the research process I was not able to obtain any additional insight on possible available data, due also to time constraint. Looking at future works, this aspect should be one of the priorities in order to obtain additional information that could support scientific work.

Based on the previous statements, I will continue to investigate this fascinating although very difficult topic, convinced of the possible improvements that intermodal transport can achieve.

RIASSUNTO IN ITALIANO

MIGLIORARE LA COMPETITIVITÀ DEL TRASPORTO INTERMODALE IN EUROPA: APPLICAZIONE SU ALCUNI CORRIDOI EUROPEI

La crescita dei flussi di merce ed il conseguente ricorso a sistemi di trasporto efficienti e meno inquinanti mette in luce l'importanza ed il ruolo centrale che il trasporto intermodale riveste a livello Europeo.

E' indubbio che il sistema di trasporto su scala europea risenta di notevoli inefficienze, che portano ad un elevato uso del trasporto stradale, causa a sua volta di importanti ripercussioni a livello sociale, congestione ed inquinamento, e sull'intero sistema dei trasporti comportando uno sbilanciamento della divisione modale.

La presente tesi di Dottorato si focalizzerà sula tematica della competitività del trasporto intermodale, investigando quelli che sono gli elementi che impediscono un pieno sviluppo di tale modalità per il trasporto merci su scala europea in relazione alle altre modalità di trasporto.

Allo scopo di perseguire tale ricerca, verrà seguita una metodologia basata su un approccio teorico all'argomento, completata da applicazioni e approfondimenti su alcuni corridoi merci in Europa.

I principali obiettivi che verranno perseguiti sono i seguenti:

- Fornire un'analisi dettagliata della situazione attuale del trasporto intermodale in Europa;
- Focalizzarsi sugli elementi che ostacolano il suo successo;

- Suggerire possibili indicazioni su come migliorare le performance del trasporto intermodale in modo tale da arrecare benefici ai soggetti coinvolti a diverso titolo nello stesso trasporto intermodale.

Allo scopo di raggiungere i sopra elencati obiettivi, sono state posti alcuni quesiti di ricerca che hanno aiutato nello svolgimento del lavoro e ai quali verrà data adeguata risposta a conclusione del processo di ricerca.

Di seguito sono presentate tali questioni:

1. Quali sono i fattori che ostacolano la competitività del trasporto intermodale in relazione al trasporto stradale in Europa e come è possibile intervenire per migliorare la situazione?
2. Quale è il ruolo dei costi esterni di trasporto e quali potrebbero essere le conseguenze di una possibile internalizzazione sul trasporto intermodale,?
3. Quali potrebbero essere ulteriori barriere che ostacolano l'effettiva competitività del trasporto intermodale in Europa?

Il valore che la presente tesi può apportare al mondo accademico e scientifico è fondamentalmente riconducibile al fatto che possa fornire una dettagliata indicazione degli elementi che influiscono sulla scelta modale e sugli aspetti che ostacolano uno sviluppo del trasporto intermodale, suggerendo degli strumenti per contrastare tali barriere.

La presenti tesi di Dottorato propone altresì due strumenti di calcolo finalizzati ad ottenere indicazioni sul puro costo di trasporto per ogni modalità di viaggio, e valori applicabili in caso di internalizzazione dei costi esterni per il trasporto intermodale ed altresì per le altre modalità di trasporto.

Possono essere individuati inoltre aspetti specifici e dettagliati per alcuni corridoi di traffico in Europa, permettendo altresì di applicare tali elaborazioni a ogni possibile origine/destinazione nel contesto europeo, essendo tali strumenti di calcolo estremamente duttili ad ogni tipologia di traffico o area geografica. Per concludere il presente lavoro offre al lettore possibili raccomandazioni su come i soggetti privati e pubblici potrebbero intervenire per aiutare un re-bilanciamento del modal split e contribuire a ridurre la produzione di inquinamento.

Il lavoro è stato sviluppato partendo dalla necessità di definire quale sia il concetto preciso di intermodalità e quali siano le relative caratteristiche tecniche ed organizzative. Nonostante una definizione univoca e generalmente accettata sia difficile da individuare, sono stati definiti i tratti distintivi di tale modalità, ovvero l'uso di diverse modalità di trasporto identificate sotto un unico contratto di trasporto, il ricorso ad un'unita di carico definita dal punto di origine fino a destinazione del trasporto, generalmente il container, e il fatto che non vi sia una rottura di carico durante l'intero viaggio. E' stato inoltre evidenziato come le informazioni statistiche ed i dati inerenti tale modalità siano pochi, frammentati e molto frequentemente raccolti con diverse metodologie, questa mancanza rappresenta un problema centrale in Europa per quanto riguarda il trasporto intermodale.

Sono stati di seguito presi in considerazioni i precedenti contributi scientifici che si sono occupati del problema della competitività a livello europeo, cercando di estrapolare i principali risultati utili al presente lavoro ed evitando di investigare aspetti precedentemente sviscerati.

A tale scopo il lavoro di Bontekoning et al. (2004) è stato particolarmente illuminante, avendo preso in considerazione 92 produzioni scientifiche che si erano precedentemente occupate di trasporto intermodale sotto diverse prospettive. In questo paper viene altresì evidenziato che: *"…Il problema generale del trasporto intermodale è la sua competitività in relazione alle atre modalità di trasporto…".*

Una serie di altri lavori sono stati esaminati, svolgendo una lettura critica di tali contributi è stato possibile individuare quali aspetti non fossero ancora stati toccati o quali approcci non fossero stati applicati alla tematica in esame. Attraverso questa revisione si è pervenuti alla conclusione che l'approccio attraverso il costo generalizzato di trasporto potesse costituire un modo nuovo di interfacciarsi al problema e di ottenere le risposte ai quesiti di ricerca posti precedentemente.

Con costo generalizzato di trasporto si intende riferirsi alla somma di costi monetari connessi al puro trasporto e a fattori non monetari considerati durante il viaggio.

Funzione di Costo Generalizzato

$$G = c + u\ (m_1, m_2, , m_3,\dots m_n,)$$

Dove: G = funzione di costo generalizzato

c = costi monetari

u (m_1, m_2, , m_3,… m_n,) = costi non monetari, funzione di diversi attributi qualitativi.

Di seguito, sulla base di una approfondita analisi di letteratura, sono stati individuati quelli che possono essere i fattori che maggiormente influenzano la scelta modale, in modo tale da poter poi agire sugli stessi.

Secondo quanto emerso dalla letteratura gli elementi considerati da spedizionieri e produttori di merce, prima di compiere una scelta modale, sono i seguenti:

1. Affidabilità del servizio
2. Tempo totale di trasporto
3. Costo/prezzo del servizio
4. Possibilità di avere danni o furti alla merce
5. Servizi al cliente.

Si è ritenuto perciò di investigare nel dettaglio ognuno di questi elementi, fondamentalmente divisi tra parte monetaria, i costi o prezzo del trasporto, e gli aspetti non monetari riconducibili ad aspetti qualitativi del servizio.

Per completare lo studio è stato approfondito il ruolo dei costi esterni, che allo stato attuale non sembra essere tra gli elementi decisivi nella scelta modale, benché costituisca un aspetto cruciale nelle politiche sociali su scala nazionale ed Europea. E’ stato perciò necessario investigare questo ulteriore aspetto considerando quanto è stato fatto in passato per analizzare i costi esterni del trasporto e come sono state sviluppate le possibili stime sulla loro valutazione.

Seguendo tale principio di analisi, i fattori considerati sono stati scorporati ulteriormente in modo da catturare ogni singolo componente sia monetario, nella fattispecie out of pocket costs, che non monetario, ovvero di tipo qualitativo.

La metodologia seguita ha perciò previsto che fossero analizzati i fattori comunemente inseriti nella funzioni di costo di trasporto, per ogni modalità. Una prima raccolta di informazioni e di dati è stata sviluppata attraverso la relativa letteratura, mentre importanti integrazioni sono venute da interviste e conferme di operatori di trasporto, svolte per ogni modalità di trasporto considerate, trasporto stradale, ferroviario, di navigazione fluviale ed intermodale. In tale modo è stato possibile acquisire anche dati di costo per ogni singola componente.

Le voci di costo considerate sono le seguenti:

Costi di trasporto

- Costi per il personale,
- Costi per energia e consumo di materiale,
- Costi di assicurazione per il veicolo,
- Costi per manutenzione e riparazione,
- Costi per tasse e pedaggi,
- Costi di struttura,
- Costi per ammortamento, affitti, leasing,
- Altri costi.

Costi di transhipment

- Costi di carico/scarico
- Costi per movimentazione e riposizionamento veicoli.

Esistono altresì costi che fanno riferimento solo uno specifico modo di trasporto, come il costo per i pneumatici nel trasporto stradale o il costo per le tracce ferroviarie nel trasporto su treno.

Sulla base di tali voci di costo sono state costruite delle funzioni per ogni modalità, tali funzioni sono alla base degli strumenti di calcolo sviluppati con il pacchetto Excel di Office, sviluppate per ottenere risultati sul costo monetario del trasporto. Oltre che al supporto teorico, lo strumento di calcolo ha previsto l'inserimento di dati di costo, informazioni tecniche e dati specifici per ogni corridoio preso in considerazione.

Conseguentemente si è cercato di individuare il legame tra costo del trasporto e prezzo finale offerto al cliente, evidenziando le differenze nelle strutture di mercato per le diverse modalità di trasporto, che possono evidentemente influenzare le politiche di prezzo degli operatori.

Quest'analisi è stata altresì completata da addizionali informazioni sull'effettiva scelta modale sui corridoi considerati, da parte degli spedizionieri intervistati.

L'approccio metodologico seguito per l'individuazione e la valutazione delle componenti qualitative, ha invece previsto il coinvolgimento di spedizionieri e shippers che hanno espresso il loro giudizio e manifestato la loro esperienza, in ambito alla scelta modale e di comparazione tra trasporto tutto strada ed intermodale. Le interviste, 45 in totale, hanno preso luogo nelle aeree del Porto di Anversa e Genova. Lo scopo di tali interiste è stato quello di individuare gli elementi che i soggetti intervistati considerano di maggior rilievo quando messi davanti ad una scelta modale.

Inoltre la valutazione dell'impatto dei fattori qualitativi è stata approfondita attraverso l'applicazione, nella funzione di costo generalizzato, di alcuni valori di tempo ottenuti da ricerche precedenti.

Ai risultati ottenuti dai calcoli sul costo monetario del trasporto sono stati aggiunti quelli ottenuti da un'inclusione del valore del tempo, individuando così il costo generalizzato per ogni modalità di trasporto.

L'approccio metodologico seguito per l'internalizzazione dei costi esterni, ha previsto lo sviluppo di uno strumento di calcolo che permettesse di ottenere, per una specifica tratta, i costi totali di inquinamento per ogni modalità di trasporto espressi in costi totali per quella tratta, o in costo per veicolo.

La principale fonte utilizzata a tale scopo è stato il Manuale per l'internalizzazione dei costi esterni, prodotto dalla Commissione Europea ed atto a dare linee guida per l'internalizzazione dei costi esterni su scala europea.

I costi esterni considerati sono:

- Costi di congestione e scarsità,
- Costi per incidenti,
- Costi da inquinamento ambientale,
- Costi da inquinamento acustico,
- Costi per variazioni climatiche,
- Costi da inquinamento per ambiente e territorio,
- Costi per inquinamento del suolo e delle acque,
- Costi esterni ottenuti da processi a monte o a valle del trasporto stesso.

Prima di procedere nella presentazione dei risultati ottenuti è necessario dare alcune brevi indicazioni sulle aree ed i corridoi in Europa analizzati in dettaglio nella presente tesi.

Dopo un'attenta analisi dei flussi di traffico su scala europea, si è deciso di focalizzare l'attenzione su due importanti porti in Europa, il porto di Anversa nel nord Europa e il porto di Genova nel bacino del Mediterraneo, e da queste aree considerare alcuni corridoi di traffico diretti verso il centro Europa, nella fattispecie verso le seguenti destinazioni: Basilea, Francoforte e Strasburgo.

Sono stati considerati sei corridoi e per ognuno di essi tutte le modalità di trasporto disponibili su tali rotte. Per i corridoi dal nord al centro Europa, trasporto stradale, ferroviario, di navigazione fluviale ed intermodale, mentre per i corridoi che collegano al porto di Genova, le possibili alternative sono chiaramente circoscritte al trasporto stradale, ferroviario ed intermodale ferroviario.

Per ogni corridoio sono state considerate le diverse caratteristiche tecniche utili allo sviluppo dei calcoli di trasporto e sono state inoltre raccolte le poche informazioni disponibili sul modal split caratterizzante gli stessi.

La parte seguente del lavoro è costituita dai risultati ottenuti per ognuna delle parti trattate e le conclusioni a cui si è potuti pervenire.

In particolar modo, nella prima parte del lavoro, sono stati analizzati i sei corridoi di interesse elencati precedentemente e per ognuno di questi si sono ottenuti risultati inerenti il costo monetario di ogni modalità di trasporto, gli stessi sono stati confrontati per ottenere un'indicazione sulla maggiore o minore economicità del trasporto da origine a destinazione, in confronto alle altre. E' stato così ottenuto un risultato complessivo per corridoio, espresso in Euro totali, ed altresì in €/vtons, €/tkm, €/h e €/km. Per la quasi totalità dei corridoi, il trasporto più conveniente, in termini di costi, è il trasporto ferroviario, mentre sono più costosi il trasporto fluviale, dove disponibile, ed il trasporto stradale.

Le soluzioni intermodali sono da considerarsi come soluzioni intermedie sotto il profilo economico, dove però un ruolo cruciale è impiegato dai costi di trasbordo.

Un elemento investigato è il peso che ogni voce di costo ha sul costo totale, quanto impatta perciò ogni singolo costo sul costo complessivo. In base alle elaborazioni sviluppate è emerso che i costi più importanti sono quelli per il personale, per l'energia consumata e per gli asset detenuti, ovvero ammortamento, leasing o affitto.

In costi variano a seconda del corridoio dove sono applicati e dai chilometri percorsi, sono però riportate alcune indicazioni di costo per ogni modalità, questo dato non è stato perciò prodotto a scopo comparativo, piuttosto per fornire al lettore delle indicazioni sul tali indici.

Il costo chilometrico per il trasporto stradale varia dai 1,01 ai 1,12 €/km, mentre quello orario dai 70,39 agli 88, 54 €/h.

I costi chilometrici del trasporto ferroviario si attestano tra i 14,08 e 18,76 €/km, mentre l'utilizzo del trasporto ferroviario per un'ora di lavoro varia tra i 628 ed i 777 €/h.

Per concludere i valori del trasporto fluviale sono di 26 €/km e tra i 239 ed i 285 €/h. Tutti i valori presentati sono stati ottenuti da elaborazioni con gli strumenti di calcolo sviluppati per il presente lavoro, dopo essere stati controllati accuratamente con gli operatori stessi del trasporto, inoltre i risultati ottenuti sono in linea con i precedenti derivanti da studi e ricerche al riguardo.

Per completare l'analisi si è reso necessario considerare la relazione tra costo e prezzo del servizio di trasporto, per ognuna delle modalità considerate. Questo allo scopo di individuare eventuali discrepanze tra i risultati ottenuti dai calcoli precedenti. Si poteva infatti ipotizzare che, benché il trasporto ferroviario fosse il più economico, vi potessero essere delle politiche di mark up in grado di sovvertire l'ordine di economicità e rendere più vantaggiosa un'altra modalità di trasporto.

Al fine di verificare questo aspetto sono stati presi in considerazione i bilanci del comparto ferroviario, stradale e del trasporto fluviale degli scorsi anni, prendendo come parametro di riferimento il profitto/perdita annuale delle compagnie di ogni settore. A causa di diverse strutture di mercato, è apparso che il trasporto stradale e di navigazione fluviale avessero avuto comunque dei profitti positivi negli ultimi anni, benché limitati, mentre il trasporto ferroviario ha evidenziato delle perdite. Questo elemento non fa che confermare che il trasporto ferroviario rimane il più economico e che nonostante questo freight forwarders e shippers prediligono il trasporto su camion.

Giunti a questa conclusione appare chiaro che i diversi stakeholders sono influenzati, oltre che dal puro costo del trasporto, anche da fattori di altra natura, essenzialmente di tipo qualitativo, per questa ragione anche questi aspetti sono stati indagati.

L'analisi ha previsto che venissero intervistati spedizionieri e produttori di beni di consumo, al fine di raccogliere la loro esperienza e percezione in relazione alla scelta modale, oltre che ad altri aspetti trasportistici e logistici.

I soggetti intervistati sono stati 45 spedizionieri, 25 nell'area del porto di Genoa e 20 nel porto di Anversa, tali interventiste sono state complementate da altre due interviste presso un grosso produttore di beni di consumo in Europa ed una società di logistica che si occupa della distribuzione di prodotti alimentali per un importante produttore su scala internazionale.

Tra gli elementi investigati, al ricorso al trasporto intermodale è stata posta particolare attenzione, ottenendo interessanti, alcunché non sorprendenti risultati sulla poca diffusione del trasporto intermodale. In relazione ai criteri maggiormente considerati nel momento della scelta modale, gli aspetti più importanti sono risultati essere l'affidabilità del trasporto, la possibilità che siano evitati danni o perdite alla merce, i servizi al cliente, il costo/prezzo e la flessibilità del trasporto.

Quando sono state confrontate le modalità tutto strada e intermodale, il primo è stato ritenuto migliore in relazione alla sua flessibilità, alla frequenza, al tempo totale impiegato e ai servizi offerti al cliente. Mentre il trasporto intermodale è risultato migliore per il costo più basso e per il miglior impatto ambientale, essendo meno inquinante.

A seguito di questi iniziali risultati, sono state prodotte ulteriori elaborazioni essenzialmente focalizzate sul valore del tempo attribuito dai decisori modali per espletare l'intero trasporto. A tale scopo sono stati considerati precedenti contributi scientifici sulla specifica tematica del valore del tempo nel trasporto merci e da tali lavori sono stati estrapolati valori che potessero essere applicati anche ai casi in esame. In tal modo è stato possibile osservare le variazioni nella funzione di costo generalizzato nel caso in cui al costo out of pocket fosse sommato il valore del tempo, così come calcolato ben capitolo VI. Tale metodologia è stata applicata con i valori proposti da De Jong (2004a). Da tale analisi è emerso che anche con l'inclusone del valore del tempo il trasporto stradale risulti quello più costoso in relazione al costo generalizzato rispetto al trasporto intermodale. Da tale risultato è stato possibile concludere che altri fattori qualitativi come la flessibilità o frequenza del trasporto intermodale, lo rendono più attrattivo del trasporto intermodale.

Dall'analisi sui fattori qualitativi è stato possibile desumerne che:

- L'affidabilità del trasporto è tra i più importanti fattori di scelta,
- Nel caso dei corridoi dal porto di Anversa, il trasporto stradale è il maggiormente usato, benché vi sia comunque un ricorso al trasporto fluviale e ferroviario; nel caso del porto di Genova, l'80% della merce esce dal porto via camion.
- Per gli spedizionieri intervistati nell'area del porto di Anversa, il trasporto stradale e ferroviario sono egualmente affidabili, mentre in Italia il trasporto stradale è percepito in modo migliore in relazione a questa caratteristica.
- Il valore del tempo è un fattore importante, ma latri aspetti qualitativi come flessibilità e frequenza sono altrettanto rilevanti.

L'ultima parte del lavoro si è focalizzata su un aspetto non particolarmente interessante agli occhi del decisore modale, ma estremamente rilevante da un punto di vista sociale, i costi esterni e la loro internalizzazione.

Se allo stato attuale, nonostante il trasporto stradale risulti più oneroso, è preferito dagli operatori, è necessario che vengano poste in essere delle misure volte ad un bilanciamento del modal split e ad una riduzione dei costi esterni. A tale proposito la presente tesi, ha voluto presentare una metodologia ed uno strumento che possa facilitare nell'implementazione di tale misura, nel momento in cui divenga obbligatorio internalizzare i costi esterni del trasporto.

Utilizzando come fonte principale il Manuale per l'internalizzazione dei costi esterni, prodotto dalla Commissione Europea, sono state implementati possibili scenari per conteggiare i costi esterni nel costo finale del trasporto.

Tali calcoli sono stati chiaramente applicati ai corridoi considerati in precedenza ed a tutte le modalità di trasporto contemporaneamente.

Sono state poste delle ipotesi tecniche, tra le quali l'utilizzo di treni elettrici, la presenza di camion con classe di emissione Euro 4 ed Euro 5, il ricorso ad autostrade, invece che a strade locali e l'ipotesi di effettuare il tragitto durante le ora di punta.

I risultati ottenuti mostrano un maggiore impatto ambientale del trasporto stradale, che di conseguenza si troverebbe ad essere maggiormente colpito da tali misure in caso di effettiva implementazione. Benché i risultati ottenuti non siano sorprendenti, è possibile comunque evidenziare l'utilità dello strumento di calcolo prodotto, che si presta ad applicazioni in contesti differenti da quelli qui trattati, grazie ad un elevato grado di versatilità.

La presente tesi di dottorato si conclude con alcune riflessioni critiche su ciò che è emerso durante il corso del lavoro, provando a fornire possibili chiavi di lettura e di intervento atte a migliorare la competitività del trasporto intermodale in Europa.

Appare chiaro che un ruolo centrale nella competitività del trasporto intermodale è giocato dagli aspetti qualitativi, più che dalle componenti di costo monetario, nella fattispecie la flessibilità, la frequenza, la velocità che contraddistinguono il trasporto stradale e di cui il trasporto intermodale sembra essere carente.

Oltre ai fattori sopra evidenziati, la scarsa diffusione e competitività del trasporto intermodale potrebbero essere giustificati dalla mancanza di volumi di traffico sufficienti, mancanza di adeguate infrastrutture di trasporto, difficoltà nella gestione della catena di trasporto intermodale, mancanza di conoscenza e promozione e delle relative potenzialità.

Al fine di contribuire a promuovere la diffusione e la competitività del trasporto intermodale possono essere fornite alcune indicazioni di interventi sia da parte dei soggetti privati che pubblici.

Per quanto riguarda gli aspetti di costo monetario è stato evidenziato come il costo per l'energia, il costo di personale ed i costi per i veicoli, sia di proprietà che con contratti di leasing o affitto, costituisco i costi maggiori per gli operatori di trasporto.

Per ridurre tali spese possono essere proposti interventi a breve, medio e lungo periodo.

Nella fattispecie, i costi energetici nel breve periodo possono essere ridotti intervenendo con un riduzione della velocità, cercando di aumentare al massimo la capacità di carico e riducendo più possibile i viaggi a vuoto. A ridurre i costi energetici potrebbe anche contribuire una riorganizzazione della flotta dei veicoli.

Nel caso invece del trasporto ferroviario, dove la principale fonte di energia è quella elettrica, un possibile intervento potrebbe essere una migliore organizzazione della flotta in funzione dei servizi offerti.

Nel medio e lungo periodo, riduzioni nel consumo di carburante ed energia potrebbero venire da miglioramenti nei sistemi di propulsione che potrebbero essere supportati da nuove tecnologie.

Per quanto riguarda i costi di personale, gli interventi che gli operatori di trasporto potrebbero mettere in atto, avrebbero essenzialmente a che fare con un migliore organizzazione delle attività svolte dal personale, in quanto esiste una dettagliata normativa sulle tariffe ed i costi per le risorse impiegate.

Per concludere, i costi di ammortamento, di leasing e affitto dei veicolo possono essere ridotti sfruttando al massimo la loro capacità sia in termini fisici, che per il loro utilizzo nel tempo.

Nel lungo periodo l'investimento in veicoli tecnologicamente più avanzati può permettere una riduzione dei costi di manutenzione e riparazione.

Per quel che invece riguarda gli aspetti qualitativi sui quali incidere per migliorare la competitività del trasporto intermodale, i principali interventi potrebbero venire dal settore pubblico soprattutto in relazione ad una maggiore diffusione del concetto di intermodalità ed ad una sua promozione.

E' indubbio che tali politiche di promozione dovrebbero essere supportate da un' effettiva efficienza, garantita a questo punto dai soggetti privati che offrono il servizio. Questo aspetto è comunque centrale in ogni politica aziendale, ovvero quello di fornire un servizio adeguato alle esigenze dei clienti.

Una prima misura di intervento può essere costituita da un effettivo mercato competitivo con accesso libero per i soggetti privati, allo stato attuale, benché formalmente operanti in un mercato aperto, la maggior parte degli operatori ferroviari fa capo una precedente compagnia statale.

Altro aspetto sul quale intervenire è la disparità nei processi informativi, organizzativi e burocratici che caratterizzano ogni legislazione nazionale, impedendo un'effettiva omologazione delle procedure su scala europea.

Non di poco conto sono gli impedimenti di natura infrastrutturale che ostacolano lo sviluppo di una rete di servizi omogenea tale da poter costituire una reale alternativa al trasporto su strada.

Il presente lavoro di ricerca ha applicato il concetto di costo generalizzato al trasporto intermodale, che per le conoscenze a disposizione non era fin ora stato considerato sotto questa prospettiva.

Inoltre sono stati prodotti e presentati due strumenti di calcolo, per i costi monetari e per il calcolo delle esternalità, che rappresentano due strumenti flessibili e adatti ad essere utilizzati per ulteriori aree geografiche o tipologie di carico.

I risultati ottenuti sono in linea con le indicazioni ottenute dai precedenti contributi accademici ed altresì confermati dai risultati delle interviste svolte durante il processo di ricerca.

NEDERLANDSE SAMENVATTING

HET CONCURRENTIEVERMOGEN VAN INTERMODAAL VERVOER IN EUROPA: TOEPASSING OP EUROPESE CORRIDORS

In het eerste hoofdstuk van het doctoraat wordt dieper ingegaan op de definitie van intermodaal vervoer, de bijhorende economische, technische en organisatorische kenmerken, en enkele indicatoren voor de evolutie van intermodaal vervoer in Europa. In de analyse komt ook de aansprakelijkheid van de intermodale operator aan bod en de relevante Europese richtlijnen.

Het was niet vanzelfsprekend om een unieke definitie van het concept intermodaal vervoer uit te werken, in de literatuur zijn immers verschillende interpretaties terug te vinden. In dit doctoraat hebben we gekozen voor volgende definitie van het intermodaal vervoer, op basis van drie hoofdkenmerken:

- *Het gebruik van verschillende vervoerswijzen binnen eenzelfde vervoerscontract.* Meestal wordt gekozen voor spoorvervoer, binnenvaart of short sea shipping als alternatief voor het unimodale wegvervoer. Vervoer over de weg blijft meestal de eerste en de laatste schakel in de vervoersketen.
- *Het gebruik van een laadeenheid die niet wijzigt tussen het oorspronkelijke vertrekpunt tot de uiteindelijke bestemming.* Een dergelijke laadeenheid kan een ISO-container zijn, een wissellaadbak, een aanhangwagen, of een semi-aanhangwagen.
- *De laadeenheid wordt van het ene vervoersmiddel op het andere overgeladen zonder dat de goederen worden behandeld*, dat is het geval gedurende de hele vervoersketen van deur tot deur.

Op basis van het eerste hoofdstuk kunnen een paar tussentijdse conclusies geformuleerd worden, die in de volgende hoofdstukken verder getest worden. Intermodaal vervoer wordt bijvoorbeeld gebruikt omdat de vraag en het aanbod elkaar vinden ten gevolge van schaalvoordelen en daling van de kosten. De vergelijking van de snelheid van het transport tussen de verschillende vervoerswijzen speelt ook een belangrijke rol bij de uiteindelijke keuze. Een negatieve rol bij de keuze van het intermodaal vervoer is de extra overslag van de goederen.

Daarnaast moet een intermodaal vervoersbedrijf beschikken over uitzonderlijke organisatorische capaciteiten, gezien de intrinsieke complexiteit van deze vervoerswijze.

Het tweede hoofdstuk bevat een literatuurstudie omtrent het concurrentievermogen van het intermodaal vervoer en de kenmerken die de vervoerswijzekeuze beïnvloeden. Op deze manier wordt de basis gelegd voor het verdere methodologisch onderzoek.

In het eerste deel 2.1 komen de belangrijkste studies aan bod over het concept van intermodaal vervoer, vooral met betrekking tot de concurrentiekracht in vergelijking met andere vervoerswijzen. Zo beschrijft Bontekoning et al. (2004) wat het meest voorkomende probleem met intermodaal vervoer is: “The general problem of intermodal transport is its competitiveness in relation to other modes…for which markets intermodal transport is attractive, how intermodal performs compared to other modes, how market share can be increased, and which pricing strategy to follow”. Deze vaststelling past perfect in het uitgangspunt van dit doctoraat, en dient als referentiepunt voor het verdere onderzoek. Op basis van de conclusies uit voorgaand werk, werd beslist het onderwerp te benaderen vanuit een economisch standpunt, met een analyse van de kosten met betrekking tot intermodaal en unimodaal vervoer en met de focus op de kostengerelateerde aspecten die de concurrentiekracht beïnvloeden. Hierbij wordt gebruik gemaakt van het concept van de gegeneraliseerde kost, zoals beschreven in deel 2.2.

In het derde deel van het hoofdstuk (deel 2.3) wordt de literatuur besproken met betrekking tot de elementen die de vervoerswijzekeuze beïnvloeden. In delen 2.4-2.6 wordt dieper ingegaan op een aantal specifieke kenmerken die de vervoerswijzekeuze beïnvloeden:

- De literatuur over de monetaire kosten (out of pocket costs) en de bijhorende methodologische werkwijze om de afzonderlijke kostenitems te bepalen (deel 2.4);
- De literatuur over de niet-monetaire kosten, namelijk de kwaliteitsvariabelen (deel 2.5);

- De literatuur over de rol van de externe kosten (deel 2.6).

In hoofdstuk III wordt het methodologisch kader van het doctoraat voorgesteld. Hierbij wordt gebruik gemaakt van het concept van de gegeneraliseerde kosten (deel 3.1):

Gegeneraliseerde kosten zijn samengesteld uit monetaire en niet-monetaire kosten. Hierbij worden de niet-monetaire kosten omgezet in monetaire waarden, waardoor de gegeneraliseerde kost uitgedrukt kan worden in geldwaarden. De verdere uitwerking van de gegeneraliseerde kost wordt beschreven in delen 3.2 tot en met 3.4. In deel 3.2 wordt de monetaire kost (out of pocket cost) in detail beschreven, waarbij getoond wordt hoe gebruik gemaakt kan worden van een zelf ontwikkeld rekenblad. Hierbij wordt tevens expliciet rekening gehouden met de relatie tussen kost en prijs. In deel 3.3 wordt getoond hoe de kwalitatieve variabelen opgenomen zullen worden in het onderzoek. Tenslotte wordt in deel 3.4 beschreven wat de rol is van de (internalisering van) externe kosten in het onderwerp van het doctoraat. Op deze manier wordt rekening gehouden met milieu-overwegingen. Hoofdstuk III werd afgetoetst op basis van interviews met verzenders en expediteurs.

In dit doctoraat werd gekozen om de focus te leggen op de havens van Antwerpen en Genua. In hoofdstuk IV wordt dieper ingegaan op de gebieden en corridors die gelinkt zijn aan deze havens, met aandacht voor economische en transport indicatoren. Hierbij worden een aantal belangrijke routes voor het vrachtvervoer geïdentificeerd.

Een vergelijking wordt gemaakt van de kenmerken van de havens van Antwerpen en Genua, waarbij de modal split één van de kenmerken is.

De twee havens verschillen op het vlak van vervoersstromen en sectorspecialisaties. Een gemeenschappelijk kenmerk vormt de belangrijkheid van het containervervoer in beide havens. Ze vormen beide zelfs twee van de belangrijkste havens in hun gebied: Hamburg-Le Havre respectievelijk het Middellandse-Zeegebied. In dit hoofdstuk wordt ook uitgelegd waarom net deze twee havens worden vergeleken, voornamelijk op grond van een continu proces van havenconcurrentie om marktaandeel te verkrijgen, vooral in hun hinterland.

Er zijn slechts weinig gegevens over de modale verdeling beschikbaar. Uit de gegevens blijkt dat wegvervoer de meest gebruikte vervoerswijze is. Desondanks vormt het vervoer via de binnenvaart een belangrijk aandeel van de modale verdeling van de haven van Antwerpen, daar waar 80% van de cargo van/naar de haven van Genua over de weg gebeurt.

Op basis van de beschikbare gegevens en enkele kwalitatieve overwegingen werden drie bestemmingen in Centraal Europa uitgekozen: Basel, Frankfurt en Straatsburg.

Voor elke corridor tussen enerzijds de havens en anderzijds de drie bestemmingen in het hinterland werd een algemene beschrijving gegeven en een overzicht van de vervoersdiensten via het spoor en de binnenvaart.

De hoofstukken V-VII gaan dieper in op de empirische resultaten van het onderzoek: analyse van de monetaire kosten (out of pocket kosten) in hoofdstuk V, de rol van de niet-monetaire kosten (kwalitatieve kenmerken) in hoofdstuk VI en de internalisering van de externe kosten in hoofdstuk VII.

Hoofdstuk V is gebaseerd op de berekening van de pure vervoerskosten van elke vervoerswijze op elk van de beschouwde routes. Na een algemene voorstelling van de kostenitems die in overweging werden genomen in deel 5.1, worden de berekeningen uitgevoerd met behulp van een rekentool in Excel die ad hoc werd uitgewerkt (zie deel 5.2). Uit die berekeningen vloeien verschillende conclusies voort, met betrekking tot de vergelijking tussen verschillende vervoerswijzen, maar ook met betrekking tot de afzonderlijke vervoerskosten die samenhangen met de specifieke vervoerswijzen.

De resultaten worden per route vergeleken, op basis waarvan de transportwijzen worden geordend, van meest voordelige tot duurste. Deze overwegingen zijn enkel gebaseerd op de pure vervoerskosten en tonen aan dat het treinvervoer in de meeste gevallen de goedkoopste optie is. Op de routes vanuit Antwerpen blijken wegvervoer en binnenvaart vaak met elkaar te concurreren, terwijl intermodale oplossingen slechts als tussenoplossingen worden beschouwd. Vervolgens wordt onderzocht welke kostenitems het zwaarste in de totale kosten doorwegen, waaruit blijkt dat in het algemeen kosten voor energie, personeel en activa, leasing of afschrijvingen het meeste doorwegen. Met behulp van een sensitiviteitsanalyse in deel 5.3 wordt getoond hoe gevoelig de resultaten zijn voor een wijziging van een aantal parameters.

Vervolgens wordt in deel 5.4 een analyse gemaakt van de verschillende marktstructuren voor elke vervoerssector, waaruit blijkt dat wegvervoer en binnenvaart een gelijkaardige marktstructuur hebben, terwijl spoorvervoer van de vorige twee verschilt.

Een groep van expediteurs werd gevraagd om informatie te verstrekken over hun eigenlijke keuze van vervoerswijzen voor de geselecteerde routes. Enkele van de geïnterviewde ondernemingen waren actief op deze routes en bevestigden wegvervoer te gebruiken, ook al kwam dat duurder uit.

Terwijl hoofdstuk V de monetaire aspecten behandelt die de keuze van de vervoerswijze beïnvloeden, komen in het hoofdstuk VI de kwalitatieve aspecten aan bod. In het kader van het doctoraal onderzoek werden interviews afgenomen bij expediteurs en verzenders die actief zijn in het vervoer tussen de haven van Antwerpen of Genua enerzijds en het hinterland anderzijds (zie deel 6.1). De belangrijkste algemene conclusies zijn de volgende:

- het meest doorslaggevende aspect dat de operatoren beïnvloedt in hun keuze voor een bepaalde vervoerswijze is de betrouwbaarheid van de dienst, ongeacht welk vervoersmiddel wordt gebruikt;
- wegvervoer wordt als beter beschouwd, vanwege de flexibiliteit, frequentie, vervoerstijd en de klantendienst;
- intermodaal vervoer zou echter de voorkeur kunnen krijgen vanwege de lagere kosten en de lagere milieu-impact.

Dit hoofdstuk werd aangevuld met een bijkomende analyse op basis van de waarde van tijd, toegepast op de betreffende routes (deel 6.2). De berekeningen zijn gebaseerd op basis van waarden van tijd per vervoerswijze, zoals gerapporteerd door De Jong (2004a) in Nederland. De waarden zijn dus niet gebaseerd op waarden van tijd per goederencategorie. Hierbij wordt gebruik gemaakt van een waarde van tijd die hoger is bij het wegvervoer in vergelijking met de andere vervoerswijzen. De waarden zoals gerapporteerd door De Jong worden toegepast op elke corridor, waardoor een indicatie van de waarde van tijd kan berekend worden. Een volgende stap bestaat dan uit de berekening van de gegeneraliseerde kost per corridor voor het vervoer van 1000 ton, opgebouwd uit de monetaire kost en de waarde van tijd. De belangrijkste conclusie is dat de gegeneraliseerde kost voor het wegvervoer hoger is dan andere unimodale en intermodale alternatieven.

Ondanks het feit dat de gegeneraliseerde kost (inclusief waarde van tijd) van wegvervoer hoger is, stelt men in de praktijk vast dat nog steeds voor deze modus gekozen wordt. Een mogelijke verklaring is dan dat er nog andere kwalitatieve variabelen een doorslaggevende rol spelen bij de keuze van de vervoerswijze zoals flexibiliteit, frequentie, enz. Dat betekent tevens dat het wegvervoer een betere service kan bieden in vergelijking met de intermodale oplossing. Naast de waarde van tijd spelen nog een aantal andere kwalitatieve factoren bij de vervoerswijzekeuze, zoals betrouwbaarheid, flexibiliteit, frequentie, kans op verlies en schade van de goederen. Deze factoren kunnen in een verder onderzoek meer in detail bestudeerd worden.

Het laatste hoofdstuk VII gaat over de internalizering van externe kosten. Eerst worden de externe kosten bepaald in deel 7.1 die te wijten zijn aan congestie en schaarste, ongevallen, luchtvervuiling, lawaai, klimaatsverandering, natuur en landschap, grond- en watervervuiling en kosten van "up-down stream processes". Hierbij wordt gebruik gemaakt van de gegevens uit het Handboek over de schatting van externe kosten in de vervoerssector, IMPACT. Vervolgens wordt een schatting van de externe kosten voor de betreffende routes gemaakt. Daartoe werd een rekenblad in Excel ontwikkeld waarmee een indicatie kon worden gegeven van de externe kosten voor elke vervoerswijze, op grond van bepaalde uitgangspunten.

Internalisering van de externe kosten zou vooral een bijkomend voordeel bieden voor het spoorvervoer, dat de goedkoopste vervoerswijze blijft, zelfs met inachtneming van de externe kosten. Het wegvervoer zou echter het meeste lijden onder deze maatregel, aangezien deze vervoerswijze de meest vervuilende is.

Deel 7.2 beschrijft een specifiek geval van internalisering van de externe kosten, enkel van toepassing op wegvervoer, het zogenaamde rekeningrijden. De oefening wordt uitgevoerd voor een aantal geselecteerde routes voor het binnenlands vervoer en het internationaal vervoer.

In de analyse wordt dieper ingegaan op de invoering van rekeningrijden en de invloed op de sector van het wegvervoer zelf en op de vervoerssector in het algemeen.

BIBLIOGRAPHY

Abshire, R.D., Premeaux, S.R., (1991), Motor carrier selection criteria: perceptual differences between shippers and carriers, Transportation Journal, pp. 31-35

Aida database (Italian Companies Database, University access)

Allen, B., Mohmoud, M., McNeil, D., (1985), The importance of time in transit and reliability of transit time for shippers, receivers, and carriers, Transportation Research B, Vol. 19/B, N. 5, pp. 447-456

Bacelli, O., (2001), La mobilità delle merci in Europa, Potenzialità del trasporto intermodale, Egea, Milano

Bagchus, R.C. and Kuipers, B., (1993), Autostrada del Mare. In: European Short Sea Shipping, Proceedings from the First European Research Round Table Conference on Short Sea Shipping, November 1992, London: Lloyds of London Press, pp. 52–65

Baumgartner, J.P., (2001), Price and costs in the railway sector, Litep, Ecole Polytechnique Federal de Lausanne

Baumol, W.J., Vinod, H.D., (1970), An Inventory Theoretic model of freight transport demand, Management Science, Vol. 16, N. 7, pp. 413-421

Beier, F.J., Frick, S.W., (1978), The limits of piggyback: light at the end of the tunnel, Transportation Journal, Vol. 18, N. 2, pp. 12–18

Belfirst database (Belgian Companies Database, University access)

Belgian Federal Science Policy Office, (2004), Integrated Freight Analysis within CiTies, (INFACT), Final report

Bergantino, A., Bolis, S., (2005), An adaptive conjoint analysis of freight service alternatives: evaluating the maritime option, Department of Economics, University of Bari, and IRE, Faculty of Economics, University of Lugano

Bergantino, A., Bolis, S., Canali, C., (2006), A methodological framework to analyze the market opportunities of short sea shipping: the Adaptive Stated Preference Approach, in B. Jourquin, P. Rietveld and K. Westin (eds.) Towards better performing European Transport Networks, Routledge, London, pp. 285-304

Beuthe, M., et al., (2002), External costs of the Belgian interurban freight traffic: a network analysis of their internalization, Transportation Research, Part D, Vol. 7, pp. 285-301

Beuthe, M., Bouffioux, C., (2005), Analyzing freight transport's qualitative attributes from orders of preference, in Bivec-Gibet Proceedings edited by Witlox,F., Dullaert, W., Vernimmen, B., pp. 133-151

Bickel, P., et al., (2005a), State-of the-art in project assessment, HEATCO (Developing Harmonised European Approaches for Transport Costing and Project Assessment) Deliverable 2. Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart. http://heatco.ier.uni-stuttgart.de/ hd2final.pdf

Bickel, P., Friedrich, R., (2005b), ExternE, Externalities of Energy, Methodology 2005 Update, ExternE Project, Institut für Energiewirtschaft und Rationelle Energieanwendung — IER, Universität Stuttgart, Germany, http://www.externe.info

Bickel et al., (2006), Introducing environmental externalities into transport pricing: measurement and implications, Transport Reviews, Vol. 26, N.4, pp. 389-415

Blauwens, G., Van De Voorde, E., (1988), The evaluation of time saving in commodity transport, International Journal of transport economics, pp. 77-87

Blauwens, G., De Baere, P., Van De Voorde, E., (2008), Transport Economics, Standaard Uitgeverij, Antwerp

Blauwens, G., Meersman, H., Sys, C., Van de Voorde, E., Vanelslander, T., (2010), Kilometerheffing in Vlaanderen, De impact op havenconcurrentie en logistiek, Steunpunt Goederenstromen, Antwerp

Boardman, B., Trusty, K., Malstrom, E., (1999), Intermodal Transportation Cost Analysis tables, Department of Industrial Engineering, University of Arkansas

Bogers, E., Henstra, D., (2003), Deliverable 4.1, State-of-the-art of Intermodal Freight Transport, Eutralog Project

Bolis, S., Maggi, R., (1999), Modelizzazione e Analisi Empirica della Domanda di Servizi Logistici e di Trasporto da parte delle Imprese, Tesi di Dottorato, Lugano

Bolis, S., and Maggi, R., (2003), Logistics strategy and transport service choices: an adaptive stated preference experiment, Growth and Change, Vol. 34, N.4, pp. 490-504

Bontekoning Y.M., et al., (2004), Is a new applied transportation research field emerging? A review of intermodal rail–truck freight transport literature, Transportation Research Part A, Vol. 38, pp.1-34

Borts, G. H., (1960), The estimation of Rail Cost Functions, Econometrica, Vol. 28, N. 1, pp. 108-31

Braekers, K. et al., (2009), Review on the comparison of external costs of intermodal transport and uni-modal road transport, Hasselt University

Bruzelius, N., (1981), Microeconomic theory and generalized cost, Transportation, Vol. 10, pp. 233-245

Bruzelius, N., (2001), The Valuation of Logistics Improvements in CBA of Transport Investments: A Survey. Report to the SAMGODS group, Swedish Institute for Transport and Communications Analysis (SIKA)

Buffa, F.P., Reynolds, J.I., (1977), The inventory-transport model with sensitivity analysis by indifference curves, Transportation Journal, Vol. 16, N. 3, pp. 83-90

Burg, H.B., Daley, J.M., (1985), Shallow draft water transportation: marketing implications of users and carrier attribute perceptions, Transportation Journal, pp. 56-67

Burns, L. D., et al., (1985), Distribution strategies that minimize transportation and inventory costs, Operations Research, Vol. 33, N. 3, pp. 469–490

Button, K., (2010), Transport Economics, Edward Elgar Publishing Ltd

Cantillo, V., Marquez, L., (2010), Modeling a strategic transport intercity freight network including external costs. A real application, WCTR Proceedings

Centro Studi Confetra, (1997), L’internalizzazione dei costi esterni, Quaderno n. 100

Clarke, M.A., et al., (2005), Integrated Services in the Intermodal Chain (ISIC), Ecorys Project

Cole, S., (2005), Applied transport economics, Kogan, London

CONFETRA, (2000), L’operatore multimodale (MTO) e l’operatore logistico (LO), Quaderno n. 88/2

Constable, G.K., Whybark, D.C., (1978,) The interaction of transportation and inventory decisions, Decision Sciences, Vol. 9, N. 4, pp. 688–699

Cullinane, K., Toy, N., (2000), Identify influential attributes in freight route/mode choice decision: a content analysis, Transportation Research E, Vol. 36, pp. 41-53

Cunningham, M.T., Kettlewood, K., (1975), The influence of the image of suppliers on buyer behavior in the freight transport market, International Journal of Physical Distribution and Logistics Management, Vol. 5, pp. 238-251

Cunningham, W., (1982), Freight Modal Choice and Competition in Transportation: A Critique and Categorization of Analysis Techniques, Transportation Journal, pp. 66-75

Danielis R., Rotaris, L., (1999), Analyzing freight transport demand using stated preference data: a survey, Trasporti Europei, Year V, N. 13, pp. 30-38

Danielis R., Rotaris, L., (2001), Rassegna critica delle stime e dei costi esterni dei trasporti, in ANFIA-ACI, “ I costi e i benefici esterni del trasporto”, Torino

Danielis, R. e Rotaris, L., (2002), “Shippers’ preferences for freight transport services: a conjoint analysis experiment for an Italian region”, Trasporti Europei, Year VII, N. 22, pp. 28-36

Danielis, R., Marcucci, E., Rotaris, L., (2005), Logistics managers’ stated preference for freight service attributes, Transportation Research, Part E, Vol. 41, pp. 201-215

Danielis, R., Marcucci, E., (2006), Trasporto stradale o intermodale ferroviario? I risultati di un'indagine sulla struttura delle preferenze di alcune aziende manifatturiere italiane, Working Paper n. 107, Università degli Studi di Trieste, Dipartimento di Scienze Economiche e Statistiche, Università degli Studi di Urbino, "Carlo Bo", Istituto di Scienze economiche

De Jong, et al., (2004a), New Values of Time and Reliability in Freight Transport in the Netherlands, Proceedings of the European Transport Conference

De Jong, et al., (2004b), The Value of Reliability, Proceedings of the European Transport Conference

De Jong et al., (2009), Preliminary Monetary Values for the Reliability of Travel Times in Freight Transport, EJTIR , Vol.9, N. 2, pp. 83-99

De Jong, et al., (2010), Price Sensitivity of European road freight transport – a review of elasticises, In: Applied Transport Economics – a management and policy perspective, E. Van de Voorde & Thierry Vanelslander (eds.), Antwerp, De Boeck

Domergue, P., Quinet, E., (2001), Situations and problems of railways industry in Europe, Japan Railway & Transport Review, www.jrtr.net

Dullaert, W., et al., (2005), An evolutionary algorithm for order splitting with multiple transport alternatives, Expert Systems with Applications, Vol. 28, pp. 201–208

Espo, (2010), Annual Report 2009-2010, Brussels

European Commission Council Directive, (1993), 93/89/EEC

European Commission, (1997), COM (97) 243 Final of 29/5/1997

European Parliament and European Council, (1999), Directive 1999/62/EC

European Commission, (2001), “European transport policy for 2010: time to decide”. White paper, Luxemburg

European Commission, (2003), “Programme for the promotion of Short Sea Shipping”. COM (2003), 155 final, April 7. Brussels

European Commission, Directive 2004/52/EC

European Commission, (2005), Externalities of Energy, ExternE Project, Methodology Update 2005

European Commission, (2006a), “Mid-Term review of the Programme for the promotion of Short Sea Shipping”. COM (2006), 380 final, July 13, Brussels

European Commission, (2006b), “Keep Europe moving, Mid-Term review of the European Commission’2001 Transport White Paper”. COM (2006), Brussels

European Commission, Directive 2006/38/EC of the European Parliament and of the Council of 17 May 2006 amending Directive 1999/62/EC

European Commission, (2008), Greening Transport Package

European Commission, (2010), Impact of proposal for amending directive 1999/62/EC on road infrastructure charging

European Commission, (2011), New White Paper: “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system”

European Commission: Motorways of the Sea Programme, http://ec.europa.eu/transport/maritime/motorways_sea/preparing_en.htm

European Commission: COST, European Cooperation in the Field of Scientific and Technical Research

European Commission: Marco Polo II, European Programme on intermodal transport, http://ec.europa.eu/transport/marcopolo/ù

European Commission: PACT, European Pilot Action for Combined Transport, http://ec.europa.eu/research/health/medical-research/cardiovascular-diseases/projects/eu-pact_en.html

European Commission, DGXII, Science, Research and Development. Office for Official Publications of the European Communities, Luxemburg

European Parliament, (2006), (CE) n. 561/2006

Eurostat, (2002), EU Intermodal Freight Transport, Key statistical Data 1992-1999, 2002 Edition, Luxembourg

Eurostat, (2009), Panorama of Transport, 2009 Edition, Luxembourg, ISBN 978-92-79-11119-8, ISSN 1831-3280, doi 10.2785/28475, Cat. No. KS-DA-09-001-EN-N

Eurostat, (2009a), Total population resident in a region. Average of population at the beginning of the year and population at the end of the year

Eurostat, (2009b), Total population divided by the surface area. For calculation of population density, the land area concept

Eurostat, (2009c), GDP (gross domestic product) is an indicator of the output of a country or a region

Evers, P.T., Harper, D.V., Needham, P.M., (1996), The determinants of shipper perceptions of modes, Transportation Journal, pp. 13-25

Ferrari, C., Parola, F., Gattorna, E., (2001), Measuring the quality of port hinterland accessibility: The Ligurian case, Transport Policy, Vol. 18, pp. 382–391

Fod Economie algemene directie statistiek en economische informatie, (2008), Vervoor Binnenscheepvaart, Vervoor Binnenscheepvaart, Brussels, http://statbel.fgov.be/

Fod Economie algemene directie statistiek en economische informatie, (2010), Goederenvervoer over de weg door Belgische voertuigen met minstens een ton laadvermogen in 2009, Brussels, http://statbel.fgov.be/

Forkenbrock, D.J., (2001), Comparison of external costs of rail and truck freight transportation, Transportation Research A, Vol. 35, pp. 321-337

Fowkes, A.S., Nash, C.A., Tweddle, G., Whiteing, A.E., (1987), Forecasting freight modal choice, focus on physical distribution and logistics management, Vo. 6, N. 7, pp. 8-20

Fowkes, A.S., Nash, C.A., Tweddle, G., (1991), Investigating the market for inter-modal freight technologies, Transportation Research A, Vol. 25, N. 4, pp. 161–172

Fridell et al., (2009), A tool for calculating external costs associated with transportation of goods, Swedish environmental research institute (IVL) for CPM – Centre for Environmental Assessment of Product and Material Systems CHALMERS UNIVERSITY OF TECHNOLOGY, Sweden

Gentile, F., (1994), La Compatibilità del trasporto combinato ed intermodale strada rotaia con i sistemi logistici industriali, Università degli Studi di Napoli Federico II, Dipartimento di Scienze Economiche e Sociali

Gibson, B.J., et al., (1993), Shipper carrier relationships and carrier selection criteria, Logistics and Transportation Review, Vol. 33, N.1, pp. 67-72

Gilmour, P., (1976), Some policy implications of subjective factors in the modal choice for freight movements, Logistics and Transportation Review, Vol. 12, N.1, pp. 39-56

Gonçalves, B.S., D'Agosto, M., (2010), Intermodal decision making in Brasil, 12 WCTR Proceedings

Gray, A., (1987a), The generalized cost dilemma, Transportation, Vol. 7, pp. 261-280

Gray, A., (1987b), Has generalized cost any benefit? Transportation, Vol. 7, pp. 417-422

Gray, R., (1982), Behavioral approaches to freight transport modal choice, Transport Reviews, Vol. 2, N.2, pp. 161-184

Hamer, R., De Jong, G., Kroes, E., (2005), The value of reliability in Transport, Provisional values for The Netherlands based on expert opinion, Rand Europe

Hoon Oum T., (1979), Derived Demand for Freight Transport and Inter-Modal Competition in Canada, Journal of Transport Economics and Policy, Vol. 13, No. 2, pp. 149-168

Hoon Oum T., and Walters II, W. G., (1996), A Survey of Recent Developments in Transportation Cost Function Research, Logistics and Transportations Review, Vol. 32, N. 4

INFRAS and IWW, University of Karlsruhe, (2000/2008), External costs of transport – Accident, environmental and congestion costs in Western Europe, Zürich/Karlsruhe

IQ ''Intermodal Quality'' Project, (1997), Final Report, Research Project of the 4th Framework Programme on Research and Development of the European Commission

Italian Customs Offices, direct contacts

ITS, University of Leeds, (2000), Unification of accounts and marginal costs for Transport Efficiency, Unite, Final Report

Janic, M., Bontekoning, Y., (2002), Intermodal Freight Transport in Europe: an Overview and Prospective Research Agenda, Paper prepared for STELLA Focus Group 1: "Globalisation, E-Economy and Trade"

Janic, M., (2007), Modeling the full costs of an intermodal and road freight transport network, Transportation Research, Part D, Vol. 12, pp. 33–44

Jeffs, V., Hills, P., (1990), Determinants of modal choice in freight transport, a case study, Transportation, Vol.17, N. 1, pp. 29-47

Katz M. L., Rosen H., S. Bolino C. A.,(2007), Microeconomia, McGraw-Hill Companies

Kim, N. S., (2010), Intermodal freight transport on the right track? Environmental and economic performances and their trade-off, PhD Thesis, Trail Research School, The Netherlands

Kleist, L., Doll, C., (2005), Economic and Environmental Impacts of Road Tolls for HGVs in Europe, In J. M. Viegas (Ed.), Interurban Road Charging for Trucks in Europe, Research in Transportation Economics, Vol. 11, Elsevier Ltd

Kofteci, S., Ergun, M., and Ay, Serpil, (2010), Modeling freight transportation preferences: Conjoint analysis for Turkish Region, Scientific Research and Essays Vol. 5, N. 15, pp. 2016–2021

Kouwenhoven, M., Schoemakers, A., Van GROL, R. and KROES, E., (2005), Development of a tool to assess the reliability of Dutch road networks, Proceedings of the European Transport Conference

Kumar at al., (2004), Modelling generalized costs of travel for rural bus users: A case study, Journal of public transportation, Vol. 7, N. 2, pp. 59-72

Kveiborg, O., (2005). A comparison of economic impacts from pricing schemes on heavy vehicles in Transport, Proceedings of the15th International Input-Output Conference, Beijing, China

Lambert, D.M., Lewis, M.C., Stock, J.R., (1993), How shippers select and evaluate general commodities ltl motor carriers, Journal of business logistics, Vol. 14, N. 1, pp. 131-143

Langley, C. J., (1980), The inclusion of transportation costs in inventory models: some considerations, Journal of Business Logistics, Vol.2, N.1, pp. 106–125

Lardner, D., (1968), Railway Economy: A Treatise on the New Art of Transport, Its Management, Prospects and Relations, A.M. Kelley (reprint), New York

Liberatore, M. J., (1979), A model of freight transport selection, Transportation Journal, Vol. 18, N. 4, pp. 92–100

Link, H., et al., (2008), Deliverable D5, Monitoring Pricing Policy Using Transport Accounts, Grace Project

Lobé, P., (1988), Computation of a perception index in intermodal transport, Stratec s.a., PTRC Proceedings, Belgium

LOGIQ Project, (2000) ‘‘Intermodal Decision: The Decision-Making Process in Intermodal Transport’’, Final report, Research Project of the4th Framework Programme on Research and Development of the European Commission

Lowe, D., (2005), Intermodal Freight Transport, Elsevier, Oxford

Macharis, C., Verbeke, A., (1999), Intermodaal Vervoer, Leuven, Garant

Macharis, C, Pekin E, Peeters, A., van Lier, T. Vrenken, H. and Vaghi, C., (2008a) Tralotra Deliverable: Transport Policies

Macharis. C., Pekin, E., Caris, A., Jourquin, B., (2008b), A decision support system for intermodal transport policy, Vubpress, Brussels

Maibach, M., et al., (2008), Handbook on estimation of external costs in the transport sector, IMPACT Project, Delft

Maier, G., Bergman, E.M., Lehner, P., (2002), Modelling preferences and stability among transport alternatives, Transportation Research Part E, Vol. 38, pp. 319–334

Makitalo, M., (2011), Why Do Open Rail Freight Markets Fail to Attract competition? Analysis on Finnish Transport Policy, EJTIR Vol. 11, N. 1, pp. 1-19

Marchese, U., (2001), Lineamenti e Problemi di Economia dei Trasporti, ECIG, Genova

Marchese, U., Musso, E., Ferrari, C., (1998), The role for ports in intermodal transports and global competition: a survey of Italian container terminals, in H. Meersman, E. Van de

Voorde, W. Winkelmans (eds.), Transport Modes and Systems. Vol. 1, Amsterdam, Pergamon, pp. 141-154

Marcucci, E. and Scaccia, L., (2004), Mode choice models with attribute cut offs analysis: the case of freight transport in the Marche region, Trasporti Europei, Vol. 25/26, pp.21-32

Matear, S., Gray, R., (1993), Factors Influencing Freight Service Choice for Shippers and Freight Suppliers, International Journal of Physical Distribution & Logistics Management, Vol. 23, N. 2, pp. 25-36

McGinnis, M.A., (1979), Shipper attitudes towards freight transportation choice: a factor analytic study, International Journal of Physical distribution and logistics management, Vol. 10, N.1, pp. 25-34

McGinnis, M.A., (1989), A comparative evaluation of freight transportation choice models, Transportation Journal, pp. 36-46

McGinnis, M.A., (1990), The relative importance of cost and services in freight transportation choice: before and after deregulation, Transportation Journal, pp. 12-19

Meersman H., Van de Voorde, E., Vanelslander, T., (2002), Port Competition and generalized cost: considerations on the impact of capacity utilization and productivity, in Notteboom, T., Current issue in port logistics and intermodality, Garant, Antwerp, pp. 39-54

Meersman H., Van de Voorde, E., Vanelslander, T., Verberght, E., (2009/2010), Indicatorenboek duurzaam goederenvervoer Vlaanderen 2009 Antwerpen: UA, Departement Transport en Ruimtelijke Economie, Steunpunt Goederenstromen

Mettle Group, et al., (2003), State of the art of Intermodal Freight Transport, Deliverable 4.1, Eutralog Project

Meyer, J. R., Peck, M. J., Stensson, J., and Zwick, C., (1959), The Economics of Competition in the Transportation Industry, Harvard Univ. Press

Midoro, R., (1997), Le strategie degli operatori trasportistici globali, ECIG, Genova

Mint Consultant, KP Transport Consultant, (2009), Vlaams vrachtmodel, technical note, (Confidential)

Misschaert, M., Vannieuwenhuyse, B., De Munck, L., Naesens, K., (2006), Een kostenstructuur voor overslag op intermodale terminals, Vil, Brussels

Murphy, P.R. et al, (1991), Selecting Links and Nodes in International Transportation: An Intermediary's Perspective, Transportation Journal, pp. 33-40

Murphy, P., Hall, P., (1995), The relative importance of cost and service in freight transportation choice before and after deregulation: an update, Transportation research E, Vol. 36, pp. 41-53

Murphy, P.R., Daley, J.M., Hall, P.K., (1997), Carrier selection: do shippers and carriers agree, or not? Transportation Research E, Vol. 33, N. 1, pp. 67-72

Musso, E., (1990), Elementi economici per una teoria del decentramento portuale, Bozzi, Genova

Musso, E., Parola, F., (2007), Mediterranean ports in the global network: how to make the hub and spoke paradigm sustainable?. In: Wang, J., Olivier, D., Notteboom, T., Slack, B. (Eds.), Ports, Cities, and Global Supply Chains. Ashgate, London, pp. 89–104

Nash C. et al, (2008), Grace Project, Generalisation of Research on Accounts and Cost Estimation: policy conclusions, www.grace-eu.int

NEA Consulting Group, (2003), Onderzoek costen per huur in de binnenvaart, NEA, Rijswijk

NEA consulting group, (2010/2011), Cost calculations for road freight transport

Notteboom, T., (2007), Inland water way transport of containerised cargo: from infancy to a fully-fledged transport mode, Journal of Maritime Research, Vol. IV, N. 2, pp. 63-80

OECD, (2009), OECD in Figures 2009, Paris

Odgaard, T., Kelly, C.E. and Laird, J.J., (2005), Current practice in project appraisal in Europe – Analysis of country reports. HEATCO Work Package 3. HEATCO – Developing Harmonised European Approaches for Transport Costing and Project Assessment. Funded by the 6th Framework RTD Programme, IER Stuttgart, Germany

Pauwels, T., (2000), Extension of cost calculations for road, rail and inland waterways made by the Author in the framework of the research project: “Towards a sustainable mobility: economic and regional effects of a growing freight transport”, for DWTC – Belgian Science Policy – 1997-2001

Pauwels, T., (2007), PhD Thesis, MODELLERING VAN HET GOEDERENVERVOER IN BELGIE, Analyse van de vervoerwijzekeuze, het transitvervoer en de relatie met de economie

Pigou, A.C., (1932), The Economics of Welfare. MacMillan, 4th edition, London

Pindyck,R., Rubinfield, D., (2008), Microeconomics 7th edition, Prentice Hall, New Jersey

PLANCO Consulting GmbH, (2007), Wasser und Schifffahrtsverwaltung des bundes

Plunkett, W.M., Taylor, G.D., English, J.R., (1998), Intermodal profitability analysis in the truckload and less than truck load industries. Arkansas University, Fayetville

Puliafito, P., et al., (2008), Piano Regionale della Logistica della Regione Liguria,Cieli, Università di Genova

REALISE Project, (2005), Regional Action for Logistical Integration of Shipping across Europe, Growth programme, European Commission

Regan, A., Garrido, R., (2002), Modeling freight demand and shipper behavior: state of the art, future directions, Institute of transportation studies, University of California, Irvine

Ribus, L., (2007), Totale logistieke kosten in multimodal goederenvervoer, Universty of Hasselt

Rotaris, L., et al., (2010), The urban road pricing scheme to curb pollution in Milan, Italy: Description, impacts and preliminary cost–benefit analysis assessment, Transportation Research Part A, Vol. 44, pp. 359–375

Rudel, R., (2005), Evaluation of quality attributes in freight transport market. Stated preference experiments in Switzerland, European Transport, Vol. 25-26, pp. 52-60

Schmidt, S., (2006), The road transport report n.1, DG TREN E1, European Unit

Schreyer, C., Maibach, M., Guyer, M., (2008), Update external costs of transport 2005 for EU27 feasibility study, INFRAS, Zurich

Sheffi, Y., Eskandari, B., Koutsopoulos, H., (1988), Transportation mode choice based on total logistic costs, Journal of Business Logistics, Vol. 9, N.2

Shinghal, N., Fowkes, T., (2002), Freight mode choice and adaptive stated preferences, Transportation Research, Part E, Vol. 38, pp. 367–378

Spady, R. H., Friedlander, A. F., (1978), Hedonic cost functions for the regulated trucking industry, The Bell Journal of Economics, Vol. 9, N.1

Stock, J.R. and La Londe, B., (1977), The transportation mode decision revisited, Transportation Journal, pp. 51-59

TLN planner (version 2010), http://www.tlnplanner.nl/

Treaties of Rome, (1957)

Tsamboulas, D.A., Kapros, S., (2000), Decision-making process in intermodal transportation. Transportation Research Record 1707, pp. 86–93

Tweddle, G., Fowkes, A. S., Nash, C. A., (1996), Impact of the channel tunnel: a survey of anglo -European unitized freight, Working Paper 474

UNCTAD/CCI, (1992), Rules for Multimodal Transport Documents

UN/ECE, ECMT, EC, UN, (2001), Terminology on Combined Transport, New York and Geneva

United Nations, Convention on Multimodal Transport of Goods, Geneva, 1980

UNITE Transport User Cost and Benefit Case Studies, D7 European project

UIRR, (2009), International Union of combined Road-Rail transport companies, Statistics 2008

Valleri M.A., Van de Voorde E., (1993), The competitive position of Mediterranean ports, I trasporti in Europa: ambiente, competitività ed occupazione, Valleri, M. A., Edit. Bari, Puglia Grafica Sud

Valleri M.A., Van de Voorde E., (1996), Port productivity: what do we know about it? L'industria portuale: per uno sviluppo sostenibile dei porti, Valleri, Marisa A. Edit. Bari, Cacucci Editore, pp. 125-141

Vandaele, E., Witlox, F. and Verleye, G., (2004), 'The Use of Correlation Analysis to Explain the Monetary Value of Quality Attributes of Transportation', Proceedings of the European Transport Conference

Vannieuwenhuyse, B., Gelders, L., Pintelon, L., (2003), An online decision support for transportation mode choice, Logistics information management , Vol. 16, N.2, pp. 125-133

Van Schijndel, W.J., Dinwoodie, J., (2000), Congestion and multimodal transport: a survey of cargo transport operators in the Netherlands, Transport Policy, Vol. 7, pp. 231–241

Vernimmen, B., Dullaert, W., Willem, P., Witlox, F., (2008), Using the inventory-theoretic framework to determine cost-minimizing supply strategies in a stochastic setting, Int. J. Production Economics, 115, pp. 248– 259

VIL, (2006), Totale logistieke kosts beslissingsondersteunend bij de bepaling van de optimale modal split

Vlaamse Belastingdienst (2011), Tarieven van de verkeersbelasting en eurovignet voor vrachtwagens. Geraadpleegd op 30/3/2011, http://www.onroerendevoorheffing.be/nlapps/docs/default.asp?id=350

Vrenken, H., Macharis, C., Wolters, P., (2005), Intermodal Transport in Europe, EIA, Hubb Vrenken, Brussels

Weinreich, S. et al., (2000), Real cost reduction of door-to-door intermodal transport (Recordit)", Deliverable 1: Accounting framework for the analysis of the cost structure of door-to-door intermodal freight transport services

Winston, C. (1981), A disaggregated model of the demand for intercity freight transportation Econometrica Vol.49, N.4, pp. 981-1006

Zhang, M., et al., (2011), The impact of CO2 pricing or biodiesel on container transport in and passing through The Netherlands, Econship Conference Proceedings

Zotti, J. e Danielis, R., (2003-4), Freight Transport Demand in the mechanical Sector of Friuli Venezia Giulia: The choice between intermodal and road transport", Trasporti Europei, N. 25-26, pp. 9-20

Consulted websites:

http://www.bancaditalia.it/

http://www.containerafvaarten.be/

http://ec.europa.eu/transport/

http://it.mappy.com/

http://www.interferryboats.be/

http://www.istat.it/it/

http://www.nbb.be/

http://www.portofantwerp.com/

http://www.porto.genova.it/

http://www.portofrotterdam.com/

www.railneteurope.com

Railways Departures List

http://www.routes.tomtom.com/t/#/

http://statbel.fgov.be/

http://www.uirr.com/

http://www.viamichelin.it/

ANNEX 1.1

POLICY AND REGULATORY FRAMEWORK OF THE EUROPEAN INTERMODAL TRANSPORT POLICY

Year/Reference	Title
1992/COM(92)494	White Paper on the future of the common Transport Policy
1992/92/106/EEC	Council Directive on the establishment of common rules for certain types of combined transport of goods between Member States
1992/93/45/EEC	Commission Decision concerning the granting of financial support for pilot schemes to promote combined transport
1997/COM(97)243	Communication on intermodality and intermodal freight transport in the EU
1995/COM(95)691	Green Paper on fair and efficient pricing
1996/COM(96)421	White Paper A strategy for revitalizing the community's railways
1996/1692/96	Community guidelines for the development of the Trans-European Transport Network
1997/COM(97)678	Green Paper on Port Infrastructure
1998/COM(98)466	White Paper on fair payment of infrastructure use
1998/2196/98	Council Regulation concerning the granting of common financial assistance for actions of an innovative nature to promote combined transport
2001/COM(2003)370	White Paper: European Transport Policy for 2010: time to decide
2003/COM(2004)56	Commission proposal for a directive on intermodal loading units
2006/COM(2006)314	Communication on the mid-term review of the European Commission's 2001 Transport White Paper
2007/COM(2007)607	Communication on the freight transport logistics action plan
2008/COM(2008)433	Communication on the greening transport
2011/COM(2011)144 final	WHITE PAPER: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system

Source: Macharis. C. et al., 2008 and additional sources

ANNEX 1.2

SELECTED EUROPEAN PROJECTS ON INTERMODAL FREIGHT TRANSPORT

Project acronym	Research subject
4 th Framework Programme (1994-1998)	
CESAR	Improvement of intermodal transport performance and quality by an appropriate information system.
IMPREND	Improvement of pre- and end-haulage at terminals, achieved by defining and testing a number of formulae on how to do that.
IQ	Analysis of the quality aspects influencing intermodal transport at both intermodal terminals and networks with the aim to improve interoperability, interconnectivity and accessibility of intermodal terminals.
LOGIQ	Identification of actors in the decision making process and provision of information on criteria and constraints employed by them for using intermodal transport.
PRECISE-IT	Optimisation of intermodal operations, particularly addressing those operational problems that can be put in relation to the position of ITUs and/or vehicles at the terminal.
ROLLING SHELF	Improving intermodal transport operations for palletised goods and parcels over short distances.
SCANDINET	Improving access to infrastructure, information and markets for intermodal transport services.
X-MODALL	Offering a fully integrated, practical, low-cost and low resource solution to radically improve intermodal freight flows in terms of time, reliability, performance and costs.
TERMINET	Identification of promising innovative directions for bundling networks new generation terminals and terminal nodes for combined and intermodal transport in Europe.
5 th Framework Programme (1998-2002)	
EUTP II	Dissemination of the existing knowledge related to the intermodal freight transfer points in the EU at both national (member states) and international (EU) levels with the purpose to provide a better co-ordination of R&D activities.
CESAR II	Identification, analysis and implementation of a pilot version of the Internet-based system, which will provide exchanging

	the information between particular actors involved in the intermodal transport chains.
SULOGTRA	Working out the different drivers of the transformation process of supply chains, and analysis of the relationship between supply chain trends and freight transport operations.
IP	Improvement of the integration of ports into intermodal transport chains, which is expected to be achieved by harmonising administrative procedures and by offering a set of information and communication (ICT) tools and services, which would facilitate exchanging of data between the partners involved in transport chains.
BEST UFS	Dissemination of the best European practice, success criteria, and bottlenecks in moving the goods in urban areas. The project is expected to contribute to integration of the urban collection and delivery services into 'door-to-door' transport and logistics chains.
THEMIS	Integration of 'Traffic Management Systems' with 'Intermodal Freight Information Systems' by disseminating activities, project clustering activities, and the experts' workshops.
RAILSERV	Revitalisation of rail transport through investigation and development of measures that will enhance rail's competitiveness in the European freight transport market;
RECORDIT	Improving the competitiveness of intermodal freight transport in Europe through the reduction of cost and price barriers, which currently hinder its development, while respecting the principle of sustainable mobility.
6 th Framework Programme (2002-2006)	
BRAVO	Project related to the implementation of intermodal volume on the Brenner corridor.
CREAM	Analyse the operational and logistics prerequisites for developing, setting up and demonstrating seamless rail freight and intermodal rail/road and rail/short sea/road services on the Trans-European mega corridor between the Benelux and Turkey.
CREATING	Stimulating waterborne transport in an economical way, by giving new impulses to inland navigation. Whereas the hinterland transport of maritime cargo such as maritime containers already takes place via inland waterways to a large extent, continental cargo is almost completely transported by rod.
FREIGHTWISE	Support the co-operation of transport management, traffic and infrastructure management and administration sectors in order to develop and demonstrate suitable intermodal transport solutions in a range of business cases.

PROMIT	Contribute to a faster improvement and implementation of intermodal freight transport technologies and procedures, and to help promoting innovative intermodal freight transport and modal shift by creating awareness on innovations, best practise and intermodal transport opportunities for potential users as well as politicians and research community.
7 th Framework Programme (2007-2013)	
PROPS	The project builds on previous EU and national activities undertaken to promote and develop short sea shipping. In particular, the aims is to work closely with the Short Sea Promotion Centres (SPCs) to develop a workable and replicable methodology that will enhance their practical promotion activities in the fields of legislative, technical, and operational actions and to extend their operations to encompass inter-modal and co-modal transport.
SMARTCM	Advanced technology implementation and research in order to overhaul the complete container door-to-door transport chain so that it is more efficient, secure, market driven, and competitive.
TELLIBOX	'Intelligent MegaSwapBoxes for Advanced Intermodal Freight Transport as an all-purpose loading unit will actively promote the EU's objectives of achieving intermodal integration and operational optimization.
EIRAC II	The project will stimulate the main public stakeholders and market players in the Intermodal and Logistics domain to invest into research;
KOMODA	KOMODA's objective is to produce a roadmap, with associated action plans, to nurture an integrated e-Logistics platform by and between modes of freight transport across Europe. Such platform must comply with a series of basic requirements: has to be based in open standards, usable by any concern, able to communicate freely between existing applications and allow the integration of legacy systems and future development.
INTEGRITY	The project will reconcile some challenges, as logistics efficiency and security, and link the elements of the supply chain through accurate, reliable, timely, value adding tracking and status data thus enhancing trade facilitation through the use of high quality, neutral, sophisticated equipment, including scanning equipment in ocean ports, whilst remaining accessible to all eligible stakeholders, large and small. INTEGRITY will develop procedures and technologies allowing for supply chain visibility, security and predictability.

Source: Janic, M., Bontekoning, Y., 2002 and additional sources based on intermodal transport topic and related ones

ANNEX 3.1

QUESTIONNAIRE

PART 1 – GENERAL INFORMATION

General Information on the Respondent

Name of the company:____

Address: ____

Country: ____

Website: ____

Name of the interviewee: ____

Position / Department: ____

Telephone: ____

e-mail address: ____

Nature of activity / Sector:

- ❒ Manufacturer (please, specify your main sector of activity):

____

- ❒ Freight forwarder
- ❒ MTO (global operator)
- ❒ Maritime Agency
- ❒ NVOCC
- ❒ Logistic company

Size:

Number of employees_________________

Annual sales _________________________

Logistics & Transport Practices

MARKET

Main Market

Please indicate the percentage of total transport:

Market	Export Flows	
	Road Only	Intermodal Service
Domestic	%	%
European	%	%
International/Overseas	%	%

Market	Import Flows	
	Road Only	Intermodal Service
Domestic	%	%
European	%	%
International/Overseas	%	%

Which are the main areas of origin/destination of your goods:

- ❒ North Italy .....%
- ❒ Centre Italy .....%
- ❒ South Italy .....%
- ❒ Switzerland .....%
- ❒ Germany .....%
- ❒ Austria .....%
- ❒ France .....%
- ❒ Spain .....%
- ❒ Belgium .....%
- ❒ The Netherlands .....%
- ❒ UK .....%
- ❒ Other .....%

Types of loading units and share of total transport

In cases where inbound and outbound logistics present very different structures (e.g. manufacturing companies), the focus should be on Outbound Logistics.

Cargo Type		Share of Total Transport
	Loading unit	%
Containerised	20 feet	%
	40 feet	%
	45 feet	%
	Flat rack	%
	Other:……………………..	%
RO-RO	Swap-body	%
	Trailer unit	%
General cargo		%
Liquid bulk		%
Dry bulk		%

Comments: ____

Transport modes used and share of total transport:

In cases where inbound and outbound logistics present very different structures (e.g. manufacturing companies), the focus should be on Outbound Logistics.

		Share of Total Transport	Cargo Type			
			Containerised	Liquid Bulk	Dry Bulk	General cargo
Transport Mode	Rail	%	%	%	%	%
	Road	%	%	%	%	%
	Inland Waterway	%	%	%	%	%
	Sea	%	%	%	%	%
	Air	%	%	%	%	%

Comments:
____

Intermodality:

Door to Door transportation chains and current modal split.

	Point of origin to intermodal terminal	Intermodal terminal to intermodal terminal	Intermodal terminal to point of destination	Percentage (%)
	Road only			…..%
Combination 1	Road Rail Inland waterway Sea Air	Rail Inland waterway Sea Air	Road Rail Inland waterway Sea Air	…..%
Combination 2	Road Rail Inland waterway Sea Air	Rail Inland waterway Sea Air	Road Rail Inland waterway Sea Air	…..%
Other Combination				…..%
				Total: 100%

Comments:
____

Distance from point of origin to Rail terminal, inland port, seaport or airport.

	The nearest:	The currently used:
Rail Terminal		
Inland Port		
Sea Port		
Airport		

Organisation of Logistics

In-house activities vs. Outsourcing.

Logistics Activities	Carried out by the company		Outsourced	
Inbound Logistics	❒	%	❒	%
Warehousing	❒	%	❒	%
Outbound Logistics	❒	%	❒	%
Physical Transport	❒	%	❒	%

Owned Transportation Assets.

Transportation Assets		Quantity
Mean of Transport		
Trucks	❒	
Barges	❒	
Sea going vessels	❒	
Locomotives	❒	
Cargo containment units		
Containers (Euro/Iso)	❒	
Trailers	❒	
Swap Bodies	❒	
Railway wagons	❒	

Transport Decision:

In cases where inbound and outbound logistics present very different structures (e.g. manufacturing companies), the focus should be on Outbound Logistics.

	Sender / Consignor	Receiver / Consignee	Freight Forwarder Logistics Operator
Who decides on the transportation solution?	❐	❐	❐
Who selects the logistics/transport providers?	❐	❐	❐

Comments:
____

Logistics Strategy

What are the main criteria for choosing this logistics structure?

____

How are you incorporating environmental issues in logistics policy / practices? Are environmental concerns taken into consideration when adopting a given logistics network?

____
____

Selection and evaluation of transport services and modes

Rating: from *not important at all* (1) to *very important* (5)

List of Criteria	Definition	Rating scale 1	2	3	4	5
RELIABILITY	Certainty of meeting the established time window	❒	❒	❒	❒	❒
FLEXIBILITY	Minimum notice time for transport order (No. of week/days/hrs before departure or delivery)	❒	❒	❒	❒	❒
RISK OF LOSS/DAMAGE	Probability of Loss / Damage by shipment	❒	❒	❒	❒	❒
FREQUENCY	General Frequency of the Transport Service	❒	❒	❒	❒	❒
COST	Price (Total costs) per shipment	❒	❒	❒	❒	❒
D2D TOTAL TRANSPORT TIME	D2D total transport time, including waiting and transhipment time	❒	❒	❒	❒	❒
CUSTOMER SERVICE	Effectiveness and efficiency of Service (Track & Trace / Customer relationship)	❒	❒	❒	❒	❒
ENVIRONMENTAL IMPACT	CO_2 emissions	❒	❒	❒	❒	❒

Particular notes:

____

____

____

Perceived quality of road transport and Short Sea Shipping

Perceived Performance of Road Transport and Intermodal transport for each evaluation criteria.

Rating: from 1 (*very bad)* to 5 (*very good)*

		Road (only) Transport					Intermodal Transport				
List of Criteria	Definition	1	2	3	4	5	1	2	3	4	5
RELIABILITY	Certainty of meeting the established time window)	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
FLEXIBILITY	Minimum notice time for transport order (No. of week/days/hrs before departure or delivery)	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
RISK OF LOSS/DAMAGE	Probability of Loss / Damage by shipment	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
FREQUENCY	General Frequency of the Transport Service	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
COST	Price (Total costs) per shipment	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
D2D TOTAL TRANSPORT TIME	D2D total transport time, including waiting and transhipment time	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
CUSTOMER SERVICE	Effectiveness and efficiency of Service (Track & Trace / Customer relationship)	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒
ENVIRONMENTAL IMPACT	CO2 emissions	❒	❒	❒	❒	❒	❒	❒	❒	❒	❒

Particular notes:

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Further Comments or Notes

ANNEX 5.1

SENSITIVITY ANALYSIS

Sensitivity Antwerp-Basel for road transport/fuel

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	20408,08	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	22162	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	23915,92	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24705,184	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24880,576	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	25669,84	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	27423,76	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	29177,68	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for road transport/wage

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	22.832,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	23.616,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.400,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.753,68	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.832,08	

IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	25.184,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	25.968,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	26.752,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for road transport/tolls

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	23532,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24036,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24540,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24767,68	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24818,08	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	25044,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	25548,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	26052,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for rail transport/track

	AVE		
Rail	20.221,00	17535,68	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	18612,68	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	19689,68	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20163,56	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20221	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20278,44	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	

road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20766,68	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	21843,68	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	22920,68	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for rail transport/energy

	AVE		
Rail	20.221,00	18138,8	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	18971,68	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	19804,56	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20179,356	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20221	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20262,644	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20637,44	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	21470,32	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	22303,2	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for rail transport/leasing

	AVE		
Rail	20.221,00	17783,5	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	18758,5	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	19733,5	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE	20172,4	
Rail	20.221,00	20172,4	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20221	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20269,9	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20708,5	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	21683,5	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	22658,5	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for iww transport/wage

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	22.891,76	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	24.210,56	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	25.529,36	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.121,56	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.255,96	

road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.848,16	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	28.166,96	
road-iww	29.147,50	29.147,50	

	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	29.485,76	
road-iww	29.147,50	29.147,50	

Sensitivity Antwerp-Basel for iww transport/fuel

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	23.296,26	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	24.408,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	25.632,51	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.077,51	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.300,01	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.745,01	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	27.968,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	29.192,51	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for iww transport/leasing

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	21.568,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	23.416,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	25.264,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.096,36	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.281,16	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	27.112,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	28.960,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	30.808,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for road-rail transport (road part)/fuel

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22086,4	
Road	24.792,88	20408,08	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.198,88	
Road	24.792,88	22162	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.311,36	
Road	24.792,88	23915,92	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.361,98	
Road	24.792,88	24705,184	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.367,60	
Road	24.792,88	24792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.373,22	
Road	24.792,88	24880,576	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.423,84	
Road	24.792,88	25669,84	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.536,32	
Road	24.792,88	27423,76	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.648,80	
Road	24.792,88	29177,68	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for road-rail transport (road part)/wage

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.098,85	
Road	24.792,88	22.832,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.210,85	
Road	24.792,88	23.616,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.322,85	
Road	24.792,88	24.400,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.373,25	
Road	24.792,88	24.753,68	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.384,45	
Road	24.792,88	24.832,08	
IWW	26.188,76	26.188,76	

road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.434,85	
Road	24.792,88	25.184,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.546,85	
Road	24.792,88	25.968,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.658,85	
Road	24.792,88	26.752,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for road-rail transport (road part)/tool

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	21.838,85	
Road	24.792,88	23532,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.054,85	
Road	24.792,88	24036,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.270,85	
Road	24.792,88	24540,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.366,85	
Road	24.792,88	24767,68	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24792,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.389,65	
Road	24.792,88	24818,08	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.486,85	
Road	24.792,88	25044,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.702,85	
Road	24.792,88	25548,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.918,85	
Road	24.792,88	26052,88	
IWW	26.188,76	26.188,76	
road-iww	27.369,61	27.369,61	

Sensitivity Antwerp-Basel for road-iww transport (iww part)/wage

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	22.891,76	
road-iww	29.147,50	25.861,10	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	24.210,56	
road-iww	29.147,50	27.167,34	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	25.529,36	
road-iww	29.147,50	28.473,58	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.121,56	
road-iww	29.147,50	29.060,14	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	29.147,50	29.147,50	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	

IWW	26.188,76	26.255,96	
road-iww	29.147,50	29.193,26	
	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.848,16	
road-iww	29.147,50	29.779,82	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	28.166,96	
road-iww	29.147,50	31.086,06	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	29.485,76	
road-iww	29.147,50	32.392,30	

Sensitivity Antwerp-Basel for road-iww transport (iww part)/fuel

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	23.296,26	
road-iww	29.147,50	26.385,00	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	24.408,76	
road-iww	29.147,50	27.447,50	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	25.632,51	
road-iww	29.147,50	28.616,25	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.077,51	
road-iww	29.147,50	29.041,25	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	29.147,50	29.147,50	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.300,01	
road-iww	29.147,50	29.253,75	

	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.745,01	
road-iww	29.147,50	29.678,75	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	27.968,76	
road-iww	29.147,50	30.847,50	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	29.192,51	
road-iww	29.147,50	32.016,25	

Sensitivity Antwerp-Basel for road-iww transport (iww part)/leasing

	AVE		
Rail	20.221,00	20.221,00	-50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	21.568,76	
road-iww	29.147,50	24.571,50	
	AVE		
Rail	20.221,00	20.221,00	-30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	23.416,76	
road-iww	29.147,50	26.401,90	
	AVE		
Rail	20.221,00	20.221,00	-10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	25.264,76	
road-iww	29.147,50	28.232,30	
	AVE		
Rail	20.221,00	20.221,00	-1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.096,36	
road-iww	29.147,50	29.055,98	
	AVE		
Rail	20.221,00	20.221,00	0%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.188,76	
road-iww	29.147,50	29.147,50	
	AVE		
Rail	20.221,00	20.221,00	1%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	26.281,16	

road-iww	29.147,50	29.239,02	
	AVE		
Rail	20.221,00	20.221,00	10%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	27.112,76	
road-iww	29.147,50	30.062,70	
	AVE		
Rail	20.221,00	20.221,00	30%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	28.960,76	
road-iww	29.147,50	31.893,10	
	AVE		
Rail	20.221,00	20.221,00	50%
road-rail	22.378,85	22.378,85	
Road	24.792,88	24.792,88	
IWW	26.188,76	30.808,76	
road-iww	29.147,50	33.723,50	

Sensitivity Antwerp-Frankfurt for road transport/fuel

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	13.998,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.156,00	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.313,76	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.834,75	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.950,53	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.471,52	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	18.629,28	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	19.787,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp- Frankfurt for road transport/wage

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.212,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.884,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.556,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.859,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.926,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.228,64	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.900,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	18.572,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp- Frankfurt for road transport/overhead

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.932,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.316,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.700,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.873,44	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.911,84	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.084,64	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.468,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.852,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for rail transport/track

	AVE		
Rail	12.289,00	10.793,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.393,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.993,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.257,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	
road-rail	12.945,85	12.945,85	0%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.321,00	
road-rail	12.945,85	12.945,85	1%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.593,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.193,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.793,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp--Frankfurt for rail transport/energy

	AVE		
Rail	12.289,00	11.129,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.593,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.057,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.265,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	
road-rail	12.945,85	12.945,85	0%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.313,00	
road-rail	12.945,85	12.945,85	1%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.521,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.985,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.449,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for rail transport/leasing

	AVE		
Rail	12.289,00	10.826,50	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.411,50	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.996,50	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.259,84	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	
road-rail	12.945,85	12.945,85	0%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.318,34	
road-rail	12.945,85	12.945,85	1%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.581,50	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.166,50	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.751,50	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for iww transport/wage

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	17.562,00	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	18.617,04	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	19.672,08	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.145,84	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.253,36	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	

IWW	20.199,60	20.727,12	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	21.782,16	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	22.837,20	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp- Frankfurt for iww transport/fuel

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	18.249,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	18.999,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	19.824,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.124,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.274,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.574,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	21.399,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	22.224,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp- Frankfurt for iww transport/leasing

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	16.503,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	17.982,00	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	19.460,40	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.125,68	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.273,52	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.938,80	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	22.417,20	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	23.895,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (road part)/fuel

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.659,02	
Road	16.892,64	13.998,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.771,50	
Road	16.892,64	15.156,00	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.889,61	
Road	16.892,64	16.313,76	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.940,22	
Road	16.892,64	16.834,75	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.951,47	
Road	16.892,64	16.950,53	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	13.002,09	
Road	16.892,64	17.471,52	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	13.120,19	
Road	16.892,64	18.629,28	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	13.232,67	
Road	16.892,64	19.787,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (road part)/wage

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.665,85	
Road	16.892,64	15.212,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.777,85	
Road	16.892,64	15.884,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.889,85	
Road	16.892,64	16.556,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.940,25	
Road	16.892,64	16.859,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.951,45	
Road	16.892,64	16.926,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	13.001,85	

Road	16.892,64	17.228,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	13.113,85	
Road	16.892,64	17.900,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	13.225,85	
Road	16.892,64	18.572,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (road part)/overhead

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.785,85	
Road	16.892,64	15.932,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.849,85	
Road	16.892,64	16.316,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.913,85	
Road	16.892,64	16.700,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.942,65	
Road	16.892,64	16.873,44	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.949,05	
Road	16.892,64	16.911,84	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.977,85	
Road	16.892,64	17.084,64	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	13.041,85	
Road	16.892,64	17.468,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	13.105,85	
Road	16.892,64	17.852,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (rail part)/track

	AVE		
Rail	12.289,00	10.826,50	-50%
road-rail	12.945,85	11.599,45	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.411,50	-30%
road-rail	12.945,85	12.139,45	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.996,50	-10%
road-rail	12.945,85	12.679,45	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.259,84	-1%
road-rail	12.945,85	12.917,05	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	
road-rail	12.945,85	12.945,85	0%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.318,34	
road-rail	12.945,85	12.974,65	1%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.581,50	10%
road-rail	12.945,85	13.219,45	
Road	16.892,64	16.892,64	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.166,50	30%
road-rail	12.945,85	13.759,45	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.751,50	50%
road-rail	12.945,85	14.299,45	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (rail part)/energy

	AVE		
Rail	12.289,00	10.826,50	-50%
road-rail	12.945,85	11.901,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.411,50	-30%
road-rail	12.945,85	12.319,45	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.996,50	-10%
road-rail	12.945,85	12.737,05	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.259,84	-1%
road-rail	12.945,85	12.924,25	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	
road-rail	12.945,85	12.945,85	0%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.318,34	
road-rail	12.945,85	12.960,25	1%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.581,50	10%
road-rail	12.945,85	13.154,65	

Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.166,50	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.751,50	50%
road-rail	12.945,85	13.989,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (rail part)/leasing

	AVE		
Rail	12.289,00	10.826,50	-50%
road-rail	12.945,85	11.808,35	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.411,50	-30%
road-rail	12.945,85	12.263,35	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	11.996,50	-10%
road-rail	12.945,85	12.718,35	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.259,84	-1%
road-rail	12.945,85	12.923,17	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	
road-rail	12.945,85	12.945,85	0%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.318,34	
road-rail	12.945,85	12.968,67	1%
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.581,50	10%
road-rail	12.945,85	13.173,35	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.166,50	30%
road-rail	12.945,85	13.628,35	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	13.751,50	50%
road-rail	12.945,85	14.083,35	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (road part)/fuel

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.659,02	
Road	16.892,64	13.998,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.771,50	
Road	16.892,64	15.156,00	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.889,61	
Road	16.892,64	16.313,76	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.940,22	
Road	16.892,64	16.834,75	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.951,47	
Road	16.892,64	16.950,53	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	13.002,09	

Road	16.892,64	17.471,52	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	13.120,19	
Road	16.892,64	18.629,28	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	13.232,67	
Road	16.892,64	19.787,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (road part)/wage

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.665,85	
Road	16.892,64	15.212,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.777,85	
Road	16.892,64	15.884,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.889,85	
Road	16.892,64	16.556,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.940,25	
Road	16.892,64	16.859,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.951,45	
Road	16.892,64	16.926,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	13.001,85	
Road	16.892,64	17.228,64	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	13.113,85	
Road	16.892,64	17.900,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	13.225,85	
Road	16.892,64	18.572,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-rail transport (road part)/overhead

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.785,85	
Road	16.892,64	15.932,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.849,85	
Road	16.892,64	16.316,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.913,85	
Road	16.892,64	16.700,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.942,65	
Road	16.892,64	16.873,44	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.949,05	
Road	16.892,64	16.911,84	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.977,85	
Road	16.892,64	17.084,64	
IWW	20.199,60	20.199,60	

road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	13.041,85	
Road	16.892,64	17.468,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	13.105,85	
Road	16.892,64	17.852,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	

Sensitivity Antwerp-Frankfurt for road-iww transport (iww part)/wage

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	17.562,00	
road-iww	22.074,14	19.461,30	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	18.617,04	
road-iww	22.074,14	20.507,10	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	19.672,08	
road-iww	22.074,14	21.552,90	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.145,84	
road-iww	22.074,14	22.021,02	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.253,36	
road-iww	22.074,14	22.127,26	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	

IWW	20.199,60	20.727,12	
road-iww	22.074,14	22.598,70	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	21.782,16	
road-iww	22.074,14	23.644,50	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	22.837,20	
road-iww	22.074,14	24.690,30	

Sensitivity Antwerp-Frankfurt for road-iww transport (iww part)/fuel

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	18.249,60	
road-iww	22.074,14	20.254,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	18.999,60	
road-iww	22.074,14	20.954,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	19.824,60	
road-iww	22.074,14	21.724,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.124,60	
road-iww	22.074,14	22.004,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.274,60	
road-iww	22.074,14	22.144,14	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	

Road	16.892,64	16.892,64	
IWW	20.199,60	20.574,60	
road-iww	22.074,14	22.424,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	21.399,60	
road-iww	22.074,14	23.194,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	22.224,60	
road-iww	22.074,14	23.964,14	

Sensitivity Antwerp-Frankfurt for road-iww transport (iww part)/leasing

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	16.503,60	
road-iww	22.074,14	18.422,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	17.982,00	
road-iww	22.074,14	19.882,94	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	19.460,40	
road-iww	22.074,14	21.343,74	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.125,68	
road-iww	22.074,14	22.001,10	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.273,52	
road-iww	22.074,14	22.147,18	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	

IWW	20.199,60	20.938,80	
road-iww	22.074,14	22.804,54	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	22.417,20	
road-iww	22.074,14	24.265,34	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	23.895,60	
road-iww	22.074,14	25.726,14	

Sensitivity Antwerp-Frankfurt for road-iww transport (road part)/fuel

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	13.998,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	21.787,31	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.156,00	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	21.899,79	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.313,76	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.017,90	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.834,75	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.068,51	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.950,53	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.079,76	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.471,52	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.130,38	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	18.629,28	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.248,48	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	19.787,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.360,96	

Sensitivity Antwerp-Frankfurt for road-iww transport (road part)/wage

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.212,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	21.794,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.884,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	21.906,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.556,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.018,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.859,04	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.066,14	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.926,24	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.079,74	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.228,64	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.130,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.900,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.242,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	18.572,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.354,14	

Sensitivity Antwerp-Frankfurt for road-iww transport (road part)/overhead

	AVE		
Rail	12.289,00	12.289,00	-50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	15.932,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	21.914,14	
Rail	12.289,00	12.289,00	-30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.316,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	21.978,14	
Rail	12.289,00	12.289,00	-10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.700,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.042,14	
Rail	12.289,00	12.289,00	-1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.873,44	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.070,94	
Rail	12.289,00	12.289,00	0%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.892,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.074,14	
Rail	12.289,00	12.289,00	1%
road-rail	12.945,85	12.945,85	
Road	16.892,64	16.911,84	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.077,34	
Rail	12.289,00	12.289,00	10%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.084,64	

IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.106,14	
Rail	12.289,00	12.289,00	30%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.468,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.170,14	
Rail	12.289,00	12.289,00	50%
road-rail	12.945,85	12.945,85	
Road	16.892,64	17.852,64	
IWW	20.199,60	20.199,60	
road-iww	22.074,14	22.234,14	

Sensitivity Antwerp-Strasbourg for road transport/fuel

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	17.812,64	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.172,00	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.531,36	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.143,07	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.279,01	

road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.890,72	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.250,08	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	24.609,44	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp- Strasbourg for road transport/wage

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.251,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.035,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.819,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.171,84	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.250,24	

road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.603,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	22.387,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.171,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp- Strasbourg for road transport/overhead

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.091,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.539,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.987,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.188,64	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.233,44	
road-iww	22.477,21	22.477,21	

	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.435,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.883,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	22.331,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for rail transport/track

	AVE		
Rail	17.033,00	14.863,80	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	15.733,80	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.603,80	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.986,60	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.079,40	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	

Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.473,80	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.343,80	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	19.213,80	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp- Strasbourg for rail transport/energy

	AVE		
Rail	17.033,00	15.351,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.023,80	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.696,60	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.998,20	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.067,80	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	

Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.369,40	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.042,20	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.715,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp- Strasbourg for rail transport/leasing

	AVE		
Rail	17.033,00	14.920,50	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	15.765,50	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.610,50	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.990,88	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.075,38	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

	AVE		
Rail	17.033,00	17.455,50	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.300,50	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	19.145,50	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road-rail transport (RAIL part)/track

	AVE		
Rail	17.033,00	14.863,80	-50%
road-rail	17.689,85	15.670,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	15.733,80	-30%
road-rail	17.689,85	16.480,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.603,80	-10%
road-rail	17.689,85	17.290,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.986,60	-1%
road-rail	17.689,85	17.646,65	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.079,40	1%
road-rail	17.689,85	17.733,05	
IWW	20.603,48	20.603,48	

Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.473,80	10%
road-rail	17.689,85	18.100,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.343,80	30%
road-rail	17.689,85	18.910,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	19.213,80	50%
road-rail	17.689,85	19.720,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road-rail transport (RAIL part)//energy

	AVE		
Rail	17.033,00	15.351,00	-50%
road-rail	17.689,85	16.123,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.023,80	-30%
road-rail	17.689,85	16.750,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.696,60	-10%
road-rail	17.689,85	17.376,65	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.998,20	-1%
road-rail	17.689,85	17.657,45	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.067,80	1%
road-rail	17.689,85	17.722,25	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	

road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.369,40	10%
road-rail	17.689,85	18.003,05	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.042,20	30%
road-rail	17.689,85	18.629,45	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.715,00	50%
road-rail	17.689,85	19.255,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road-rail transport (RAIL part)/leasing

	AVE		
Rail	17.033,00	14.920,50	-50%
road-rail	17.689,85	15.902,35	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	15.765,50	-30%
road-rail	17.689,85	16.617,35	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.610,50	-10%
road-rail	17.689,85	17.332,35	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	16.990,88	-1%
road-rail	17.689,85	17.654,21	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.075,38	1%
road-rail	17.689,85	17.725,71	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

	AVE		
Rail	17.033,00	17.455,50	10%
road-rail	17.689,85	18.047,35	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	18.300,50	30%
road-rail	17.689,85	18.762,35	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	19.145,50	50%
road-rail	17.689,85	19.477,35	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road rail transport (road part)/fuel

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.403,02	
IWW	20.603,48	20.603,48	
Road	21.211,04	17.812,64	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.515,50	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.172,00	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.633,61	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.531,36	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.684,22	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.143,07	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.695,47	
IWW	20.603,48	20.603,48	

Road	21.211,04	21.279,01	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.746,09	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.890,72	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.864,19	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.250,08	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.976,67	
IWW	20.603,48	20.603,48	
Road	21.211,04	24.609,44	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road rail transport (road part) /wage

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.409,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.251,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.521,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.035,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.633,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.819,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.681,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.171,84	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.695,45	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.250,24	

road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.745,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.603,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.857,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	22.387,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.969,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.171,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road rail transport (road part)/overhead

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.529,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.091,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.593,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.539,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.657,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.987,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.686,65	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.188,64	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.693,05	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.233,44	
road-iww	22.477,21	22.477,21	

	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.721,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.435,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.785,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.883,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.849,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	22.331,04	
road-iww	22.477,21	22.477,21	

Sensitivity Antwerp-Strasbourg for road iww transport (road part)/fuel

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	17.812,64	
road-iww	22.477,21	22.190,39	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.172,00	
road-iww	22.477,21	22.302,87	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.531,36	
road-iww	22.477,21	22.420,97	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.143,07	
road-iww	22.477,21	22.471,59	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.279,01	

road-iww	22.477,21	22.482,84	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.890,72	
road-iww	22.477,21	22.533,45	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.250,08	
road-iww	22.477,21	22.651,56	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	24.609,44	
road-iww	22.477,21	22.764,04	

Sensitivity Antwerp-Strasbourg for road iww transport (road part) /wage

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	17.812,64	
road-iww	22.477,21	22.197,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.172,00	
road-iww	22.477,21	22.309,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.531,36	
road-iww	22.477,21	22.421,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.143,07	
road-iww	22.477,21	22.471,61	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.279,01	

road-iww	22.477,21	22.482,81	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.890,72	
road-iww	22.477,21	22.533,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.250,08	
road-iww	22.477,21	22.645,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	24.609,44	
road-iww	22.477,21	22.757,21	

Sensitivity Antwerp-Strasbourg for road iww transport (road part)/overhead

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	17.812,64	
road-iww	22.477,21	22.317,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	19.172,00	
road-iww	22.477,21	22.381,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	20.531,36	
road-iww	22.477,21	22.445,21	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.143,07	
road-iww	22.477,21	22.474,01	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.279,01	
road-iww	22.477,21	22.480,41	

	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.890,72	
road-iww	22.477,21	22.509,21	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	23.250,08	
road-iww	22.477,21	22.573,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	24.609,44	
road-iww	22.477,21	22.637,21	

Sensitivity Antwerp-Strasbourg for road iww transport (iww part)/wage

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	18.091,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	19.990,29	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	19.096,28	
Road	21.211,04	21.211,04	
road-iww	22.477,21	20.985,69	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.101,08	
Road	21.211,04	21.211,04	
road-iww	22.477,21	21.981,09	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.552,28	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.426,65	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.654,68	

Road	21.211,04	21.211,04	
road-iww	22.477,21	22.527,77	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	21.105,88	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.976,49	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	22.110,68	
Road	21.211,04	21.211,04	
road-iww	22.477,21	23.971,89	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	23.115,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	24.967,29	

Sensitivity Antwerp-Strasbourg for road iww transport (iww part) /fuel

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	18.084,73	
Road	21.211,04	21.211,04	
road-iww	22.477,21	20.088,46	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	19.053,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	21.007,21	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.119,10	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.017,84	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.506,60	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.385,34	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.700,35	
Road	21.211,04	21.211,04	

road-iww	22.477,21	22.569,09	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	21.087,85	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.936,59	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	22.153,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	23.947,21	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	23.219,10	
Road	21.211,04	21.211,04	
road-iww	22.477,21	24.957,84	

Sensitivity Antwerp-Strasbourg for road iww transport (iww part)/leasing

	AVE		
Rail	17.033,00	17.033,00	-50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	17.083,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	19.001,21	
	AVE		
Rail	17.033,00	17.033,00	-30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	18.491,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	20.391,61	
	AVE		
Rail	17.033,00	17.033,00	-10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	19.899,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	21.782,01	
	AVE		
Rail	17.033,00	17.033,00	-1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.533,08	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.407,69	
	AVE		
Rail	17.033,00	17.033,00	0%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.603,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	22.477,21	
	AVE		
Rail	17.033,00	17.033,00	1%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	20.673,88	
Road	21.211,04	21.211,04	

road-iww	22.477,21	22.546,73	
	AVE		
Rail	17.033,00	17.033,00	10%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	21.307,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	23.172,41	
	AVE		
Rail	17.033,00	17.033,00	30%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	22.715,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	24.562,81	
	AVE		
Rail	17.033,00	17.033,00	50%
road-rail	17.689,85	17.689,85	
IWW	20.603,48	24.123,48	
Road	21.211,04	21.211,04	
road-iww	22.477,21	25.953,21	

Sensitivity Genoa-Basel for road transport/fuel

	AVE		
			-50%
Rail	17111	17111	
road-rail	19425,85	19425,85	
Road	21367,68	17.954,88	
Rail	17111	17111	-30%
road-rail	19425,85	19425,85	
Road	21367,68	19.320,00	
Rail	17111	17111	-10%
road-rail	19425,85	19425,85	
Road	21367,68	20.685,12	
Rail	17111	17111	-1%
road-rail	19425,85	19425,85	
Road	21367,68	21.299,42	
Rail	17111	17111	0%
road-rail	19425,85	19425,85	
Road	21367,68	21.367,68	
Rail	17111	17111	1%
road-rail	19425,85	19425,85	
Road	21367,68	21.435,94	
Rail	17111	17111	10%
road-rail	19425,85	19425,85	
Road	21367,68	22.050,24	
Rail	17111	17111	30%
road-rail	19425,85	19425,85	
Road	21367,68	23.415,36	
Rail	17111	17111	50%
road-rail	19425,85	19425,85	
Road	21367,68	24.780,48	

Sensitivity Genoa- Basel for road transport/wage

	AVE		
			-50%
Rail	17111	17111	
road-rail	19425,85	19425,85	
Road	21367,68	19.407,68	
Rail	17111	17111	-30%
road-rail	19425,85	19425,85	
Road	21367,68	20.191,68	
Rail	17111	17111	-10%
road-rail	19425,85	19425,85	
Road	21367,68	20.975,68	
Rail	17111	17111	-1%
road-rail	19425,85	19425,85	
Road	21367,68	21.328,48	
Rail	17111	17111	0%
road-rail	19425,85	19425,85	
Road	21367,68	21.367,68	
Rail	17111	17111	1%
road-rail	19425,85	19425,85	
Road	21367,68	21.406,88	
Rail	17111	17111	10%
road-rail	19425,85	19425,85	
Road	21367,68	21.759,68	
Rail	17111	17111	30%
road-rail	19425,85	19425,85	
Road	21367,68	22.543,68	
Rail	17111	17111	50%
road-rail	19425,85	19425,85	
Road	21367,68	23.327,68	

Sensitivity Genoa- Basel for road transport/overhead

	AVE		
			-50%
Rail	17111	17111	
road-rail	19425,85	19425,85	
Road	21367,68	20.247,68	
Rail	17111	17111	-30%
road-rail	19425,85	19425,85	
Road	21367,68	20.695,68	
Rail	17111	17111	-10%
road-rail	19425,85	19425,85	
Road	21367,68	21.143,68	
Rail	17111	17111	-1%
road-rail	19425,85	19425,85	
Road	21367,68	21.345,28	
Rail	17111	17111	0%
road-rail	19425,85	19425,85	
Road	21367,68	21.367,68	
Rail	17111	17111	1%
road-rail	19425,85	19425,85	
Road	21367,68	21.390,08	
Rail	17111	17111	10%
road-rail	19425,85	19425,85	
Road	21367,68	21.591,68	
Rail	17111	17111	30%
road-rail	19425,85	19425,85	
Road	21367,68	22.039,68	
Rail	17111	17111	50%
road-rail	19425,85	19425,85	
Road	21367,68	22.487,68	

Sensitivity Genoa-Basel for rail transport/track

	AVE		
Rail	17111	15.405,56	-50%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	16.089,56	-30%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	16.773,56	-10%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	17.074,52	
road-rail	19425,85	19425,85	-1%
Road	21367,68	21367,68	
Rail	17111	17.111,00	
road-rail	19425,85	19425,85	0%
Road	21367,68	21367,68	
Rail	17111	17.147,48	
road-rail	19425,85	19425,85	1%
Road	21367,68	21367,68	
Rail	17111	17.457,56	10%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	18.141,56	30%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	18.825,56	50%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	

Sensitivity Antwerp--Basel for rail transport/energy

	AVE		
Rail	17111	15.788,60	-50%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	16.317,56	-30%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	16.846,52	-10%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	17.083,64	
road-rail	19425,85	19425,85	-1%
Road	21367,68	21367,68	
Rail	17111	17.111,00	
road-rail	19425,85	19425,85	0%
Road	21367,68	21367,68	
Rail	17111	17.138,36	
road-rail	19425,85	19425,85	1%
Road	21367,68	21367,68	
Rail	17111	17.375,48	10%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	17.904,44	30%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	18.433,40	50%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	

Sensitivity Antwerp--Basel for rail transport/leasing

	AVE		
Rail	17111	15.323,50	-50%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	16.038,50	-30%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	16.753,50	-10%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	17.075,36	
road-rail	19425,85	19425,85	-1%
Road	21367,68	21367,68	
Rail	17111	17.111,00	
road-rail	19425,85	19425,85	0%
Road	21367,68	21367,68	
Rail	17111	17.146,86	
road-rail	19425,85	19425,85	1%
Road	21367,68	21367,68	
Rail	17111	17.468,50	10%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	18.183,50	30%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	
Rail	17111	18.898,50	50%
road-rail	19425,85	19425,85	
Road	21367,68	21367,68	

Sensitivity Genoa-Basel for road rail transport (road part)/fuel

	AVE		
			-50%
Rail	17111	17111	
road-rail	19425,85	19.139,02	
Road	21367,68	17.954,88	
Rail	17111	17111	-30%
road-rail	19425,85	19.251,50	
Road	21367,68	19.320,00	
Rail	17111	17111	-10%
road-rail	19425,85	19.369,61	
Road	21367,68	20.685,12	
Rail	17111	17111	-1%
road-rail	19425,85	19.420,22	
Road	21367,68	21.299,42	
Rail	17111	17111	0%
road-rail	19425,85	19.425,85	
Road	21367,68	21.367,68	
Rail	17111	17111	1%
road-rail	19425,85	19.431,47	
Road	21367,68	21.435,94	
Rail	17111	17111	10%
road-rail	19425,85	19.482,09	
Road	21367,68	22.050,24	
Rail	17111	17111	30%
road-rail	19425,85	19.600,19	
Road	21367,68	23.415,36	
Rail	17111	17111	50%
road-rail	19425,85	19.712,67	
Road	21367,68	24.780,48	

Sensitivity Genoa-Basel for road rail transport (road part)//wage

	AVE		
			-50%
Rail	17111	17111	
road-rail	19425,85	18.865,85	
Road	21367,68	19.407,68	
Rail	17111	17111	-30%
road-rail	19425,85	19.089,85	
Road	21367,68	20.191,68	
Rail	17111	17111	-10%
road-rail	19425,85	19.313,85	
Road	21367,68	20.975,68	
Rail	17111	17111	-1%
road-rail	19425,85	19.414,65	
Road	21367,68	21.328,48	
Rail	17111	17111	0%
road-rail	19425,85	19.425,85	
Road	21367,68	21.367,68	
Rail	17111	17111	1%
road-rail	19425,85	19.437,05	
Road	21367,68	21.406,88	
Rail	17111	17111	10%
road-rail	19425,85	19.537,85	
Road	21367,68	21.759,68	
Rail	17111	17111	30%
road-rail	19425,85	19.761,85	
Road	21367,68	22.543,68	
Rail	17111	17111	50%
road-rail	19425,85	19.985,85	
Road	21367,68	23.327,68	

Sensitivity Genoa-Basel for road rail transport (road part)//overhead

	AVE		
			-50%
Rail	17111	17111	
road-rail	19425,85	19.265,85	
Road	21367,68	20.247,68	
Rail	17111	17111	-30%
road-rail	19425,85	19.329,85	
Road	21367,68	20.695,68	
Rail	17111	17111	-10%
road-rail	19425,85	19.393,85	
Road	21367,68	21.143,68	
Rail	17111	17111	-1%
road-rail	19425,85	19.422,65	
Road	21367,68	21.345,28	
Rail	17111	17111	0%
road-rail	19425,85	19.425,85	
Road	21367,68	21.367,68	
Rail	17111	17111	1%
road-rail	19425,85	19.429,05	
Road	21367,68	21.390,08	
Rail	17111	17111	10%
road-rail	19425,85	19.457,85	
Road	21367,68	21.591,68	
Rail	17111	17111	30%
road-rail	19425,85	19.521,85	
Road	21367,68	22.039,68	
Rail	17111	17111	50%
road-rail	19425,85	19.585,85	
Road	21367,68	22.487,68	

Sensitivity Genoa-Basel for road rail transport (rail part)/track

	AVE		
Rail	17111	15.405,56	-50%
road-rail	19425,85	17.802,69	
Road	21367,68	21367,68	
Rail	17111	16.089,56	-30%
road-rail	19425,85	18.453,69	
Road	21367,68	21367,68	
Rail	17111	16.773,56	-10%
road-rail	19425,85	19.104,69	
Road	21367,68	21367,68	
Rail	17111	17.074,52	
road-rail	19425,85	19.391,13	-1%
Road	21367,68	21367,68	
Rail	17111	17.111,00	
road-rail	19425,85	19.425,85	0%
Road	21367,68	21367,68	
Rail	17111	17.147,48	
road-rail	19425,85	19.460,57	1%
Road	21367,68	21367,68	
Rail	17111	17.457,56	10%
road-rail	19425,85	19.755,69	
Road	21367,68	21367,68	
Rail	17111	18.141,56	30%
road-rail	19425,85	20.406,69	
Road	21367,68	21367,68	
Rail	17111	18.825,56	50%
road-rail	19425,85	21.057,69	
Road	21367,68	21367,68	

Sensitivity Genoa-Basel for road rail transport (rail part)//energy

	AVE		
Rail	17111	15.788,60	-50%
road-rail	19425,85	18.167,25	
Road	21367,68	21367,68	
Rail	17111	16.317,56	-30%
road-rail	19425,85	18.670,69	
Road	21367,68	21367,68	
Rail	17111	16.846,52	-10%
road-rail	19425,85	19.174,13	
Road	21367,68	21367,68	
Rail	17111	17.083,64	
road-rail	19425,85	19.399,81	-1%
Road	21367,68	21367,68	
Rail	17111	17.111,00	
road-rail	19425,85	19.425,85	0%
Road	21367,68	21367,68	
Rail	17111	17.138,36	
road-rail	19425,85	19.451,89	1%
Road	21367,68	21367,68	
Rail	17111	17.375,48	10%
road-rail	19425,85	19.677,57	
Road	21367,68	21367,68	
Rail	17111	17.904,44	30%
road-rail	19425,85	20.181,01	
Road	21367,68	21367,68	
Rail	17111	18.433,40	50%
road-rail	19425,85	20.684,45	
Road	21367,68	21367,68	

Sensitivity Genoa-Basel for road rail transport (rail part)//leasing

	AVE		
Rail	17111	15.323,50	-50%
road-rail	19425,85	17.963,35	
Road	21367,68	21367,68	
Rail	17111	16.038,50	-30%
road-rail	19425,85	18.548,35	
Road	21367,68	21367,68	
Rail	17111	16.753,50	-10%
road-rail	19425,85	19.133,35	
Road	21367,68	21367,68	
Rail	17111	17.075,36	
road-rail	19425,85	19.396,69	-1%
Road	21367,68	21367,68	
Rail	17111	17.111,00	
road-rail	19425,85	19.425,85	0%
Road	21367,68	21367,68	
Rail	17111	17.146,86	
road-rail	19425,85	19.455,19	1%
Road	21367,68	21367,68	
Rail	17111	17.468,50	10%
road-rail	19425,85	19.718,35	
Road	21367,68	21367,68	
Rail	17111	18.183,50	30%
road-rail	19425,85	20.303,35	
Road	21367,68	21367,68	
Rail	17111	18.898,50	50%
road-rail	19425,85	20.888,35	
Road	21367,68	21367,68	

Sensitivity Genoa-Frankfurt for road transport/fuel

	AVE		
			-50%
Rail	26038	26038	
road-rail	26664,85	26664,85	
Road	35280	29.520,00	
Rail	26038	26038	-30%
road-rail	26664,85	26664,85	
Road	35280	31.824,00	
Rail	26038	26038	-10%
road-rail	26664,85	26664,85	
Road	35280	34.128,00	
Rail	26038	26038	-1%
road-rail	26664,85	26664,85	
Road	35280	35.164,80	
Rail	26038	26038	0%
road-rail	26664,85	26664,85	
Road	35280	35.280,00	
Rail	26038	26038	1%
road-rail	26664,85	26664,85	
Road	35280	35.395,20	
Rail	26038	26038	10%
road-rail	26664,85	26664,85	
Road	35280	36.432,00	
Rail	26038	26038	30%
road-rail	26664,85	26664,85	
Road	35280	38.736,00	
Rail	26038	26038	50%
road-rail	26664,85	26664,85	
Road	35280	41.040,00	

Sensitivity Genoa- Frankfurt for road transport/wage

	AVE		-50%
Rail	26038	26038	
road-rail	26664,85	26664,85	
Road	35280	31.920,00	
Rail	26038	26038	-30%
road-rail	26664,85	26664,85	
Road	35280	33.264,00	
Rail	26038	26038	-10%
road-rail	26664,85	26664,85	
Road	35280	34.608,00	
Rail	26038	26038	-1%
road-rail	26664,85	26664,85	
Road	35280	35.212,80	
Rail	26038	26038	0%
road-rail	26664,85	26664,85	
Road	35280	35.280,00	
Rail	26038	26038	1%
road-rail	26664,85	26664,85	
Road	35280	35.347,20	
Rail	26038	26038	10%
road-rail	26664,85	26664,85	
Road	35280	35.952,00	
Rail	26038	26038	30%
road-rail	26664,85	26664,85	
Road	35280	37.296,00	
Rail	26038	26038	50%
road-rail	26664,85	26664,85	
Road	35280	38.640,00	

Sensitivity Genoa- Frankfurt for road transport/overhead

	AVE		-50%
Rail	26038	26038	
road-rail	26664,85	26664,85	
Road	35280	33.360,00	
Rail	26038	26038	-30%
road-rail	26664,85	26664,85	
Road	35280	34.128,00	
Rail	26038	26038	-10%
road-rail	26664,85	26664,85	
Road	35280	34.896,00	
Rail	26038	26038	-1%
road-rail	26664,85	26664,85	
Road	35280	35.241,60	
Rail	26038	26038	0%
road-rail	26664,85	26664,85	
Road	35280	35.280,00	
Rail	26038	26038	1%
road-rail	26664,85	26664,85	
Road	35280	35.318,40	
Rail	26038	26038	10%
road-rail	26664,85	26664,85	
Road	35280	35.664,00	
Rail	26038	26038	30%
road-rail	26664,85	26664,85	
Road	35280	36.432,00	
Rail	26038	26038	50%
road-rail	26664,85	26664,85	
Road	35280	37.200,00	

Sensitivity Genoa-Frankfurt for rail transport/track

	AVE		
Rail	26038	22.226,88	-50%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	23.408,88	-30%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	24.590,88	-10%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	25.110,96	-1%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	25.174,00	
road-rail	26664,85	26664,85	0%
Road	35280	35280	
Rail	26038	25.237,04	
road-rail	26664,85	26664,85	1%
Road	35280	35280	
Rail	26038	25.772,88	10%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	26.954,88	30%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	28.136,88	50%
road-rail	26664,85	26664,85	
Road	35280	35280	

Sensitivity Antwerp--Frankfurt for rail transport/energy

	AVE		
Rail	26038	23.752,80	-50%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	24.666,88	-30%
road-rail	26664,85	26664,85	
Road	35280	35280	
	26038	25.580,96	-10%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	25.990,72	-1%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	26.038,00	
road-rail	26664,85	26664,85	0%
Road	35280	35280	
Rail	26038	26.085,28	
road-rail	26664,85	26664,85	1%
Road	35280	35280	
Rail	26038	26.495,04	10%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	27.409,12	30%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	28.323,20	50%
road-rail	26664,85	26664,85	
Road	35280	35280	

Sensitivity Antwerp-Frankfurt for rail transport/leasing

	AVE		
Rail	26038	23.113,00	-50%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	24.283,00	-30%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	25.453,00	-10%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	25.979,68	-1%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	26.038,00	
road-rail	26664,85	26664,85	0%
Road	35280	35280	
Rail	26038	26.096,68	
road-rail	26664,85	26664,85	1%
Road	35280	35280	
Rail	26038	26.623,00	10%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	27.793,00	30%
road-rail	26664,85	26664,85	
Road	35280	35280	
Rail	26038	28.963,00	50%
road-rail	26664,85	26664,85	
Road	35280	35280	

Sensitivity Genoa-Frankfurt for road rail transport (road part)/fuel

	AVE		
			-50%
Rail	26038	26038	
road-rail	26664,85	26.378,02	
Road	35280	29.520,00	
Rail	26038	26038	-30%
road-rail	26664,85	26.490,50	
Road	35280	31.824,00	
Rail	26038	26038	-10%
road-rail	26664,85	26.608,61	
Road	35280	34.128,00	
Rail	26038	26038	-1%
road-rail	26664,85	26.659,22	
Road	35280	35.164,80	
Rail	26038	26038	0%
road-rail	26664,85	26.664,85	
Road	35280	35.280,00	
Rail	26038	26038	1%
road-rail	26664,85	26.670,47	
Road	35280	35.395,20	
Rail	26038	26038	10%
road-rail	26664,85	26.721,09	
Road	35280	36.432,00	
Rail	26038	26038	30%
road-rail	26664,85	26.839,19	
Road	35280	38.736,00	
Rail	26038	26038	50%
road-rail	26664,85	26.951,67	
Road	35280	41.040,00	

Sensitivity Genoa-Frankfurt for road rail transport (road part)//wage

	AVE		
	AVE		-50%
Rail	26038	26038	
road-rail	26664,85	26.104,85	
Road	35280	31.920,00	
Rail	26038	26038	-30%
road-rail	26664,85	26.328,85	
Road	35280	33.264,00	
Rail	26038	26038	-10%
road-rail	26664,85	26.552,85	
Road	35280	34.608,00	
Rail	26038	26038	-1%
road-rail	26664,85	26.653,65	
Road	35280	35.212,80	
Rail	26038	26038	0%
road-rail	26664,85	26.664,85	
Road	35280	35.280,00	
Rail	26038	26038	1%
road-rail	26664,85	26.676,05	
Road	35280	35.347,20	
Rail	26038	26038	10%
road-rail	26664,85	26.776,85	
Road	35280	35.952,00	
Rail	26038	26038	30%
road-rail	26664,85	27.000,85	
Road	35280	37.296,00	
Rail	26038	26038	50%
road-rail	26664,85	27.224,85	
Road	35280	38.640,00	

Sensitivity Genoa-Frankfurt for road rail transport (road part)/overhead

	AVE		
			-50%
Rail	26038	26038	
road-rail	26664,85	26.504,85	
Road	35280	33.360,00	
Rail	26038	26038	-30%
road-rail	26664,85	26.568,85	
Road	35280	34.128,00	
Rail	26038	26038	-10%
road-rail	26664,85	26.632,85	
Road	35280	34.896,00	
Rail	26038	26038	-1%
road-rail	26664,85	26.661,65	
Road	35280	35.241,60	
Rail	26038	26038	0%
road-rail	26664,85	26.664,85	
Road	35280	35.280,00	
Rail	26038	26038	1%
road-rail	26664,85	26.668,05	
Road	35280	35.318,40	
Rail	26038	26038	10%
road-rail	26664,85	26.696,85	
Road	35280	35.664,00	
Rail	26038	26038	30%
road-rail	26664,85	26.760,85	
Road	35280	36.432,00	
Rail	26038	26038	50%
road-rail	26664,85	26.824,85	
Road	35280	37.200,00	

Sensitivity Genoa-Frankfurt for road-rail transport (rail part)/track

	AVE		
Rail	26038	22.226,88	-50%
road-rail	26664,85	23.859,85	
Road	35280	35280	
Rail	26038	23.408,88	-30%
road-rail	26664,85	24.984,85	
Road	35280	35280	
Rail	26038	24.590,88	-10%
road-rail	26664,85	26.109,85	
Road	35280	35280	
Rail	26038	25.110,96	-1%
road-rail	26664,85	26.604,85	
Road	35280	35280	
Rail	26038	25.174,00	
road-rail	26664,85	26.664,85	0%
Road	35280	35280	
Rail	26038	25.237,04	
road-rail	26664,85	26.724,85	1%
Road	35280	35280	
Rail	26038	25.772,88	10%
road-rail	26664,85	27.234,85	
Road	35280	35280	
Rail	26038	26.954,88	30%
road-rail	26664,85	28.359,85	
Road	35280	35280	
Rail	26038	28.136,88	50%
road-rail	26664,85	29.484,85	
Road	35280	35280	

Sensitivity Genoa-Frankfurt for road-rail transport (rail part)//energy

	AVE		
Rail	26038	23.752,80	-50%
road-rail	26664,85	24.489,85	
Road	35280	35280	
Rail	26038	24.666,88	-30%
road-rail	26664,85	25.359,85	
Road	35280	35280	
Rail	26038	25.580,96	-10%
road-rail	26664,85	26.229,85	
Road	35280	35280	
Rail	26038	25.990,72	-1%
road-rail	26664,85	26.619,85	
Road	35280	35280	
Rail	26038	26.038,00	
road-rail	26664,85	26.664,85	0%
Road	35280	35280	
Rail	26038	26.085,28	
road-rail	26664,85	26.709,85	1%
Road	35280	35280	
Rail	26038	26.495,04	10%
road-rail	26664,85	27.099,85	
Road	35280	35280	
Rail	26038	27.409,12	30%
road-rail	26664,85	27.969,85	
Road	35280	35280	
Rail	26038	28.323,20	50%
road-rail	26664,85	28.839,85	
Road	35280	35280	

Sensitivity Genoa-Frankfurt for road-rail transport (rail part)/leasing

	AVE		
Rail	26038	23.113,00	-50%
road-rail	26664,85	24.064,85	
Road	35280	35280	
Rail	26038	24.283,00	-30%
road-rail	26664,85	25.104,85	
Road	35280	35280	
Rail	26038	25.453,00	-10%
road-rail	26664,85	26.144,85	
Road	35280	35280	
Rail	26038	25.979,68	-1%
road-rail	26664,85	26.613,01	
Road	35280	35280	
Rail	26038	26.038,00	
road-rail	26664,85	26.664,85	0%
Road	35280	35280	
Rail	26038	26.096,68	
road-rail	26664,85	26.717,01	1%
Road	35280	35280	
Rail	26038	26.623,00	10%
road-rail	26664,85	27.184,85	
Road	35280	35280	
Rail	26038	27.793,00	30%
road-rail	26664,85	28.224,85	
Road	35280	35280	
Rail	26038	28.963,00	50%
road-rail	26664,85	29.264,85	
Road	35280	35280	

Sensitivity Genoa-Strasbourg for road transport/fuel

	AVE		-50%
Rail	20157	20157	
road-rail	20989,85	20989,85	
Road	27071,84	22.665,44	
Rail	20157	20157	-30%
road-rail	20989,85	20989,85	
Road	27071,84	24.428,00	
Rail	20157	20157	-10%
road-rail	20989,85	20989,85	
Road	27071,84	26.190,56	
Rail	20157	20157	-1%
road-rail	20989,85	20989,85	
Road	27071,84	26.983,71	
Rail	20157	20157	0%
road-rail	20989,85	20989,85	
Road	27071,84	27.071,84	
Rail	20157	20157	1%
road-rail	20989,85	20989,85	
Road	27071,84	27.159,97	
Rail	20157	20157	10%
road-rail	20989,85	20989,85	
Road	27071,84	27.953,12	
Rail	20157	20157	30%
road-rail	20989,85	20989,85	
Road	27071,84	29.715,68	
Rail	20157	20157	
road-rail	20989,85	20989,85	50%
Road	27071,84	31.478,24	

Sensitivity Genoa- Strasbourg for road transport/wage

	AVE		-50%
Rail	20157	20157	
road-rail	20989,85	20989,85	
Road	27071,84	24.551,84	
Rail	20157	20157	-30%
road-rail	20989,85	20989,85	
Road	27071,84	25.559,84	
Rail	20157	20157	-10%
road-rail	20989,85	20989,85	
Road	27071,84	26.567,84	
Rail	20157	20157	-1%
road-rail	20989,85	20989,85	
Road	27071,84	27.021,44	
Rail	20157	20157	0%
road-rail	20989,85	20989,85	
Road	27071,84	27.071,84	
Rail	20157	20157	1%
road-rail	20989,85	20989,85	
Road	27071,84	27.122,24	
Rail	20157	20157	10%
road-rail	20989,85	20989,85	
Road	27071,84	27.575,84	
Rail	20157	20157	30%
road-rail	20989,85	20989,85	
Road	27071,84	28.583,84	
Rail	20157	20157	
road-rail	20989,85	20989,85	50%
Road	27071,84	29.591,84	

Sensitivity Genoa- Strasbourg for road transport/overhead

	AVE		-50%
Rail	20157	20157	
road-rail	20989,85	20989,85	
Road	27071,84	25.631,84	
Rail	20157	20157	-30%
road-rail	20989,85	20989,85	
Road	27071,84	26.207,84	
Rail	20157	20157	-10%
road-rail	20989,85	20989,85	
Road	27071,84	26.783,84	
Rail	20157	20157	-1%
road-rail	20989,85	20989,85	
Road	27071,84	27.043,04	
Rail	20157	20157	0%
road-rail	20989,85	20989,85	
Road	27071,84	27.071,84	
Rail	20157	20157	1%
road-rail	20989,85	20989,85	
Road	27071,84	27.100,64	
Rail	20157	20157	10%
road-rail	20989,85	20989,85	
Road	27071,84	27.359,84	
Rail	20157	20157	30%
road-rail	20989,85	20989,85	
Road	27071,84	27.935,84	
Rail	20157	20157	
road-rail	20989,85	20989,85	50%
Road	27071,84	28.511,84	

Sensitivity Genoa-Strasbourg for rail transport/track

	AVE		-50%
Rail	20157	17.987,80	
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	18.857,80	-30%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	19.727,80	-10%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	20.110,60	
road-rail	20989,85	20989,85	-1%
Road	27071,84	27071,84	
Rail	20157	20.157,00	
road-rail	20989,85	20989,85	0%
Road	27071,84	27071,84	
Rail	20157	20.203,40	
road-rail	20989,85	20989,85	1%
Road	27071,84	27071,84	
Rail	20157	20.597,80	10%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	21.467,80	30%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	22.337,80	50%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	

Sensitivity Antwerp- Strasbourg for rail transport/energy

	AVE		-50%
Rail	20157	18.475,00	
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	19.147,80	-30%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	19.820,60	-10%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	20.122,20	
road-rail	20989,85	20989,85	-1%
Road	27071,84	27071,84	
Rail	20157	20.157,00	
road-rail	20989,85	20989,85	0%
Road	27071,84	27071,84	
Rail	20157	20.191,80	
road-rail	20989,85	20989,85	1%
Road	27071,84	27071,84	
Rail	20157	20.493,40	10%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	21.166,20	30%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	21.839,00	50%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	

Sensitivity Antwerp-Strasbourg for rail transport/leasing

	AVE		-50%
Rail	20157	18.044,50	
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	18.889,50	-30%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	19.734,50	-10%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	20.114,88	
road-rail	20989,85	20989,85	-1%
Road	27071,84	27071,84	
Rail	20157	20.157,00	
road-rail	20989,85	20989,85	0%
Road	27071,84	27071,84	
Rail	20157	20.199,38	
road-rail	20989,85	20989,85	1%
Road	27071,84	27071,84	
Rail	20157	20.579,50	10%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	21.424,50	30%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	
Rail	20157	22.269,50	50%
road-rail	20989,85	20989,85	
Road	27071,84	27071,84	

Sensitivity Genoa-Strasbourg for road rail transport (road part)/fuel

	AVE		-50%
Rail	20157	20157	
road-rail	20989,85	20.703,02	
Road	27071,84	22.665,44	
Rail	20157	20157	-30%
road-rail	20989,85	20.815,50	
Road	27071,84	24.428,00	
Rail	20157	20157	-10%
road-rail	20989,85	20.933,61	
Road	27071,84	26.190,56	
Rail	20157	20157	-1%
road-rail	20989,85	20.984,22	
Road	27071,84	26.983,71	
Rail	20157	20157	0%
road-rail	20989,85	20.989,85	
Road	27071,84	27.071,84	
Rail	20157	20157	1%
road-rail	20989,85	20.995,47	
Road	27071,84	27.159,97	
Rail	20157	20157	10%
road-rail	20989,85	21.046,09	
Road	27071,84	27.953,12	
Rail	20157	20157	30%
road-rail	20989,85	21.164,19	
Road	27071,84	29.715,68	
Rail	20157	20157	
road-rail	20989,85	21.276,67	50%
Road	27071,84	31.478,24	

Sensitivity Genoa-Strasbourg for road rail transport (road part)/wage

	AVE		-50%
Rail	20157	20157	
road-rail	20989,85	20.429,85	
Road	27071,84	24.551,84	
Rail	20157	20157	-30%
road-rail	20989,85	20.653,85	
Road	27071,84	25.559,84	
Rail	20157	20157	-10%
road-rail	20989,85	20.877,85	
Road	27071,84	26.567,84	
Rail	20157	20157	-1%
road-rail	20989,85	20.978,65	
Road	27071,84	27.021,44	
Rail	20157	20157	0%
road-rail	20989,85	20.989,85	
Road	27071,84	27.071,84	
Rail	20157	20157	1%
road-rail	20989,85	21.001,05	
Road	27071,84	27.122,24	
Rail	20157	20157	10%
road-rail	20989,85	21.101,85	
Road	27071,84	27.575,84	
Rail	20157	20157	30%
road-rail	20989,85	21.325,85	
Road	27071,84	28.583,84	
Rail	20157	20157	
road-rail	20989,85	21.549,85	50%
Road	27071,84	29.591,84	

Sensitivity Genoa-Strasbourg for road rail transport (road part)/overhead

	AVE		-50%
Rail	20157	20157	
road-rail	20989,85	20.829,85	
Road	27071,84	25.631,84	
Rail	20157	20157	-30%
road-rail	20989,85	20.893,85	
Road	27071,84	26.207,84	
Rail	20157	20157	-10%
road-rail	20989,85	20.957,85	
Road	27071,84	26.783,84	
Rail	20157	20157	-1%
road-rail	20989,85	20.986,65	
Road	27071,84	27.043,04	
Rail	20157	20157	0%
road-rail	20989,85	20.989,85	
Road	27071,84	27.071,84	
Rail	20157	20157	1%
road-rail	20989,85	20.993,05	
Road	27071,84	27.100,64	
Rail	20157	20157	10%
road-rail	20989,85	21.021,85	
Road	27071,84	27.359,84	
Rail	20157	20157	30%
road-rail	20989,85	21.085,85	
Road	27071,84	27.935,84	
Rail	20157	20157	
road-rail	20989,85	21.149,85	50%
Road	27071,84	28.511,84	

Sensitivity Genoa-Strasbourg for road-rail transport(rail part)/track

	AVE		-50%
Rail	20157	17.987,80	
road-rail	20989,85	18.970,25	
Road	27071,84	27071,84	
Rail	20157	18.857,80	-30%
road-rail	20989,85	19.780,25	
Road	27071,84	27071,84	
Rail	20157	19.727,80	-10%
road-rail	20989,85	20.590,25	
Road	27071,84	27071,84	
Rail	20157	20.110,60	
road-rail	20989,85	20.946,65	-1%
Road	27071,84	27071,84	
Rail	20157	20.157,00	
road-rail	20989,85	20.989,85	0%
Road	27071,84	27071,84	
Rail	20157	20.203,40	
road-rail	20989,85	21.033,05	1%
Road	27071,84	27071,84	
Rail	20157	20.597,80	10%
road-rail	20989,85	21.400,25	
Road	27071,84	27071,84	
Rail	20157	21.467,80	30%
road-rail	20989,85	22.210,25	
Road	27071,84	27071,84	
Rail	20157	22.337,80	50%
road-rail	20989,85	23.020,25	
Road	27071,84	27071,84	

Sensitivity Genoa-Strasbourg for road-rail transport(rail part)/energy

	AVE		-50%
Rail	20157	18.475,00	
road-rail	20989,85	19.423,85	
Road	27071,84	27071,84	
Rail	20157	19.147,80	-30%
road-rail	20989,85	20.050,25	
Road	27071,84	27071,84	
Rail	20157	19.820,60	-10%
road-rail	20989,85	20.676,65	
Road	27071,84	27071,84	
Rail	20157	20.122,20	
road-rail	20989,85	20.957,45	-1%
Road	27071,84	27071,84	
Rail	20157	20.157,00	
road-rail	20989,85	20.989,85	0%
Road	27071,84	27071,84	
Rail	20157	20.191,80	
road-rail	20989,85	21.022,25	1%
Road	27071,84	27071,84	
Rail	20157	20.493,40	10%
road-rail	20989,85	21.303,05	
Road	27071,84	27071,84	
Rail	20157	21.166,20	30%
road-rail	20989,85	21.929,45	
Road	27071,84	27071,84	
Rail	20157	21.839,00	50%
road-rail	20989,85	22.555,85	
Road	27071,84	27071,84	

Sensitivity Genoa-Strasbourg for road-rail transport (rail part)/leasing

	AVE		-50%
Rail	20157	18.044,50	
road-rail	20989,85	19.202,35	
Road	27071,84	27071,84	
Rail	20157	18.889,50	-30%
road-rail	20989,85	19.917,35	
Road	27071,84	27071,84	
Rail	20157	19.734,50	-10%
road-rail	20989,85	20.632,35	
Road	27071,84	27071,84	
Rail	20157	20.114,88	
road-rail	20989,85	20.954,21	-1%
Road	27071,84	27071,84	
Rail	20157	20.157,00	
road-rail	20989,85	20.989,85	0%
Road	27071,84	27071,84	
Rail	20157	20.199,38	
road-rail	20989,85	21.025,71	1%
Road	27071,84	27071,84	
Rail	20157	20.579,50	10%
road-rail	20989,85	21.347,35	
Road	27071,84	27071,84	
Rail	20157	21.424,50	30%
road-rail	20989,85	22.062,35	
Road	27071,84	27071,84	
Rail	20157	22.269,50	50%
road-rail	20989,85	22.777,35	
Road	27071,84	27071,84	

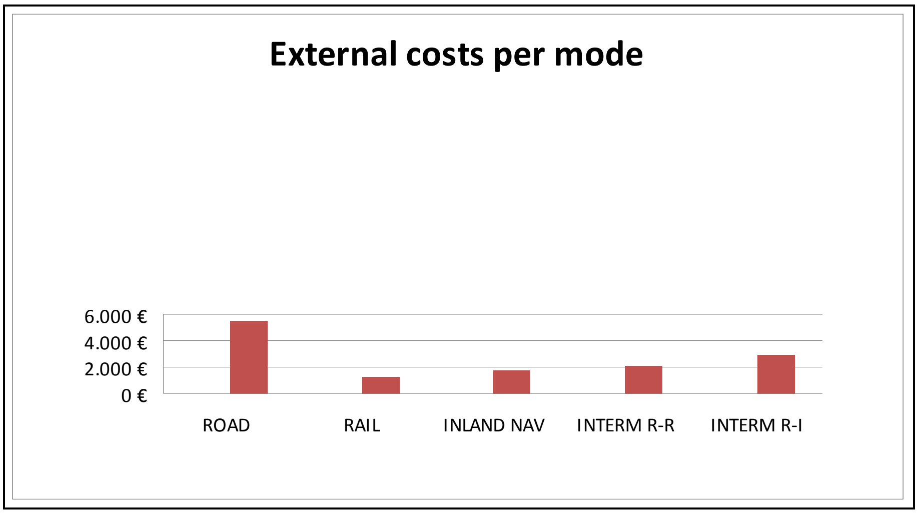
ANNEX 7.1

ADDITIONAL EXTERNAL COSTS CALCULATIONS

External costs for the Antwerp-Basel Corridor (During night, electric train)

Antwerp-Basel			
Mode	**Out of pocket cost (AVE)**	**L.D. 100%**	**Sum**
Rail	20.221,00	1319,07	21.540,07
Road-Rail	22.378,85	2106,21	24.485,06
IWW	24.792,88	1774,07	26.566,95
Road	26.188,76	5517,54	31.706,30
Road-Iww	29.147,50	2903,90	32.051,40

Source: own elaborations



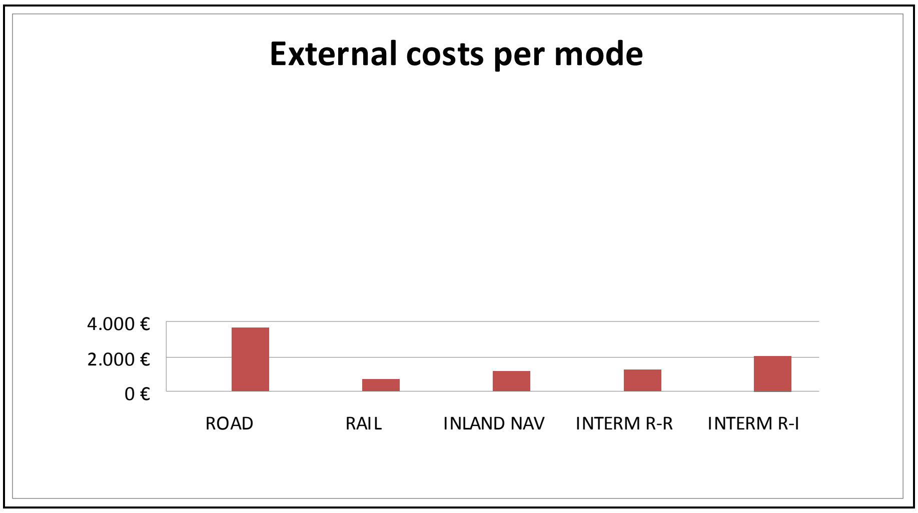
External costs per mode for the Antwerp-Basel Corridor (During night, electric train)

Source: own elaborations

External costs for the Antwerp-Frankfurt Corridor (During night, electric train)

Antwerp-Frankfurt			
Mode	**Out of pocket cost (AVE)**	**L.D. 100%**	**Sum**
Rail	12.289,00	734,86	13.023,86
Road-Rail	12.945,85	1288,32	14.234,17
Road	16.892,64	3642,12	20.534,76
IWW	20.199,60	1196,00	21.395,60
Road-Iww	22.074,14	2036,80	24.110,94

Source: own elaborations



External costs per mode for the Antwerp-Frankfurt Corridor (During night, electric train)

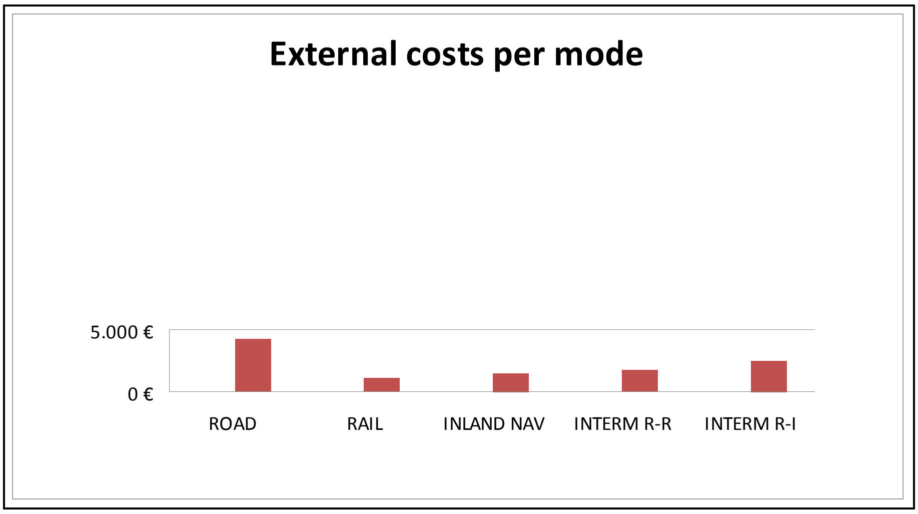
Source: own elaborations

External costs for the Antwerp-Strasbourg Corridor (During night, electric train)

Antwerp-Strasbourg			
Mode	**Out of pocket cost (AVE)**	**L.D. 100%**	**Sum**
Rail	17.033,00	1065,54	18.098,54
Road-Rail	17.689,85	1751,28	19.441,13
IWW	20.603,48	1544,83	22.148,31
Road-Iww	21.211,04	2560,05	23.771,09

Road	22.477,21	4276,32	26.753,53

Source: own elaborations



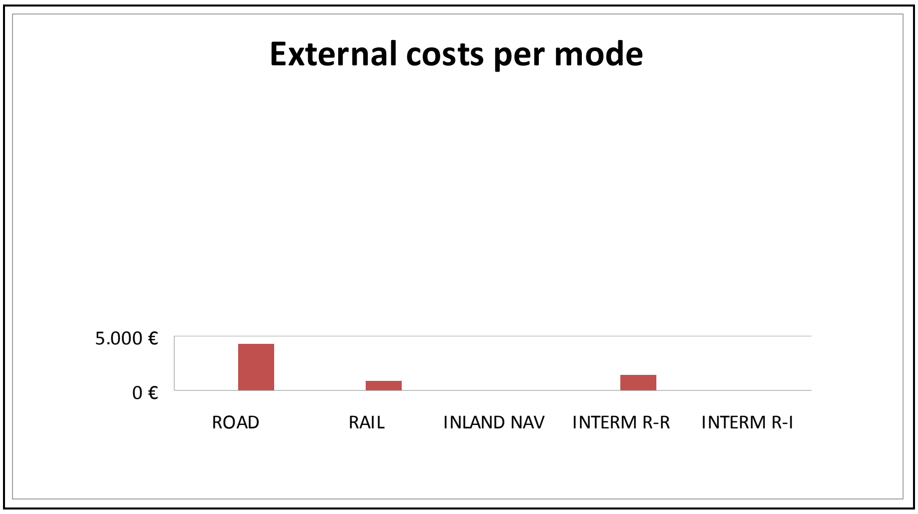
External costs per mode for the Antwerp-Strasbourg Corridor (During night, electric train)

Source: own elaborations

External costs for the Genoa-Basel Corridor (During night, electric train)

Genoa-Basel			
Mode	**Out of pocket cost (AVE)**	**L.D. 100%**	**Sum**
Rail	17111	837,74	17.948,74
Road-Rail	19425,85	1478,64	20.904,49
Road	21367,68	4294,44	25.662,12

Source: own elaborations



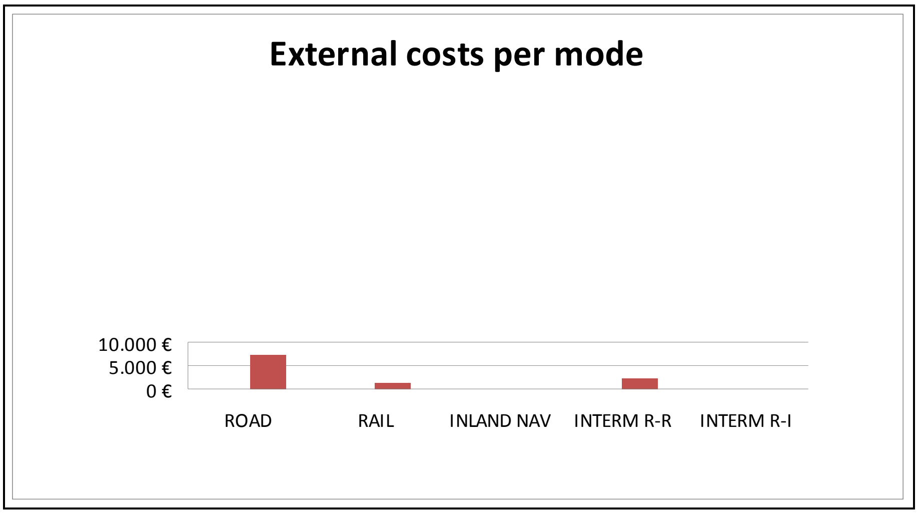
External costs per mode for the Genoa-Basel Corridor (During night, electric train)

Source: own elaborations

External costs for the Genoa-Frankfurt Corridor (During night, electric train)

Genoa-Frankfurt			
Mode	**Out of pocket cost (AVE)**	**L.D. 100%**	**Sum**
Rail	26038	1447,67	27.485,67
Road-Rail	26664,85	2291,40	28.956,25
Road	35280	7248,00	42.528,00

Source: own elaborations



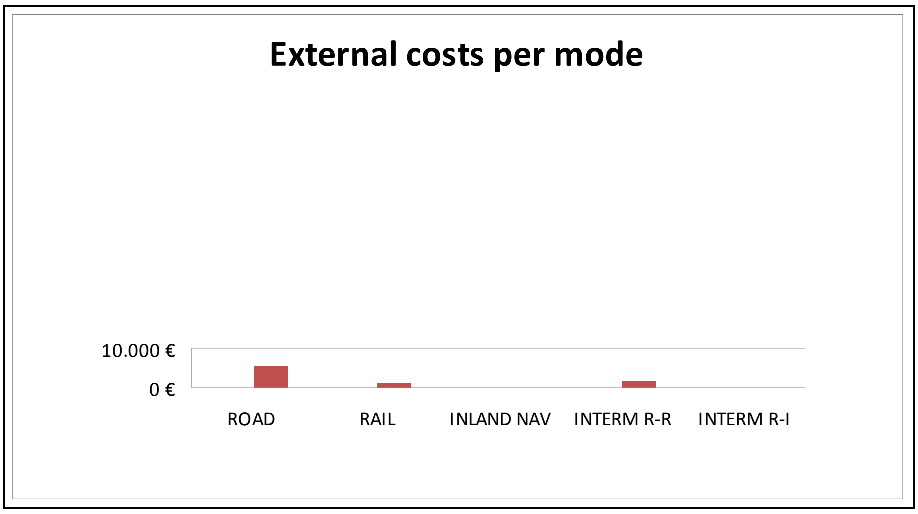
External costs per mode for the Genoa-Frankfurt Corridor (During night, electric train)

Source: own elaborations

External costs for the Genoa-Strasbourg Corridor (During night, electric train)

Genoa-Strasbourg			
Mode	**Out of pocket cost (AVE)**	**L.D. 100%**	**Sum**
Rail	20157	1065,54	21.222,54
Road-Rail	20989,85	1751,28	22.741,13
Road	27071,84	5544,72	32.616,56

Source: own elaborations



External costs per mode for the Genoa-Strasbourg Corridor (During night, electric train)

Source: own elaborations

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