Charging and pricing in the area of inland waterways

Practical guideline for realistic transport pricing

Final report

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Summary

Background

In the White Paper the European Commission has expressed its interest in charging for infrastructure use as a means to increase efficiency and sustainability of the transport system. Economic theory clearly indicates that pricing policies based on marginal costs lead to better usage of the available transport capacity than pricing policies based on average costs or cost recovery rules.

The purpose of this study is to enable the Commission to prepare a Community Framework for infrastructure charging based on marginal costs on the inland waterways in the European Union.

Theoretical framework

The marginal (social) costs are defined as the costs generated by an additional transport unit when using the infrastructure. Some of these costs are internal costs and are borne by those who cause them, other are external marginal costs that are not borne by those who cause them, but affect third parties (such as pollution and accidents). If the external costs are however not borne by those who generate them, then the market mechanism fails to allocate resources efficiently. By taking into account the external costs in the marginal costs the volume of transport activity will reach the socially optimal level.

The study focuses on short run marginal costs, assuming that capacity of the infrastructure is constant. Long-run marginal costs include also the capital costs of increasing capacity to accommodate an increase in output; they are difficult to measure. Linking charges to long-run marginal costs would lead to inefficiencies where excess transport capacity exists. Although this study focuses on the short-term marginal costs an indication will be given of what happens if investment costs are included.

The short run marginal social costs generated when an additional vessel uses an inland waterway can be divided into the following main types of costs:

- *Infrastructure costs*; the increased costs of operating, maintenance and repair of infrastructure and technical facilities as a result of an additional vessel.
- *Environmental costs*; additional damage resulting from emissions to air, water and soil from an additional vessel, including noise pollution.
- *Safety and accident costs*; the economic value of the change in accident risk when a user enters the traffic flow (this risk relates to the user himself as well as to others). These costs include repair costs, medical costs, suffering and delays imposed on others as a result of an accident.
- *Congestion costs*; increased operation costs and costs of extra time spent travelling as a result of an additional vessel entering the traffic flow or an accident.

Marginal infrastructure costs

In order to determine marginal infrastructure costs three main approaches have been followed in five case studies;

- Econometric approach;
- Engineering approach;
- Cost-allocation approach.

The decision on the type of approach was driven by the availability and quality of input data. All three methods have advantages and caveats. *Econometric approaches* are based on observed behaviour of costs, but the observed costs do not always follow technical needs resulting from the use of infrastructure, i.e. do not necessarily reflect true marginal costs. *Engineering-based methods* are built on technical relationships between costs and usage of the infrastructure, but this does not necessarily reflect actual spending. It gives rather an estimate of marginal costs under the assumption that all infrastructure assets are properly maintained and renewed. Both econometric and engineering based approaches require a considerable amount of high-quality data with a demanding level of detail.

The *cost-allocation approach* tries to split up relevant costs into fixed and variable costs. Fixed costs do not vary with the number of vessels, variable costs have a direct relation with the number of vessels. For this approach the same applies as for the econometric approach: the observed costs do not necessarily reflect the true costs due to for example postponement of infrastructure costs. An advantage of this method is that the need for cost information is considerably lower compared to the econometric and engineering based approach.

In the case studies the econometric approach proved to be a problematic one: an adequate sample size with sufficient variability amongst the explanatory variables required disaggregate data for individual stretches of infrastructure and this kind of information was not always available. It became also clear that expenditures on maintenance and renewals are influenced by the financial resources of the organisation responsible: maintenance cost were low due to postponement or maintenance costs suddenly increased because there was not enough financial resources to replace parts of the infrastructure leading to higher maintenance costs. The engineering based approach was not practical at all: there was no knowledge available within the organisations to follow this approach.

The cost-allocation approach was the method commonly used. This method however required a thorough analysis of the available data, lots of interaction with the organisation providing the data and decision making which is always influenced by the judgement of the researcher. Also for this approach the same applies as for the econometric approach: the observed costs did not always reflect the true costs due to amongst others postponement of infrastructure costs.

Our view is that the methodological approach of cost-allocation to determine the marginal costs of inland waterways has potential as general approach to be used for inland waterways in other countries. A potentially major inherent drawback of the approach is that it is depending on detailed data specific to the waterway concerned, which may not be readily available in other countries.

Before a common approach of cost-allocation can be introduced it is in our opinion necessary to introduce a common method of cost registration: how are the costs of waterways to be registered, what costs can be attributed to inland shipping (and what cost to for example flood protection, water management etc.), what kind of cost items have to be identified, what do these cost items comprise, what percentage of the different costs items vary with usage, etc.

Second best solution

As a result of the difficulties in obtaining the right data it was hard to determine the real current marginal infrastructure costs for inland waterways in the different case studies. As a second best solution, in order to get an indication of the marginal costs, the average user-dependent costs have been determined. These costs are determined by dividing the total (freight)user dependent costs by the total number of (freight) vessel kilometres (average (freight) user-dependent costs = total (freight) user dependent costs / total (freight) number of vessel kilometres). The following table gives an overview of the range of the average user-dependent costs per freight vessel-kilometre, which have been assessed in the various case studies.

Table 0.1 Average user-dependent costs for freight vessels per waterway

Waterways	CEMT	Lower	Upper
Amsterdam-Rhine Channel (NL)	VIb (6400-12000)	€ 1,14	€ 1,15
Prinses Margriet Channel (NL)	Va (1500-3000)	€ 0,27	€ 0,45
Van Starkenborgh Channel (NL)	Va (1500-3000)	€ 0,67	€ 0,91
Basin Rhone-Saone (F)	1500 up to 6000 tons	€ 0,06	€ 0,50
Danube – Austria (A)	VIa-c (3200-18000)	€ 0,14	€ 0,18
Main-Danube Channel (D)	Vb (3200-6000)	€ 2,45	€ 3,31

Marginal environmental costs

The marginal environmental costs consist of the damage resulting from emissions and/or noise pollution, caused by the usage of the infrastructure. These costs can be determined with a top-down approach, starting with the total costs on a macro-level and dividing them to the total amount of activity leading to the costs. This however will lead to average costs that generally do not account for differences in location, environment and conditions. Another method is the bottom-up approach, starting at a micro-level and modelling the path from emission to impact and costs. This method is called the *impact pathway approach*.

This impact pathway approach was developed in the EU funded ExternE project and can be considered as state-of-the-art for air pollution and noise valuations. The impact pathway approach can be based on the TREMOVE data. This data is required through a model that covers passenger and freight transport in the EU-15 countries plus 6 other countries. For the inland waterway transport 21 types of vessels and sizes of vessels are distinguished. Regarding the valuation of the emissions the BeTA database can be used, which eventually resulted from the ExternE project. In our opinion it is thus possible to determine the marginal environmental costs at least for the EU-15 countries.

For the noise costs a simplified *cost-allocation* method is proposed. Specific information is needed on the number of households that are exposed to a certain noise level. However this information should be relatively easy made available in the countries. The valuation of the noise pollution will ideally be based on a specific willingness-to-pay, but can also be based on the EC Workshop that established a valuation between € 5,00 and € 50,00 per household per dB per year. It must thus, according to our opinion, also be possible to determine the total noise costs for the different EU countries. However, to arrive at marginal costs – the additional noise costs that arise when an additional vessel enters the traffic flow – one can estimate the monetarised change in noise level and attribute the corresponding costs to the change in the number of vessels.

Marginal safety and accidents costs
A cost-allocation method is proposed to determine the marginal safety and accidents costs. In general, the *risk elasticity approach* is used. In this approach the *risk* must be determined, that varies between type of waterway, usage of infrastructure and type of vessel. The second step is to determine the *elasticity*, that is the relation between the risk and the number of users of the infrastructure. This is very difficult to determine. In previous studies, such as the EU funded UNITE project, this risk elasticity is set at 0,01. The third step is to determine the monetary value for changes in accidents frequencies, which are ideally based on the willingness-to-pay. Finally the last step is to determine which part of the safety costs is related to internal costs that are covered by paid insurance.

This approach requires detailed information on the number and severity of accidents on the inland waterway, and the involvement of inland shipping vessels within these accidents. This data will not be available on a detailed level for all countries. For the Netherlands the case studies have demonstrated that the registration level is not completely accurate. The data however showed that most accidents in the inland waterway transport do not lead to human losses, but only to damage on the infrastructure, vessel and perhaps cargo. The percentage of these costs that are covered by the insurance premiums is not known. In our opinion it will be rather difficult to determine the accidents costs in detail for the different countries, since in most countries the safety and accident statistics or not accurate, especially for the inland waterway transport. However, related to the total transport performance, these costs seem of minor importance.

Marginal congestion costs
The marginal congestion costs are very difficult to determine. In general the congestion costs for a specific mode of transport are determined using speed-flow functions or demand-delay functions. For the inland waterway transport, information on these functions is lacking. This requires detailed information on passing times of bridges and locks.

The congestion costs have rarely been estimated and are expected to be rather small. However for a waterway that has several locks and/or bridges that need to be opened, the congestion costs can be significant.

In a previous study ECORYS has developed a 'waiting-time lock model'. In this model the relationship is modelled between intensity, capacity of the lock and average waiting time. Together with a valuation of waiting time for freight vessels the total waiting time costs in a year for a lock can be determined. Dividing these costs by the number of vessels will result in average congestion costs for one vessel.

Disadvantage of this method is that not the marginal congestion costs are determined, but the average congestion costs. And these average congestion costs are already paid by the inland shipping companies: by doing business the shipping company has already taken into account the fact that there will be waiting times for using locks. It would therefore be unfair to let shipping companies pay these congestion costs again, now only as really out-of-pocket expenses. This means that they have to pay the congestion costs twice. What we are looking for are the additional congestion costs that arise when one additional vessel enters the traffic flow. These are the real marginal congestion costs.

A practical way to determine these costs is by using the 'waiting-time lock model' for two following years. The change in the total waiting-time costs in the t+1 year can attributed to the change in the number of vessels and these costs can be seen as the marginal congestion costs. A further improvement of the method would be if the valuation of waiting time could be more specified, taking into account the type of vessels.

Practical guidelines

Main objective of the study was to provide the European Commission with a practicable and transparent methodology, which could be easily applied by the Member States in order to calculate infrastructure costs that could be allocated to freight vessels in particular. The last section of the report provides practical guidelines, which enable to:

- Translate yearly infrastructure expenditures to yearly infrastructure costs;
- Calculate the various constituent elements of the marginal costs for inland shipping.

Guidelines to come from yearly expenditures to yearly costs1

For a number of reasons maintenance costs being registered by administrators do not always reflect the actual yearly infrastructure costs. When infrastructure expenditure figures are available (preferably for three to four years but at least for two years), infrastructure administrators should perform the following data checks, and if necessary should adapt figures accordingly, in order to translate yearly expenditures into yearly cost:

1) *Has the waterway been upgraded to a higher CEMT category during the years for which the cost figures are available?*
   If the waterway infrastructure has been upgraded, maintenance costs must be increased since upgrading of infrastructure will result in lower regular maintenance costs for the relevant year(s) the waterway has been upgraded. This will be of relevance especially for dredging costs and embankment costs.
2) *Have there been tight budgetary restrictions resulting in backlogging of maintenance?*

[1] It must be noted that the guidelines proposed here will be preceding a more elaborated methodology which will be developed on behalf of the Commission in the study "From infrastructure expenditure to infrastructure costs", also headed by ECORYS. This future methodology will provide a real practical and policy solution for proper registration of infrastructure costs. Therefore the guidelines presented here can be applied, for the time being, to translate yearly expenditures on infrastructure into yearly infrastructure costs.

Budget restrictions are expected to result in relative low actual maintenance expenditures. It should be determined, with what factor the expenditures should be upgraded to arrive at the actual costs, which are necessary to prevent backlogging.

3) *Have any reservations been made?*
   It has to be determined whether or not reservations are made in one year that results in lower expenditures in the next year. If reservations have been made waterway authorities/administrators have to assess the actual amount of these reservations first. Subsequently, actual expenditures have to be corrected from year to year.
4) *Are infrastructure costs always been registered in the 'right' year?*
   Sometimes bills are not being paid in the (fiscal) year the costs were actually made, however these costs show up in the next year. Therefore cost figures collected should be checked on yearly fluctuations (see also point 5).
5) *Are maintenance costs subject of strong fluctuations from year to year?*
   Maintenance and renewal costs, which show relatively strong cost fluctuations from year to year, should be averaged over the years. High maintenance costs made in one year should be averaged over a 10-year period.
6) *Has there been a change in the cost registration method as a whole or in the costs registration of certain cost units?*
   If this is the case it must be determined whether cost fluctuations between years are caused by this methodological modifications, and if so a correction must be made.
7) *Has there been a shortage of personnel?*
   If this has occurred in certain years, expenditures for personnel should be increased with the amount that is necessary to employ these people in order to arrive at the necessary costs.

When the expenditures on the inland waterway are translated into the necessary costs, one can start to calculate the total (short run) marginal costs of using an inland waterway. A practical way of doing this is hereafter.

Guidelines to calculate the various marginal cost elements of inland shipping

The report describes in detail how the various costs elements of inland shipping can be calculated. In this summary we provide the practical formulas for marginal infrastructure costs, accident costs, environmental costs and congestion costs.

In order to calculate marginal infrastructure costs a four step approach can be followed:

Table 0.2 Calculating marginal infrastructure costs

Step 1: Total infrastructure costs of an inland waterway made for inland shipping = **%** of total inland waterway costs made for inland shipping[1)] x total infrastructure costs of the relevant inland waterway *1) Share of total inland waterway costs made for inland shipping is 71% to 80% in the case studies*
Step 2: Variable infrastructure costs of an inland waterway made for inland shipping = % of variable costs[2)] x total infrastructure costs of an inland waterway made for inland shipping[3)] *2) = 15-28% in the Dutch case studies* *3) = Result of step 1*

Step 3: Variable infrastructure costs of an inland waterway made for freight vessels = % of variable costs attributable to freight vessels x variable infrastructure costs of an inland waterway made for inland shipping[4)]

4) = Result of step 2

Step 4: Marginal infrastructure costs per vessel km = (variable costs in year t+1 – variable costs in year t) ÷ (number of vessel km in year t+1 – number of vessel km in year t)

In order to calculate marginal accident, environmental and congestion costs the following formulas can be applied:

Table 0.3 Calculating marginal accident, environmental and congestion costs

Marginal (external) accident costs per passage on a river/canal = (total damage costs per year to infrastructure
+ total costs per year of victims injuries/deaths x 0,5 + total administrative costs per hospitalized person) x risk elasticity ÷ number of tonne-kilometres

Marginal (external) air pollution costs per vessel kilometre per type of emission = emission factor per vessel kilometre per type of pollutant x monetary valuation of emissions

Marginal noise costs = Number of households or people exposed to a noise level > 60 dB(A) due to inland shipping x valuation of noise per household or person per dB(A)[1)] ÷ total number of vessel kilometres by type
1) Valuation of noise = € 23,50 per dB per household or € 10 per person

Marginal congestion costs per vessel = (total waiting time in year t+1 x value of waiting time[2)]) – (total waiting time in year t x value of waiting time) ÷ (number of vessels in year t+1 – number of vessels in year t)
2) Value of waiting time: € 78 per hour for container shipments and € 74 for non-container shipments

1 Introduction

1.1 Background

Economic view on transport problems

The European transport infrastructure is of great importance for economic growth, labour mobility and competitiveness of the European Community. Therefore its provision and use should be as efficient as possible. However infrastructure managers are reluctant to invest due to growing financial burdens and the wish to develop involvement of the private sector. At the same time the market fails to reflect external costs in its prices, so that the use of some modes is at time excessive. The tax and charge differentials distort prices of the market and thus distort transport choices. An economic view to these issues could help to understand the problems.

Increasing efficiency of transport system by charging its usage

In the White Paper it is mentioned that in an efficient and competitive transport sector the different costs are taken into account by the provision and use of infrastructure. For the provision the decision should be based on socio-economic cost-benefit analysis and regarding the use of infrastructure the decision should be based on the actual variable costs (both internal and external). The European Commission has thus expressed its interest in charging for infrastructure use as a means to increase efficiency and sustainability of the transport system.

Charging policies are most effective if based on marginal costs

Economic theory clearly indicates that pricing policies based on marginal costs lead to better usage of the available transport capacity than pricing policies based on average costs or cost recovery rules. The marginal costs are those variable costs that reflect the cost of an additional vessel using the infrastructure. In order to attain a certain level of practicability, the Commission stated in its White Paper that the marginal costs should reflect infrastructure damage, congestion and pollution costs and should thus vary over factors like vessel size, peak times and engine emissions. Despite the preference of marginal costs, these are much more difficult to determine than average costs.

Research to deepen theoretical knowledge of marginal costs

The last years several research projects were carried out to deepen the theoretical knowledge and to bridge the gap to implementation. Particularly the UNITE research project was an ambitious attempt to broaden the theoretical and practical basis for social marginal cost charging. The results of this project were very promising, but the need for practical working knowledge does exist. This study aims to increase the working knowledge of social cost charging for inland waterway transport.

Necessity of one Community Framework
Besides practical working knowledge it is important for the Commission to provide a Community Framework in order to decrease differences between charging systems in EU member states, since this creates market distortions.

1.2 Aim of the project

The purpose of this study is to enable the Commission to prepare a Community Framework for infrastructure charging on the inland waterways in the European Union.

Therefore this study will describe in a practical way the methods and cost calculations for transport pricing on different types of inland waterways. The cost calculations will be explained by using a number of case studies.

1.3 How to read this report

This report is divided into four main sections. The first section called *theoretical framework* starts with the general framework and definition of (marginal) costs. Subsequently, each of the (marginal) cost categories will be subject of further analysis in the following chapters (3-6), by identifying the relevant cost drivers and by describing the method to estimate marginal costs in theory. The second part deals with the *practical application* of the theoretical framework regarding infrastructure costs into *case studies*. After a short introduction (chapter 7), this part of the report presents the results for each case study achieved in separate chapters (8-12). In chapter 13 the existing infrastructure charging mechanisms are described, after which in chapter 14 conclusions regarding to the marginal infrastructure costs are given. The third part of this report deals with the practical application of the theoretical framework regarding the other marginal costs elements (safety costs, congestion costs and environmental costs, in respective chapters 15-17). The final (fourth) part of this study, the *Practical guidelines*, describes in short a step-by-step method to be followed in practice for translating yearly expenditures into yearly costs (chapter 18) and calculating the various constituent elements of the marginal costs of inland shipping (chapter 19).

Part I: Theoretical framework

2 Charging for infrastructure use: marginal pricing issues

Towards a Community framework for infrastructure charging

In the past, EU Member States generally have chosen their own method of charging or taxing infrastructure use. In most cases, the charging principles are not related to the costs of providing and maintaining this infrastructure, neither do they reflect the marginal external costs of the use of this infrastructure. The differences between the charging systems in EU member states clearly create market distortions in the European transport market, as is clearly demonstrated in the EU white paper "Fair payment for infrastructure use" (chapter 2). The major issues in this respect are the following:

- Market distortions between Member States.
- Distortions of competition between modes and within modes
- Failure to consider social and environmental aspects of transport
- Difficulties in funding infrastructure investments.

It is the aim of the EU to base the framework on marginal social cost pricing, since it will solve most of the signalled distortions that occur nowadays.

Definition of marginal costs

The High Level Working Group on infrastructure charging defines the marginal costs as the costs generated by an additional transport unit (in case of IWT a vessel) when using infrastructure (in this case inland waterways). These costs include variable costs that vary with the level of traffic. Some of these costs are *internal* costs and are borne by those who cause them. There are however also *external* marginal costs that are not borne by those who cause them, but affect third parties; these costs have not been internalized in the charges paid.

Difference between short and long run marginal costs

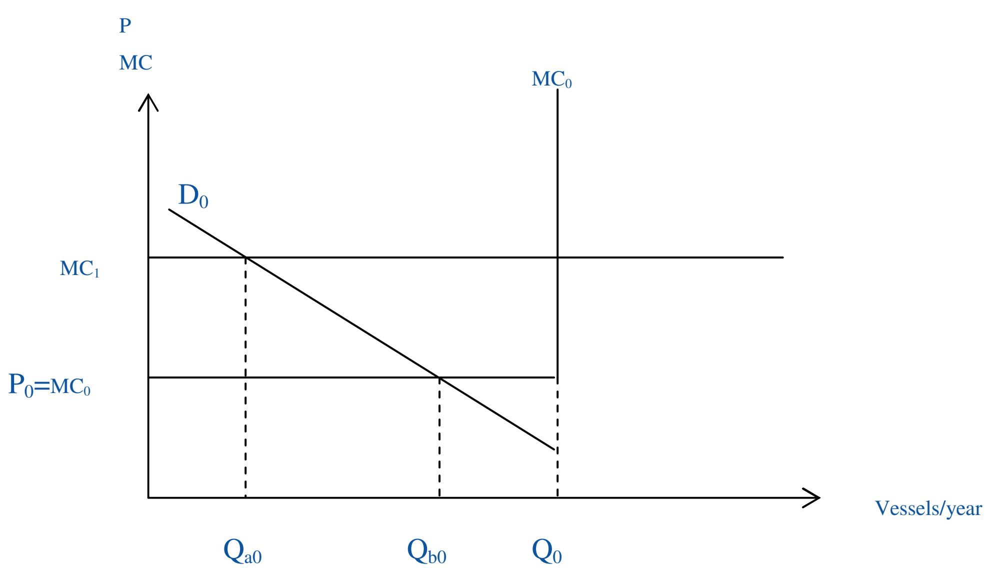
There is a rather large theoretical difference between short and long run marginal costs. When a longer period is observed obviously more costs are variable, including cost categories such as investment costs. Short run marginal costs are defined for a period in which the capacity is fixed. In this study the focus lies on short run marginal costs, according to the High Level Working Group and the UNITE project. This can be explained in the following.

In an optimal situation capacity is assumed to be perfectly flexible in the sense that it can be varied as demand varies. In reality, the output or capacity of transport infrastructure is often fixed in the short run. This means that without investment in extra capacity, there is a physical limitation on output in the short term.

The capital costs of physical transport infrastructure are often much higher than the associated operating and maintenance costs, and can be very long-lasting. As a result, infrastructure facilities like inland waterways, locks, ports, bridges etc. give rise to significant economies of scale.

Figure 2.1 illustrates the classic pricing problems associated with transport infrastructure, arising from the existence of high fixed costs and significant scale economies (in this example, in digging and operating a canal). Q or the number of vessels using the canal each year represents the output of the canal. Assuming that all costs increase proportionally with traffic flow, MC_0 would measure short run marginal maintenance costs per vessel using the canal and MC_1 would be comprised of this plus the capital cost per vessel (long run marginal costs). Before the canal is constructed, the capacity flow of vessels can be varied continuously by varying the size and design of the canal, but once digged, capacity is fixed at Q_0, with a fixed capital cost of (MC_1 minus MC_0 multiplied by Q_0).

Figure 2.1 Pricing problems with transport infrastructure



Assume a situation of excess capacity. In this situation, if the marginal user costs were set based on the short run marginal costs, the price would be MC_0 and output or number of vessels using the canal each year would be Q_{b0}. The amount of excess capacity would be Q_0 minus Q_{b0}. Setting the price at this level (P_0), however, would result in a large financial loss to the canal operators, equivalent to the capital costs. This loss will be equal to MC_1 minus MC_0 multiplied by Q_0.

The justification for setting prices equal to short-run marginal cost (under conditions of partial equilibrium) is as follows: suppose under these conditions of excess capacity the canal operators were to set a toll greater than P_0 (MC_0), say, at MC_1. At such a price the number of vessels would fall to Q_{a0} and excess capacity would increase to Q_0 minus Q_{a0}. At this level of demand, the marginal social cost of increased output MC_0 is less than the value that consumers place on the marginal unit of consumption, which is measured by price. Hence, net social benefits are increased by increasing output and utilizing otherwise idle capacity: the capital costs are treated as 'sunken' and could be ignored[2]. In general, therefore, the policy should be that the prices are set in relation to short-run marginal costs, which may lie above, below or equal to long-run marginal costs. Linking charges to long-run marginal costs would lead to significant inefficiencies where excess transport capacity exits.

The financial consequence of (short term) marginal cost pricing for inland waterways can however be that capital costs will not be covered. This will be the case if demand turns out to have been overestimated. The inland waterway operator will still have to meet his 'financial obligations' in respect of the waterway. This could for example be achieved through lump-sum taxes by the government.

Although this study focuses on the short-term marginal costs an indication will be given of what happens if investment costs are included.

Common costs

When the principle of marginal cost pricing is applied to the transport sector one has to take into account common costs. Common costs are incurred as a result of providing services to a range of users. Both recreational vessels and freight vessels may use an inland waterway. If the use of the waterway is terminated for recreational vessels, for example the maintenance costs of locks still have to be borne by the freight vessel. A proportion of inland waterway costs may be allocable to certain users, but a large proportion may not be.

Short Run Marginal cost categories

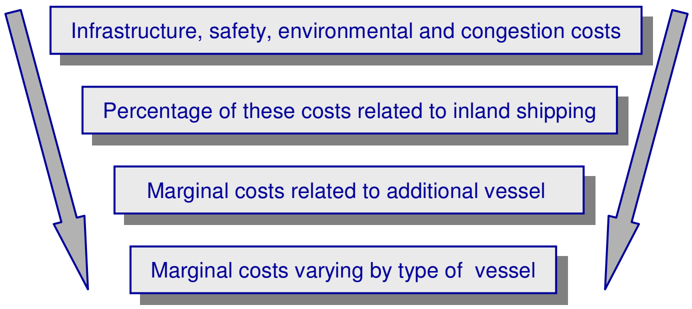
This study focuses on short run marginal costs, assuming that capacity is constant. The additional costs generated when an additional vessel uses the infrastructure can be divided into the following main types:

- *Infrastructure costs*; the increased costs of operating, maintenance and repair of infrastructure and technical facilities as a result of an additional vessel. This thus includes for instance maintenance of embankment, dredging of the waterway, operating locks and bridges and upholding waterway regulations. It is important to determine the amount of infrastructure costs that can be attributable to traffic flows.
- *Environmental costs*; additional damage resulting from emissions to air, water and soil from an additional vessel, including noise pollution.
- *Safety and accident costs*; the economic value of the change in accident risk when a user enters the traffic flow (this risk relates to the user himself as well as to others). These costs thus include repair costs, medical costs, suffering and delays imposed on others as a result of an accident.
- *Congestion costs*; increased operation costs and costs of extra time spent travelling as a result of an additional vessel entering the traffic flow or an accident.

2 If the demand curve was estimated to be D* before the canal was dredged, then the user cost per vessel would be set at MC_1 and the number of vessels using the canal would be Q_0. The user costs will be equivalent to long-run marginal cost and the canal will break even, in that, total revenue will equal total costs, including capital costs. Long-run and short-run marginal costs will be identical at this level of output.

Framework to determine short run marginal costs
Previously, the short run marginal costs were defined as the variable costs generated by an additional transport unit (vessel) when using the infrastructure. In general this means that the following figure should be completed.

Figure 2.2 General approach to marginal costs



First of all the total costs of (using) inland waterways have to be determined. In the next step it has to be determined which part of these costs can be attributed to inland shipping: the costs related to other functions of the waterway, for example water supply, recreation, fishing, irrigation etc. must be subtracted (taken into account the common costs). The resulting costs are the costs made for inland shipping. Analyses of these costs and the number of vessels must lead to the marginal costs related to an additional vessel. If enough information is available these marginal costs can be further specified according to the type of vessel.

Marginal costs versus average costs
The difference between average costs and marginal costs can be explained by using the figure above. Once the percentage of the total external costs that are related to inland shipping is determined, the average costs are estimated by dividing the total costs minus the external costs by the amount of vessels. If these average costs are used in pricing practices, the users are not confronted with the external costs they cause. It is obvious that different types of vessels cause different external costs in different waterways. With the marginal cost theory of an additional vessel it is possible to show the (more) actual external costs, leading to a more fair and efficient pricing principle.

3 Infrastructure costs

3.1 General

Marginal infrastructure costs are the increased costs of operating, maintenance and repair of infrastructure and technical facilities as a result of an additional vessel. This thus includes for instance maintenance of embankment, dredging of the waterway, operating locks and bridges and upholding waterway regulations.

The infrastructure costs consist of capital costs and running costs. Since not all capital costs are varying with the traffic volume it is necessary to distinguish between fixed and variable capital costs[3]. The running costs are expected to be completely variable and are included in the marginal costs. The infrastructure costs are the sum of the variable capital costs and the running costs.

The existing European literature does not contain many estimates for marginal infrastructure costs of inland waterway transport[4]. This is partly due to the lack of necessary data and the general lack of interest in the sector as such (only five member states have significant inland waterway transport). In the Netherlands several studies have been performed by CE and NEA[5] with regards to the variable costs of dredging, operation of locks and bridges, river police and maintenance and management on inland ports. The results varied from 2.4 - 3.9 Euro per vehicle kilometre, depending on which part of the total infrastructure maintenance costs should be considered as being related to inland shipping. Within the EU funded UNITE project the case study approach is chosen to determine the marginal infrastructure costs for the inland waterways. It appeared that for the Rhine case study, the infrastructure maintenance costs related to inland shipping were relatively small.

3.2 Method of estimating marginal costs

Determining cost functions

The infrastructure costs are determined by a cost function, which represents the relationship between cost drivers and the level of infrastructure costs. Depending on the cost category different cost drivers have to be used to assign cost elements to inland

[3] There are two main approaches to distinguish between fixed and variable costs, namely the asset-based approach and the service-based approach (UNITE D3, page 12).

[4] For example the 4th Framework Programs, such as PETS and CAPRI do not include inland waterway transport, only road, rail and air. The final reports of the expert advisors to the High Level Group on Infrastructure Charging do also not explicitly mention inland waterway transport, they focus on road and rail transport.

[5] CE (1999) – Efficiënte Prijzen Verkeer en NEA (2001) – Vergelijkingskader.

shipping. The next table present relevant cost drivers to assign variable infrastructure cost.

Table 3.1 Relevant cost drivers regarding infrastructure costs

Vehicle	Infrastructure	Traffic	Location
Vessel type	Geometry of waterway	Number of vessels	Water level
Vessel size	Construction of waterway		Water velocity
Speed of vessel Draught of vessel	Type of bank stabilization system		Soil type and gradient

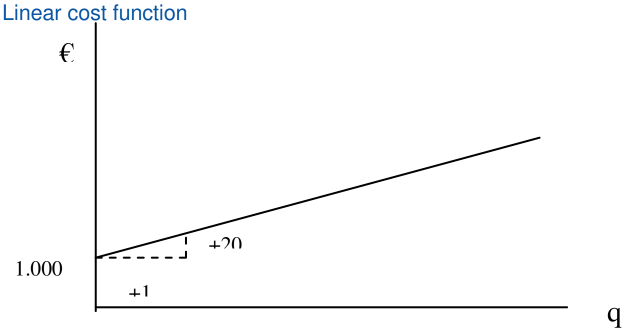
An important question is the form of the cost function: a linear cost curve means that marginal costs are constant (not varying with traffic volume). Such a linear cost function could be:

TC = TVC + TCC
TC = α*q + constant costs

Where TC = total infrastructure costs
TVC = total variable infrastructure costs
TCC = total constant infrastructure costs
α = coefficient (to be estimated)
q = number of vessel kilometres

The next figure gives an illustration of the linear cost function TC = 20*q + 1.000

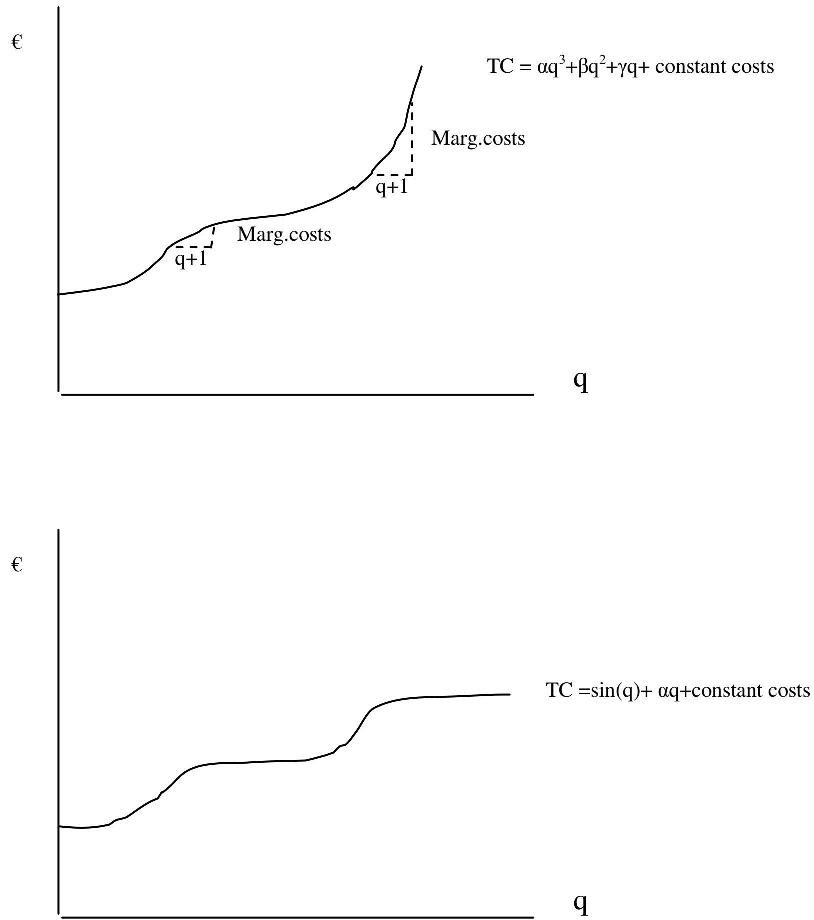
Figure 3.1 Linear cost function



One additional vessel kilometre leads to an increase of the total costs with € 20. To determine the marginal cost (MC) function we have to determine the first derivative of the costs function: MC = 20

In practice however a linear costs function is generally not justified and confirmed by empirical evidence. Other types of functions that therefore can be used to determine the marginal infrastructure costs are the following ones:

Figure 3.2 Specific types of function



As can be seen from the figures above an increase in the number of vessel kilometres does not lead to the same increase in (marginal) costs. The marginal costs can be determined by the first derivative of the total infrastructure cost function.

In order to determine the marginal costs it is therefore necessary to estimate a cost function and to estimate the change in cost with a change in use. In general there are two main approaches to determine cost functions, the econometric and the engineering approach.

The *econometric approach* starts with the real occurring costs and seeks for a function to estimate the marginal costs. This means that the total expenditures, if necessary modified to reflect the equilibrium level of expenditure required, are analysed by using methods such as time series analysis or cross-section analysis. It is obvious that the actual or observed costs do not always follow technical needs resulting from the use of infrastructure, i.e. do not necessarily reflect true marginal costs. During our interviews it has been expressed by several of the respondents that in practice the actual level of maintenance cost expenditures in many cases seems to be more closely related to budgetary and policy developments, than to maintaining certain constant quality levels of maintenance. This would clearly result in misinterpretations when econometric results would come available and would be assessed right away. This means that in order to establish the marginal costs from the real occurring costs, an adaptation will have to be made for postponement of infrastructure costs.

The *engineering approach* starts with estimating the costs of a single infrastructure section based on a technical relationship between input and output, but which are not necessarily reflected in actual spending, and generalizes the results afterwards.

The engineering approach assumes specific knowledge of how specific infrastructure costs are determined and influenced. It has to be known for example how the maintenance costs of canal banks are influenced: what is the exact relation with the type of embankment (peat, concrete, etc), the velocity of the water, the type of ships using the canal, etc. By specifying this exact relation the total costs can be determined as a function of a number of variables. The resulting equation is than manipulated to derive marginal costs.

The econometrics approach is generally preferred since it provides objective evidence of cost causation, not depending on the judgement of the researcher, except regarding issues such as selection of variables. However, it is also problematic. To get an adequate sample size with sufficient variability amongst the explanatory variables generally requires disaggregate data for individual stretches of infrastructure, rather than data for an organisation or a country as a whole. Expenditure on maintenance and renewals may be lagged many years behind the traffic that caused it, so that misleading results may be obtained if an organisation is not pursuing a ‘steady state’ maintenance policy but running down its assets or adjusting maintenance and renewals according to the state of its finances. This applies to inland shipping in particular, because infrastructure damage as a consequence of postponed maintenance and repair occurs in very slow pace.

Since both econometric and engineering based approaches require a considerable amount of high-quality data with a demanding level of detail in practice a third method can be used, the *cost-allocation approach*. This method starts with the cost registration and tries to split up relevant costs into fixed and variable costs on a level of detail that is better (i.e. nearer to marginal cost) than simply applying average costs. For this approach the same applies as for the econometric approach: the observed costs do not necessarily reflect the true costs due to for example postponement of infrastructure costs. An advantage of this method is that the need for cost information is considerably lower compared to the econometric and engineering based approach.

As mentioned before, there is not much relevant literature available regarding the marginal costs of inland waterway transport. Therefore in UNITE a *case study approach* is chosen for the inland waterways. In our project some additional case studies are performed in order to provide insight in the margin in the results and a generalization of the results.

> In the case studies both the engineering and the econometric approach will be used. If it is not possible to estimate practical and generic cost functions, another rather pragmatic solution is to estimate a marginal cost figures via a well-substantiated cost allocation principle.

Contribution of inland shipping to infrastructure maintenance costs

An important complication in calculating the infrastructure costs of inland shipping is that not all costs related to investments, maintenance and management of inland waterways are related to inland shipping. Other functions of waterways for instance water management, flood protection, recreational vessels, and recreational facilities on embankments, also contribute to the costs. Besides the other functions of the waterway the crossing modality is also important. For instances bridges cannot be attributed solely to the inland shipping, since it is at least also partly related to the road traffic. The same applies to some of the locks; these locks are necessary because certain water management measures have been taken in the past. By assessing the importance of a certain stretch of inland waterway for each of the functions that a waterway can have (inland shipping, water management, other users) the allocation of the share of inland shipping in the infrastructure costs can be established.

(Inter)national literature

It has been remarked in previous studies (CE, 2004 and NEA, 2001), that the main difficulty in this respect is to disentangle direct transport related share of waterway maintenance and management costs from other uses of waterways (flood prevention, recreation, irrigation, industrial use, water consumption).

Literature does not contain many estimates with respect to marginal infrastructure costs of inland waterways, due to the fact that only four EU Member States (France, Netherlands, Germany, Belgium) have significant volumes of professional inland shipping. In recent studies infrastructure costs are assigned quite arbitrarily to different functions. In a recent study focusing on the Dutch IWT, variable costs have been divided into:

- Traffic control
- Vessels (patrol)
- Operations (locks and bridges)

It was assessed that around 80% of total traffic control and vessel cost (amounting EUR 36 million) were related to inland waterways. 50% of these costs were variable costs that could be assigned to inland waterway traffic (both professional and recreational), of which around two-third was allocated to freight vessels. Further 50% of operations costs were assumed to be variable costs as well, being assigned to freight vessels (80%) and recreational vessels (20%).

Inland waterway infrastructure costs

Two recent studies[6] have tried to assess the infrastructure and maintenance costs that can be allocated to professional inland waterway transport using a top down approach. Based upon a succession of years (1985-2005), total costs for inland waterways infrastructure for the Netherlands were estimated at EUR 247 million per year, which includes only costs for maintenance and management (building and construction costs are excluded). As already indicated these total costs cannot be allocated exclusively to inland waterway transport, because of the different waterway functions that exist. Relevant costs considered, were costs for:

- Dredging
- Operation of locks and bridges
- River police
- Maintenance and management on inland ports

Subsequently, relevant costs assigned to inland waterways were estimated in between EUR 165 million and EUR 100 million[7], which resulted in an average cost of EUR 2,40 – EUR 3,90 per vessel kilometre. This rough estimate has been assigned to five categories of vessels in proportion to the fleet size (see next table).

Table 3.2 Average infrastructure costs in IWT in the Netherlands

Vessel size (loading capacity in tons	Euro per vehicle kilometre
< 650 ton	0,60
650-1000 ton	1,20
1000-1500 ton	2,40
1500 3000 ton	3,60
> 3000 ton	4,80

Source: NEA, 2001

In 2004 more detailed figures have been calculated for the IWT infrastructure in the Netherlands using cost allocation[8]. A distinction is made into variable and fixed infrastructure cost. Variable costs are costs that change with the fluctuation in number of vessels. Variable costs include:

- Traffic control (including buoys and signalling) amounting EUR 29 million of these costs 80% are made for inland shipping (the other 20% are made for seaports). Of the remaining costs 50% is assumed to be variable, resulting in EUR 12 million. These variable costs are divided over recreational and freight vessels according to the share in the total number of ship passages on a (representative) selection of inland waterways. This resulted in variable traffic control costs attributable to freight vessels of EUR 8 million ;
- Vessels (i.e. patrol vessels and crew) amounting EUR 6 million. For pragmatic reasons it is assumed that 50% of these costs are variable. These variable costs are again divided over recreational and freight vessels according to the share in the total number of ship passages on a (representative) selection of inland

6 Efficiënte prijzen voor het verkeer. Raming van maatschappelijke kosten van het gebruik van verschillende vervoermiddelen, CE, 1999.
Vergelijkingskader Modaliteiten, NEA/Sterc/Transcare, 2001.

7 The exact cost allocation process is not clearly described in the study.

8 Onderhoud en beheer van infrastructuur voor goederenvervoer: structuur en hoogte van kosten, CE, September 2004.

waterways. This resulted in variable costs for ‘vessels’ attributable to freight vessels of EUR 2 million;

- Operational costs (locks and bridges) amounting EUR 50 million. Of this amount 50%, or EUR 25 million, is assumed to be variable. A department of the Ministry of Transport (DWW) estimated that of these variable costs, 20% could be attributed to recreational vessels (EUR 5 million) and 80% to freight vessels (EUR 20 million).

Based on the above assumptions it was calculated that approximately EUR 29 million could be assigned to freight vessels, which results in an average marginal infrastructure cost of EUR 0,53 per vessel kilometre.

Total fixed costs of inland waterway infrastructure amount approximately EUR 300 million in 2002. Allocation of variable and fixed costs to professional inland shipping results in marginal costs per vessel kilometre ranging from EUR 1,95 for the smallest vessel (<250 ton) up to EUR 8,64 for the biggest vessel (>300 ton).

4 Safety and accident costs

4.1 General

Marginal safety cost is the economic value of the change in accident risk when a user enters the traffic flow (this risk relates to the user himself as well as to others).

In general, when a user is entering the traffic flow, he exposes himself to the average accident risk and at the same time changes the risk for other users in the same mode and in some cases other modes. The risk he exposes himself to, is internalized in his decision to travel. Besides the fact that the user internalizes his own risk, he also internalizes part of the external costs through insurance premiums. These insurance premiums must therefore be extracted from the accident costs.

The external accident costs, being the cost one imposes on others, differ between a victim and an injurer. The *victim* has no external accident costs (other than his decision to travel), while for the *injurer* all costs are external costs except for paid insurance and compensation.

4.2 Cost drivers

Table 4.1 Relevant cost drivers regarding safety and accident costs

Vehicle	Infrastructure	Traffic	Location
Vessel size	Maintenance level	Degree of intensity	Location
Technological development	Construction of waterway		Time of day
	Level of segregation between systems		Weather conditions

4.3 Method of estimating marginal costs

General

The valuation of an accident is complicated. Usually the *risk elasticity approach* is used, which is applicable to all modes of transport. The three main parameters are risk, elasticity and marginal private costs of accidents. The *risk* differs between type of waterway (passing of bridges, locks and other vessels) and type of vessel. The *elasticity* is the relationship between the risk and the number of users and depends on vessel type, infrastructure type and traffic volume. The private *marginal costs* consist of the value of a statistical life and costs for the rest of the society (including administrative, material, production losses etc.), modified for the legal and insurance costs. In general the risk and insurance costs are not to be generalized, but the valuation of accidents however can be generalized, taking into account transfers between countries.

The risk elasticity approach consists of four steps:

- Estimate risk; taking into account deaths, injuries and material damage and distinguish between injurers (who cause accidents) and victims (who suffer from accidents).
- Apply risk elasticity; the relationship between traffic volume and accident frequency must be determined, including the marginal increase. This information must be collected from literature, case studies or models.
- Evaluate monetary value; this monetary value for changes in accident frequency can be determined by the willingness-to-pay/avoid method. The marginal safety costs consist of the change in frequency of accidents multiplied by the costs per occurrence.
- Estimate internal and external costs; the marginal costs consist of internal and external costs. The external safety costs are corrected for paid compensation, insurance and fines.

5 Congestion costs

5.1 General

Marginal congestion costs are the increased operation costs and costs of extra time spent travelling as a result of an additional vessel entering the traffic flow or an accident.

For the congestion costs the same applies as for the safety costs; the congestion costs of the user are internalized, but the change in congestion costs for all other users has to be determined. The external congestion costs are for some modes extremely sensitive to small changes in traffic demand. For road transport the change in congestion costs of an additional vehicle is usually determined by speed flow functions. For waterborne transport, methods for estimating congestion have rarely been implemented. Arguments that congestion for non-road modes is internal (particularly if only one service operator exists) or is overcome through realistic timetabling, have often dominated the discussion.

5.2 Cost drivers

Table 5.1 Relevant cost drivers regarding congestion costs

Vehicle	Infrastructure	Traffic	Location
Vessel size	Infrastructure capacity	Intensity of traffic	Locks
Vessel speed	Demand-delay relationship	Mix in traffic	Bridges

5.3 Method of estimating marginal costs

The methods of determining congestion costs for the different modes of transport are generally based on speed-flow functions (road transport) or delay-demand functions (rail transport). The general procedure to calculate the marginal external congestion costs for a specific mode of transport consists of four steps:

- Estimate the relationship between traffic volume and speed (depending on the type of facility, traffic volumes and vehicles characteristics).
- Estimate the relationship between accidents, weather-determined costs and traffic volumes.
- Determine average cost functions.
- Estimate marginal external costs.

For inland waterway transport the marginal congestion costs have rarely been estimated. The increased operation and travel time costs of an additional vessel are expected to be rather small. However for a waterway that has several locks or bridges that have to be opened, the congestion costs can be of greater significance.

This requires detailed information on the passing time of bridges and locks on the specific inland waterway segment. For most segments there will however be no significant congestion for locks and bridges. In part III we will provide a practical guideline to determine the congestion costs.

6 Environmental costs

6.1 General

Marginal environmental costs exist of the damage resulting from emissions to air, water and soil from an additional vessel, including noise pollution. These costs include both vessel use and fuel production. Besides these costs global warming costs might be included.

The definition of environmental marginal costs excludes economic damage related to the presence of infrastructure, such as landscape deterioration, since these costs are not varying with the traffic flow. Changes in noise levels or emissions due to an additional vessel are very small and probably indistinguishable. This could lead to the conclusion that there are no externalities. However, as the sum of all increments has obviously some effect on human beings, each increment can be assigned an increment of cost.

6.2 Cost drivers

Table 6.1 Relevant cost drivers regarding environmental costs

Vehicle	Infrastructure	Traffic	Location
Vessel type	Waterway construction (depth and width)[a]	Receptor density	Population density
Fuel quality		Existing level of traffic	Time of emission
Operation mode		Direction (upstream / downstream)	

a) Depth and width of the waterway influences water flow velocity; at low water levels vessels might have to steer through mud which necessitates more power and thus fuel.

External costs are obviously highly site-specific as can be concluded form the cost drivers mentioned above. The impact depends among others on the population density close to the waterway, the wind direction and speed and flow of the water. Besides the location, the vessel technologies are very important; amongst others the fuel type, fuel use and state of the motor determine the emissions.

6.3 Method of estimating marginal air pollution and noise costs

In general the environmental external effects are determined by estimating the increase in burden, the associated effect and the monetary valuation of the effect.

There are two approaches that can be used;

- *Top-down approach*: The total costs due to externalities are determined for a macro-level (mostly a geographical unit, such as a country). These total costs are then divided by the total amount of activity leading to the costs. In practice this means that allocation is based on the shares of pollutant emissions, vehicle mileage etc. The *average* costs thus obtained do generally not account for differences in location, environment and conditions.
- *Bottom-up approach*: This approach starts at a micro-level; the traffic flow on a particular route. The marginal external costs of one additional vehicle are then determined for this route. This is done by modelling the *path* from emission to impact and costs, which involves modelling emissions, dispersion of emissions, estimation of impacts and applying monetary values. This method is called the *impact pathway approach*.

The High Level Working Group (WG2) recommends the bottom-up methodology as for instance the *Impact Pathway Approach*. They state however that the methodology should provide simplified functions for the relationship between marginal external costs and the most relevant parameters. The Impact Pathway Approach was developed in the ExternE-project (funded by the European Commission from 1996 to 2001) and is often applied in more recent studies on marginal costs, like UNITE (2003). The Impact Pathway Approach can be considered as state of the art for air pollution and noise valuation methods.

Air pollution

In order to determine the air pollution of inland waterway transport, the following five steps from the Impact Pathway approach will be used.

1. Estimate emission from source of airborne pollutants: the emission per vessel should be estimated and modelled. For all categories of inland waterway transport the output of emissions must be determined along with the concentration of these emissions in the different environments. The degree of concentration and exposure to emissions determines the *dose* of pollution received.
2. Determine type of impact: the impact of additional emissions on its receptors must be determined. This means that the relation between additional emissions and impacts on human health, agriculture and environment must be determined. With *dose-response relationships* the impact of different pollutants can be measured.
3. Estimate number of persons, animals and plants exposed to pollution: in this step the emission factors are related to a specific situation.
4. Establish relationship between exposure to pollutants and welfare effects: the physical effects on for instance human health, crops and buildings of the pollution can be determined.
5. Calculate monetary values for the physical effects: This can be done by using market prices if they exist. However in most cases there are no market prices available. Then the willingness-to-pay to avoid certain exposures must be determined. This willingness-to-pay can be determined by using concepts of compensating and equivalent variation.

The basis of this calculation can be found in the TREMOVE data. The TREMOVE model is a policy assessment model to study the effects of different transport and environment policies on the emissions of the transport sector. The model covers passenger and freight transport in the EU-15 plus Switzerland, Norway, the Czech Republic, Hungary, Poland and Slovenia and covers the period 1995-2030. TREMOVE distinguishes 21 types of inland waterway transport vessels, namely 3 types of vessels (cargo, tanker and pusher) and 7 sizes (from under 250 ton until over 3.000 ton). In chapter 19 we will describe in more detail how to derive the air pollution costs. The following table briefly presents some results for the Netherlands.

Table 6.2 Emission costs for most common types of ships (Euro per vessel kilometre)

	RURAL AREA				URBAN AREA (300.000 inhabit.)			
	SO2	Nox	PM	VOC	SO2	Nox	PM	VOC
Dry Cargo 400-650 ton	0,03	0,34	0,07	0,01	0,09	0,34	0,49	0,01
Dry Cargo 1500-3000 ton	0,09	1,28	0,28	0,03	0,31	1,28	1,98	0,03
Tanker 400-650 ton	0,02	0,34	0,06	0,01	0,08	0,34	0,46	0,01
Tanker 1500-3000 ton	0,14	1,98	0,45	0,05	0,49	1,98	3,16	0,05
Push barge400-650 ton	0,12	1,67	0,36	0,04	0,43	1,67	2,51	0,04
Push barge 1500-3000 ton	0,12	1,67	0,36	0,04	0,42	1,67	2,58	0,04

Noise costs

Marginal noise can be interpreted as the impact of noise of additional vessel on amenity and human health. Vibrations lead to amenity losses and damages to buildings. The time of day is an important cost driver for the marginal noise costs. Noise disturbance at night will lead to higher marginal costs than at other times of the day.

For inland waterway transport the marginal noise costs will be rather small and were expected to be negligible within the UNITE study, since the noise impact of a vessel is general low and the population density directly located to the waterway is also low. The main noise emissions will result from handling activities at terminals, but this is not specifically related to inland waterway transport. For the noise costs also the five steps based on the Impact Pathway Approach can be used.

Part II: Marginal infrastructure costs

The case studies

7 Examples of applying the theoretical framework

In this section of the report the marginal infrastructure costs are determined with the use of case studies. In order to have a sound basis for determining which cost drivers are relevant and to develop a practicable methodology, the framework regarding the determination of the marginal infrastructure costs as described in the previous chapters is applied in five case studies. These case studies are chosen in a way that differences in for instance infrastructure characteristics that exist between European waterways will be reflected.

Free flowing rivers, canals and lakes with high and low traffic volume and with different levels of accessibility are subject of these case studies. Aspects as water levels, the number of bridges, locks and ports that might be relevant for development of the marginal cost methodology also play an important role in selecting case study waterways. Last, because the methodology should be practicable and transparent, the availability of data both on costs and infrastructure characteristics is an important criterion in the selection of case studies. Data from official sources (i.e. National Statistical Office, Department for Transport, Governmental bodies, branch organizations), which are released frequently, will be used for this purpose. Following these criteria the following waterways have been selected for case study purposes.

Table 7.1 Criteria for case study selection

Case study	Country	Accessibility (Tonnes)	Infrastructure characteristics	Length
Amsterdam-Rhine Channel	NL	VIb (6400-12000)	Many bridges, locks	73 km
IJsselmeer + Northern Canals	NL	Va (1500-3000)	Lake, free flowing and smaller canals with locks and bridges	74 km
Basin Rhone-Saone	F	Va (1500-3000)	Many locks (126)	860 km
Danube	A	1500 up to 6000 tons	Free flowing river	350 km
Main-Danube Channel	D	VIa-c (3200-18000)	Canal	170 km

The next chapters describe each waterway in more detail. We clearly address, that for instance infrastructure costs (i.e. costs for dredging, servicing locks, bridges) will vary with traffic volume. At the same time traffic volume can vary a lot depending on the waterway section that is studied. Waterway infrastructure, which we analyze in a certain case study, is split into different ‘sections’ for that reason. This guarantees an optimal match of the different costs and cost drivers in a consistent way. By clearly allocating costs to the cost drivers of a certain section first, a robust methodology reflecting the relation between costs and their cost drivers is achieved. The ‘other’ marginal costs (congestion costs, safety costs and environmental costs) are described in **chapter 15-17** since these costs are not case specific.

8 Case study 1: Amsterdam-Rhine Channel

8.1 General information

The Amsterdam-Rhine Channel (ARC) connects Amsterdam with the central and Eastern part of the Netherlands and via the rivers Rhine and Waal with Germany (figure). The ARC measures 73 kilometres in length, whereas 30 bridges are crossing the waterway and 3 locks have to be passed if total length is being crossed. Vessels up to 12000-tonnage capacity can cross all sections. Vessel size permitted on the ARC measures 200m x 23m x 4m (length/width/depth).

Larger cities along this waterway are Utrecht (around 233.000 inhabitants), Diemen (around 24.000 inhabitants) and Wijk bij Duurstede (around 23.000 inhabitants). The ARC mainly serves as freight transport infrastructure. Almost 90% of total traffic is freight transport.

Figure 8.1 Map Amsterdam-Rhine Channel (ARC)

The ARC can be split into three main sections with traffic volume varying because other large waterway connections are crossing here:

- ARC 1: between Amsterdam / IJ and Lek Channel
- ARC 2: between Lek Channel and river Lek-Nederrijn
- ARC 3: between rivers Lek-Nederrijn and Waal

For each of these sections characteristics will be described and quantified in more detail hereafter.

Infrastructure characteristics

The next table shows for each section length, accessibility, and number of ports, bridges and locks.

Table 8.1 Infrastructure characteristics ARC

	ARC-1	ARC-2	ARC-3
Length (km)	42,6	18,6	12,1
Accessibility			
• CEMT	VIb (6400-12000)	VIb (6400-12000)	VIb (6400-12000)
• Ship length	200m	200m	200m
• Ship width	23m	23m	23m
• Ship depth	4m	4m	4m
Number of bridges	20	4	6
Number of locks	0	1	2
Number of ports	4	3	2

Source: Vaarwegkenmerken in Nederland (AVV)

Traffic volume

Traffic volume varies from section to section as is shown in the next table. However, freight transport vessels are dominating traffic for all sections. Total traffic has increased substantially during the period 1996-2002, so has share of freight transport.

Table 8.2 Development total traffic (number of vessels)

Year	1996	1997	1998	1999	2000	2001	2002
ARC-1: total number of vessels	80.423	92.849	92.105	97.889	96.378	94.278	95.990
• recreational	11%	11%	9%	8%	8%	8%	9%
• professional non-freight	6%	5%	6%	5%	5%	5%	5%
• professional freight	83%	84%	85%	86%	87%	87%	86%
ARC-2: total number of vessels	34.427	39.319	40.563	42.203	43.057	41.565	39.687
• recreational	10%	8%	7%	6%	6%	6%	6%
• professional non-freight	3%	4%	4%	3%	4%	4%	4%
• professional freight	87%	88%	89%	90%	90%	91%	90%
ARC-3: total number of vessels	32.439	37.799	38.497	40.580	42.463	42.722	38.916
• recreational	7%	7%	7%	6%	6%	5%	7%
• professional non-freight	3%	3%	3%	2%	2%	2%	3%
• professional freight	90%	90%	90%	91%	92%	92%	91%

Source: Nederland en de scheepvaart op de binnenwateren, Statline (AVV/CBS)

Ship size freight transport

During the last seven years freight traffic has shown a substantial increase (around 20% in the period 1996-2002). The next table clearly shows that an increase in scale has occurred for all sections of the ARC. The number of vessels with a capacity of more than

1000 tonnes increased, whereas the number of vessels less than 650 tons capacity declined.

Table 8.3 Development vessel size (number of freight vessels)

Year	1996	1997	1998	1999	2000	2001	2002
ARC-1: total freight vessels	67.107	77.852	78.380	84.490	83.410	82.031	82.354
21-250 tonnes	783	824	853	798	569	569	570
250-400 tonnes	4.457	5.051	4.559	4.063	3.450	3.049	2.499
400-650 tonnes	13.553	14.920	14.665	13.934	12.512	10.988	10.232
650-1000 tonnes	17.654	20.716	20.040	21.851	21.008	19.721	18.692
1000-1500 tonnes	15.999	19.173	19.915	22.284	22.175	22.178	22.103
1500-2000 tonnes	5.706	6.776	7.136	8.396	8.919	8.749	9.796
2000-3000 tonnes	6.161	7.084	7.078	8.254	9.784	10.984	11.996
> 3000 tonnes	2.794	3.308	3.982	4.742	4.829	5.643	6.326
Unknown	0	0	152	168	164	150	140
ARC-2: total freight vessels	30.004	34.705	36.110	38.072	38.924	37.709	35.602
21-250 tonnes	235	315	394	376	219	187	194
250-400 tonnes	1.207	1.123	1.126	1.123	929	806	629
400-650 tonnes	6.958	7.609	7.082	6.685	6.316	5.193	4.410
650-1000 tonnes	8.418	9.891	10.722	11.624	11.595	10.320	9.142
1000-1500 tonnes	6.733	8.192	8.778	9.541	10.134	10.057	9.488
1500-2000 tonnes	2.146	2.533	2.719	2.884	3.039	3.520	3.926
2000-3000 tonnes	2.837	3.350	3.383	3.700	4.333	4.968	4.990
> 3000 tonnes	1.470	1.692	1.868	2.091	2.308	2.616	2.791
Unknown	-	-	38	48	51	42	32
ARC-3: total freight vessels	29.269	34.188	34.776	37.054	38.881	39.332	35.297
21-250 tonnes	233	316	254	389	207	219	127
250-400 tonnes	983	878	912	901	914	825	699
400-650 tonnes	6.653	7.150	6.633	6.539	6.529	5.479	4.697
650-1000 tonnes	7.969	9.752	10.595	11.210	11.426	10.547	9.293
1000-1500 tonnes	6.807	8.333	8.370	9.320	9.989	10.849	9.209
1500-2000 tonnes	2.213	2.596	2.681	2.777	3.129	3.796	3.675
2000-3000 tonnes	2.916	3.440	3.443	3.766	4.320	4.970	4.792
> 3000 tonnes	1.495	1.723	1.842	2.105	2.309	2.612	2.760
Unknown	-	-	46	47	58	35	45

Source: Nederland en de scheepvaart op de binnenwateren, Statline (AVV/CBS)

The next paragraphs describe the costs related to the ARC waterway infrastructure.

8.2 Infrastructure costs

8.2.1 Cost drivers

Starting point for an estimation of the marginal infrastructure costs of the ARC are the actual total costs of this canal. In the next step these total costs have to be divided between costs made for inland vessel movements and other functions of the canal (for example drainage, drinking water, swimming water etc.).

The total infrastructure costs are a function of the infrastructure characteristics (number of locks, bridges etc.) and the number and characteristics of the vessels. According to the people interviewed, climate conditions and geographical conditions do not play a role in the total infrastructure costs of the ARC. The total infrastructure costs can therefore be described as:

$$TC_{infrastructure} = f\,(I, V)$$

Where I = infrastructure characteristics and
V = vessels (number and characteristics)

From the interviewed authorities information regarding the actual infrastructure costs related to vessel movements was received. The table below shows these infrastructure costs related to vessel movement for the ARC, where a segmentation according to type of cost is made when possible. There are no costs figures available for the period previous of 2001.

Table 8.4 Total actual infrastructure costs ARC that can be attributed to vessels

in k Euro	2001	2002	2003	Necessary maintenance costs
Maintenance costs (periodical and structural)	13.083	16.480	12.871	17.000 (a)
for locks	6.944	9.489	6.064	?
for canal banks	3.755	4.191	3.394	?
for radar maintenance	350	350	350	?
for various items (b)	2.034	2.450	3.063	?
Dredging costs (ports near the locks)	0	0	0	500
Total operational costs locks and traffic guidance	2.155	2.350	2.642	?
costs for locks	1.255	1.360	1.445	?
costs for traffic post Wijk bij Duurstede	900	990	1.197	?
Patrol costs for Ministry (crew and exploitation costs vessels)	1.090	1.015	1.156	?
Police costs	Not known	Not known	Not known	
Total infrastructure costs attributed to vessels	**16.328**	**19.815**	**16.669**	?

(a) In order to compensate for backlogging of maintenance costs an additional 6 million euro/year is needed.
(b) For example removal of car wreckages, depth measurement, removal of (ship) garbage etc.
Source: Transport Department, regional office Utrecht

With regard to the total maintenance costs it was mentioned that the actual expenditures are too low compared to what is really needed, due to budgetary restrictions. It is estimated that the necessary total maintenance costs (see the last column of table 8.4) are around 6 million Euro higher than the actual expenditures on maintenance.

The maintenance costs for locks show an increase in the year 2002 compared to 2001 and 2003. This is due to the fact that big maintenance costs have been made for one lock in that year (Irene lock).

There are no costs for bridges taken into account since all the bridges are at 'Rhine traffic level' (9,10 meters), meaning that these bridges do not have to be opened for freight vessels. The costs of the bridges can therefore be attributed to road traffic and are therefore not taken into account.

There are no dredging costs made (since 1994) although dredging should take place (mainly near the locks). This has resulted in restrictions (depth and speed) for freight vessels near certain locks. The bigger vessels however have engines that are powerful enough to steer through local muddy places.

There is a Traffic Post on the ARC to guide the vessels on the ARC. On the ARC also patrol vessels of the transport ministry supervise the traffic at the canal during a 24-hour period. Cost for the function of water police do also exist. These costs are however not known.

8.2.2 Estimation of marginal costs

It was decided not to use the econometric or the engineering approach in order to determine marginal costs for the ARC. The econometric approach was not used for several reasons:

- Costs figures are only available for a three year period (2001-2003), which is too short for applying the economic approach (as well as the engineering approach);
- The explanatory variable 'Number of vessels' is not known yet for the year 2003, leaving us with only 2 years for econometric analyses: this period is too short for making elaborate econometric analyses. (If the number of vessels in the year 2003 becomes available it will not be a correct number since it is already known that the numbers for the first 3 months are not correct due to computer problems);
- The actual costs made for the ARC do not reflect the necessary costs: due to budgetary reasons the actual costs made are too low compared to what is necessary.

The engineering approach was not used because there was no knowledge available within the Ministry with regard to the relation between costs and variables that influence these costs. Within the Ministry maintenance costs are determined by the technical lifespan. Regular inspections show if this technical lifespan is correct or has to be adapted. If the latter is the case this can have its implications on the maintenance costs. There is however no relation known or used to determine maintenance costs (for example maintenance costs of locks) and a number of explanatory variables (for example number of vessels, type of lock, depth of water).

Therefore the cost-allocation approach is followed. First of all an estimation is made of the costs that would have been made if enough money had been available. The table below gives the result. The maintenance costs have, in accordance with the Province

Utrecht, all been raised with 20%. The maintenance costs for locks have been corrected for the increase in the year 2002 resulting from big maintenance: these costs are now spread over a period of 10 years (after consulting the Province Utrecht). Finally dredging costs are taken into account. Police costs are not known.

Table 8.5 Estimation total infrastructure costs needed for ARC that can be attributed to vessels

in k Euro	2001	2002	2003
Maintenance costs (periodical and structural) of which:	17.101	16.976	16.844
• for locks	9.673	8.517	8.608
• for canal banks	4.544	5.071	4.107
• for radar maintenance	424	424	424
• for various items	2.461	2.965	3.706
Dredging costs (ports near the locks)	500	500	500
Total operational costs for locks and guidance of traffic	2.155	2.350	2.642
• Operational costs of locks	1.255	1.360	1.445
• Operational costs of traffic post Wijk bij Duurstede	900	990	1.197
Patrol costs for Ministry (crew and exploitation costs vessels)	1.090	1.015	1.156
Police costs	Not known	Not known	Not known
Total infrastructure costs attributed to vessels	**20.346**	**20.341**	**20.642**

Source: ECORYS

Based on a discussion note send to the Department of Transport of the Provence Utrecht a division was made between the share of costs that depend on the number of vessels and the share of costs that are more or less fixed. Below the results are presented.

Maintenance costs for locks

Only a weak relationship exists between the maintenance costs for locks and the number of vessels. This relationship exists due to little damages to locks that can arise when vessels pass (scratching of lock doors etc.). For the greater part however the maintenance costs of locks have no relation with the number of vessels. The 'fixed' part of the maintenance costs for locks are estimated at 70%, the part of the user-dependent costs at 30%. Of the user-dependent costs of locks 90% is estimated to have a direct relation with freight vessels and 10% with recreational vessels: freight vessels are in general much heavier than recreational vessels so the forces on parts of the locks are also much higher.

Maintenance costs for canal banks

The idea was that additional (large) vessels might have an impact on the maintenance costs for canal banks. According to the persons interviewed this is however not the case: maintenance costs for canal banks have only a marginal relation with the number of vessels passing. The banks of the ARC are so called steel-dam-walls and their wear is only marginal influenced by the number of vessels passing by. The part of the maintenance costs for canal banks is therefore estimated to be user-dependent for only 10%, 90% of the costs are non-user dependent. The user-dependent costs are allocated for 60% to freight vessels and for 40% to recreational vessels: recreational vessels sail often too fast and cause relatively high waves.

Maintenance radar costs

The maintenance costs for radar have no direct relationship with the number of vessels. 100% of these costs are characterized as non-user dependent costs.

Various maintenance costs

The various maintenance costs also have for the greatest part no direct relationship with the number of vessels: 80% is estimated to be non-user dependent. Of the user-dependent part the greater part, 60% is attributed to freight vessels and 40% to recreational vessels.

Dredging costs

The question is what the relation is between dredging costs and the number of vessels. At one hand we can say that only for the bigger vessels dredging has to take place, on the other hand we see that the bigger vessels are strong enough to sail through local muddy places. Additional bigger vessels might somewhat increase the scouring effect of the waterway, allowing for a very small marginal external benefit. This relation could however not be quantified. Overall it was concluded that independent of the number of vessels using the ARC, the canal has to be dredged: 80% of the dredging costs are estimated to be non-user dependent. Of the 20% user-dependent dredging costs, all of these costs are attributed to freight vessels: since these are the bigger ships dredging has to start sooner for these ships compared to recreational vessels.

Operational costs of locks

The operation of the locks may result in marginal costs as a result of the energy used for closing and opening of a lock ant the personnel needed for operation. The operation of the locks however takes place with permanently employed staff (1 person during the night, 2 persons by day). This means that only the energy costs of locks have a direct relation with the number of vessels. These costs are however not known but negligible small. Overall it is estimated that 70% of the operational costs of locks are non-user dependent costs and 30% are user-dependent costs. Of these last costs, 80% can be attributed to freight vessels: when the number of freight vessels would decline the locks would still be operational for a 24-hour period since the ARC is an important shipping canal and the locks must be opened 24-hours a day. This would not be the case for recreational vessels.

Operational costs of traffic post

The operational costs of the traffic post Wijk bij Duurstede are estimated to be a 100% user-dependent. If only one vessel would sail on the ARC guidance by the traffic post would not be necessary, as the number of vessels increases more personnel is needed to guide all the vessels. User-dependent costs are all attributed to the freight vessels.

Patrol costs

There is surveillance by ship on the ARC during 24-hours. If the number of passing vessels would decrease surveillance is still needed but maybe not a 24-basis, part of the patrol costs will however still have to be made. When traffic would increase more surveillance might be needed. Therefore 50% of the patrol costs are determined to be user-dependent and 50% non-user dependent. Since the accent of the surveillance is on freight traffic 70% of the user-dependent costs is attributed to freight vessels and 30% to recreational vessels.

Based on the division between user-dependent and non-user-dependent costs, the division of user-dependent costs between freight and recreational vessels and the share of freight and recreational vessels in the total number of vessels on the ARC, the total user-dependent costs for freight and recreational vessels was calculated for the years 2001 and 2002. In a next step the change in these costs (year 2002 minus year 2001) was divided by the change in the number of kilometres travelled by freight and recreational vessels, resulting in marginal costs of € 2,21/km for freight vessels and € 0,36/km for recreational vessels (see table). The marginal costs were also determined by dividing the change in costs through the change in kilometres that took place in the previous year (see table), to find out if there was a relation between expenditures and traffic density with a one-year delay (due to possible organizational or budget issues). The results were however not satisfying: the marginal costs for freight vessels were negative in the year 2003, the same accounts for recreational vessels in the year 2002.

Table 8.6 Marginal costs per kilometre of ARC (Euro)

Year	Marginal costs freight vessel		Marginal costs recreational vessel	
	Km current year	Km previous year	Km current year	Km previous year
2002	2,21	1,31	0,36	-1,33
2003	- (a)	-6,52	- (a)	0,13

(a): not possible to determine since the number of km travelled through the ARK is not known for 2003.

Second best solution

Since it is difficult to determine the marginal costs for the ARC the average user-dependent costs have been calculated as a second best solution. To obtain the average user-dependent costs, the total user dependent costs were divided by the total number of vessel kilometres. The results can be compared with the previously mentioned study in the Netherlands by CE towards the user dependent costs per vessel kilometre[9]. The results can be found in the next table.

Table 8.7 Average user-dependent cost that can be allocated to freight and recreational vessels

Year	Average user-dependent costs	
	Freight vessel	Recreational vessel
2001	1,15	0,25
2002	1,14	0,26

In the study of CE the user dependent costs for inland shipping are estimated at € 0,47 - € 0,53 per freight vessel kilometre. Compared to the results for the ARK it can be concluded that the user dependent costs per kilometre on the ARK are higher that the costs calculated for the whole of The Netherlands. A possible reasons for the difference can be that in the study of CE the actual costs are used, no correction has been made to arrive at the necessary costs as has been done for the ARK. Another reason can be that in this study we have looked in detail at the different costs items and for each item we have tried to establish the user dependent part. In the study of CE the method used was more

[9] 'De prijs van een reis', CE, september 2004

rough: only total national figures were used and the division of the costs between user dependent and non-user dependent costs was not done on such a detailed level as in this study.

Conclusions

As a result the following conclusions can be drawn with regard to the ARC channel:

- Due to a lack of sufficient data the econometric method could not be used to determine the marginal costs
- Due to a lack of knowledge within the transport ministry the engineering approach could also not be applied;
- In order to follow the cost allocation method the infrastructure expenditures had to be adapted, with the help of the providers of the data, to arrive at the infrastructure costs;
- The providers of the data also made a division between the share of infrastructure costs that depend on the number of vessels and the share of costs that are more or less fixed;
- The resulting marginal costs for freight vessels in the year 2002 were calculated at € 2,21/km for freight vessels and € 0,36/km for recreational vessels. Due to a lack of data the marginal costs could not be calculated for other years;
- The average user-dependent costs are calculated at € 1,14 for freight vessels and € 0,25 for recreational vessels. For freight vessels these costs are twice as high as calculated in a previous study for The Netherlands as a whole. This is however not judged to be strange since the national study only used rough national figures and the division of costs was not done on such a detailed level as for the ARC.

9 Case study 2: IJsselmeer route

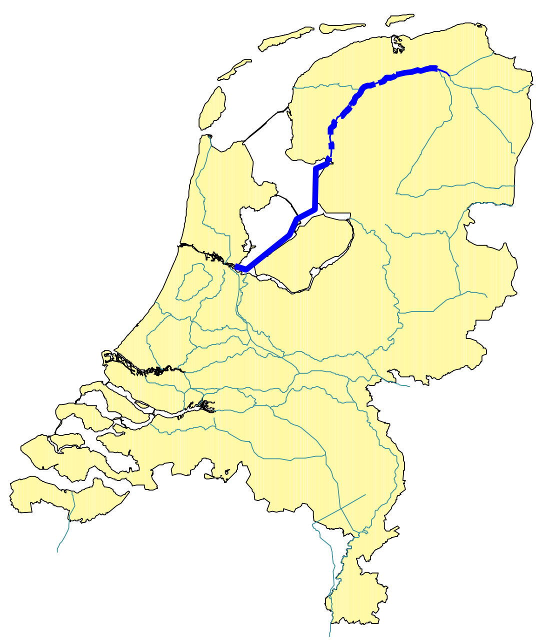
9.1 General information

The IJsselmeer route studied here comprises a route of inland waterways connecting Amsterdam with the Provinces Friesland and Groningen in the northern part of the Netherlands (figure). This route, via a lake (IJsselmeer) and channels, measures 168 kilometres. Five locks are located on this route between Amsterdam and Groningen. Accessibility differs per section. Larger vessels are permitted on the IJsselmeer, whereas accessibility declines at the channels further to the north. The channels still can handle vessels up to 3000 tons capacity (CEMT Va).

The IJsselmeer has a strong recreational function compared to other important waterways. More than 50% of total traffic is recreational vessels.

Larger cities located close to this route are Almere (around 136.000 inhabitants), Lelystad (around 61.500 inhabitants) and Groningen (around 171.000 inhabitants).

Figure 9.1 Map Ijsselmeer route (Amsterdam-Lemmer-Groningen)



The IJsselmeer route can be split into four main sections. The first two sections are actually part of the IJsselmeer (lake), from the IJsselmeer onwards to the city Groningen the route is via channels:

- IJsselmeer 1: between 'Oranjesluizen' and junction Krabbegatsluizen/Houtribsluizen
- IJsselmeer 2: between junction Krabbegatsluizen/Houtribsluizen and Lemmer
- Prinses Margriet Channel (PMC)
- Van Starkenborg Channel (VSC)

Each of the four sections will be characterized and quantified in more detail hereafter.

Infrastructure characteristics

The next table shows for each section length, accessibility, number of ports, bridges and locks.

Table 9.1 Infrastructure characteristics Ijsselmeer route

	IJsselmeer-1	IJsselmeer-2	PMC	VSC
Length (km)	11,7	62,5	66,7	26,9
Accessibility				
• CEMT	Vb (3200-6000)	Vb (3200-6000)	Va (1500-3000)	Va (1500-3000)
• Ship length	190m	190m	110,5m	110,5m
• Ship width	17,5m	17,5m	11,5m	11,5m
• Ship depth	3,5m	3,5m	3,05m	3,20m
Number of bridges	0	0	12	14
Number of locks	0	1	2	2
Number of ports	1	3	10	1

Source: Vaarwegkenmerken in Nederland (AVV)

Traffic volume

Traffic volume varies from section to section as is shown in the next table. Because of the recreational function of the IJsselmeer and the smaller lakes in the Province of Friesland (which are partly along this route) share of recreational vessels is very high, with the IJsselmeer more than 60% recreational traffic. Total traffic on the IJsselmeer has increased substantially from 1996 to 2002, with both years of growth and decline in between. This was probably caused by periods of perfect weather, recreational conditions and special events (i.e. Sail Amsterdam events), which attract more water recreation. A peak level in recreational traffic on the northern canals is also reached in 2000, with decline since.

Table 9.2 Development total traffic (number of vessels)

Year	1996	1997	1998	1999	2000	2001	2002
IJMR- 1: total number of vessels	98.182	111.120	102.740	117.586	116.819	109.532	114.454
recreational	60%	60%	56%	57%	61%	62%	65%
professional non-freight	5%	6%	6%	6%	5%	5%	5%
professional freight	35%	34%	39%	37%	34%	33%	30%
IJMR-2: total number of vessels	44.267	59.066	59.792	66.068	66.986	58.690	60.830
Recreational	57%	56%	51%	55%	55%	50%	52%

Year	1996	1997	1998	1999	2000	2001	2002
professional non-freight	5%	6%	6%	5%	5%	6%	6%
professional freight	38%	38%	43%	40%	40%	44%	42%
PMC: total number of vessels	30.585	38.876	46.209	49.278	53.034	48.286	48.067
Recreational	28% (a)	42%	51%	54%	58%	57%	60%
professional non-freight	3%	3%	2%	2%	2%	2%	2%
professional freight	69%	55%	46%	43%	40%	41%	38%
VSC: total number of vessels	21.939	22.936	23.645	23.272	24.318	22.910	22.786
Recreational	31%	33%	34%	31%	34%	33%	33%
professional non-freight	2%	2%	2%	2%	2%	3%	4%
professional freight	67%	65%	64%	67%	64%	64%	63%

Source: Nederland en de scheepvaart op de binnenwateren, Statline (AVV/CBS)

(a) in 1996 the lock has been closed for recreational vessels due to a replacement of the bridge crossing the lock.

Ship size freight transport

Freight traffic volume has also increased from mid 90's, but declines since 1999/2000. However in the Province of Groningen freight traffic levels on the Van Starkenborgh Channel are more or less stable since 1996.

As from 2000 freight traffic is declining on all sections of the route Amsterdam-Lemmer-Groningen. The next table shows that the number of vessels as from 1500 tons capacity is steadily increasing for the IJsselmeer sections and the Prinses Margriet Channel. The number of vessels less than 1500 tons capacity is stable or declines. Northwards into Groningen the number of vessels with a capacity under 400 tons are increasing slowly as well.

Table 9.3 Development vessel size (number of freight vessels)

Year	1996	1997	1998	1999	2000	2001	2002
IJMR-1: total freight vessels	34.153	37.961	39.585	44.073	39.714	36.484	34.615
21-250 tonnes	778	856	1.484	1.909	1.584	1.418	1.085
250-400 tonnes	2.461	2.805	2.657	2.481	2.222	1.749	1.207
400-650 tonnes	7.828	8.551	8.389	8.609	7.149	5.942	5.434
650-1000 tonnes	11.596	12.369	11.497	14.011	12.254	10.995	10.555
1000-1500 tonnes	8.084	9.764	10.779	11.662	10.787	9.918	9.666
1500-2000 tonnes	2.645	2.774	3.431	3.494	3.400	3.420	3.543
2000-3000 tonnes	730	794	997	1.356	1.874	2.544	2.625
> 3000 tonnes	31	48	67	125	119	239	267
Unknown			284	426	325	259	233
IJMR-2: total freight vessels	16.773	22.728	25.686	26.486	26.662	25.646	25.729
21-250 tonnes	460	557	380	411	315	262	186
250-400 tonnes	1.042	1.453	1.518	1.233	1.182	920	799
400-650 tonnes	3.771	4.965	4.986	4.846	4.903	4.693	4.351
650-1000 tonnes	4.477	6.218	6.551	7.432	7.277	6.638	6.964
1000-1500 tonnes	4.757	6.669	8.286	8.434	8.361	8.009	7.774
1500-2000 tonnes	1.830	2.273	2.918	2.867	2.822	2.658	2.980
2000-3000 tonnes	423	553	846	1.062	1.567	2.111	2.282
> 3000 tonnes	13	40	63	76	80	205	245

Year	1996	1997	1998	1999	2000	2001	2002
Unknown			138	125	155	150	148
PMC: total freight vessels	21.026	21.273	21.346	21.398	21.191	19.767	18.235
21-250 tonnes	167	163	165	168	155	212	97
250-400 tonnes	804	939	867	634	779	762	508
400-650 tonnes	4.256	3.928	3.607	3.032	2.907	2.557	2.348
650-1000 tonnes	6.084	6.261	6.018	5.536	5.689	5.070	4.897
1000-1500 tonnes	6.945	7.349	7.735	7.388	8.084	7.448	6.717
1500-2000 tonnes	2.403	2.289	2.444	2.393	2.529	2.538	2.386
2000-3000 tonnes	306	278	439	482	939	1.066	1.167
> 3000 tonnes	1	1	1	5	6	27	32
Unknown	60	65	70	1.760	103	87	83
VSC: total freight vessels	14.666	14.794	15.090	15.501	15.518	14.676	14.340
21-250 tonnes	148	111	55	93	49	216	606
250-400 tonnes	579	695	683	745	763	989	764
400-650 tonnes	2.641	2.610	2.457	2.315	2.016	1.824	1.751
650-1000 tonnes	4.411	4.268	4.184	4.077	3.853	3.334	3.321
1000-1500 tonnes	4.891	5.055	5.383	5.596	5.829	5.442	5.144
1500-2000 tonnes	1.752	1.800	1.863	2.135	2.112	1.798	1.600
2000-3000 tonnes	244	254	399	498	826	980	1.040
> 3000 tonnes		1	1	3	4	20	28
Unknown			65	39	66	73	86

Source: Nederland en de scheepvaart op de binnenwateren, Statline (AVV/CBS)

The next paragraphs describe the costs related to the IJsselmeer and northern canals infrastructure.

9.2 Infrastructure costs

9.2.1 Cost drivers

IJsselmeer: 'Oranjesluizen' - junction Krabbegatsluizen/Houtribsluizen- Lemmer

This part of the Ijsselmeer route can be characterized as an 'open'/natural water shipping lane. The related infrastructure costs are:

Table 9.4 (Average) infrastructure costs of Oranjesluizen – junction Krabbegatsluizen/Houtribsluizen-Lemmer

Cost categories	2003 (in k EUR)
Maintenance costs beacons/concrete	130
Maintenance costs locks Houtribsluizen	
- fixed costs	350
- variable costs	not known
Maintenance accompanying dams	30
Personnel costs operating locks Houtribsluizen	550
Patrolling costs related to freight traffic	110
CMIJ[a)] related to freight traffic	40

Cost categories	2003 (in k EUR)
Maintenance costs for places to stay overnight	100
Police costs	not known
Total	**1.310**

a): 'Centrale Meldkamer IJsselmeer' or Central reporting office IJsselmeer.

Source: Ministry of Transport-Department IJsselmeer

It must be mentioned that the above mentioned figures are characterized as 'soft' by the Ministry of Transport-Department Ijsselmeer: the department fails manpower to give more details of the costs or to give an overview of the actual costs during a certain time-period. The figures must therefore be regarded as average cost figures. With regard to the variable maintenance costs of the Houtrib locks (24-hours service) the Ministry mentions that these costs increase each year due to postponement of the necessary maintenance, this figure is therefore not provided. The costs for the CMIJ (Centrale Meldkamer IJsselmeer) refer to a central reporting unit that serves for the total of the IJsselmeer area in case of problems/accidents for both freight and passenger vessels.

Compared to the ARC channel the infrastructure costs of this part of the waterway are relatively low. This is partly due to the fact that it is a waterway that goes through an inside (former) sea. This results for example in the fact that no maintenance costs for canalbanks have to be made. In order to keep the waterway at depth, dredging has to take place. There are however limited to no dredging costs for the ministry since the sand is used by the construction sector resulting in the fact that companies pay the Ministry in order to obtain the sand. There is also no traffic post to guide the vessels, nor are there any bridges that have to be opened for freight vessels.

Costs made by the water police are not known.

Prinses Margriet Channel (PMC)

The total costs of the Prinses Margriet Channel (PMC) for the period 1996-2003 are listed in the next table[10].

[10] Information was also available for the years 1994 and 1995 but different costs categories were used in these years. It was therefore decided not to use the information for these years.

Table 9.5 Total infrastructure costs Prinses Margriet Channel (x 1000 Euro, incl VAT)

In K euro	1996	1997	1998	1999	2000	2001	2002	2003 (excl. VAT)
Channel	**1.030,9**	**407,9**	**368,5**	**408,6**	**498,5**	**487,4**	**488,4**	**140,4**
Maintenance canal banks	123,6	78,5	23,1	59,5	135,3	98,4	80,0	63,0
Big maintenance canal banks (not yearly)	295,1	1,9	15,5	-2,1	41,5	80,9	80,4	1,0
Dredging	18,6	0,2	17,6	84,8	38,9	0,5	19,7	19,7
Beacon/Concrete	54,0	46,3	23,5	31,6	38,2	31,1	34,9	28,9
Equipment costs	278,9	244,6	278,6	190,7	203,6	225,6	238,7	193,7
Taxes	7,2	9,8	9,6	13,8	13,2	23,5	14,6	13,9
Interest/ subsidies/write-off	0,0	0,0	0,0	22,8	21,9	27,3	20,0	0
Other	253,6	26,6	0,7	7,5	6,0	0	0	-179,6
Bridges	**1.203,1**	**1.268,6**	**1.157,2**	**1.407,2**	**1.213,1**	**1.220,9**	**1.186,8**	**1.170,9**
Equipment costs	689,5	808,3	795,8	651,5	651,8	784,3	763,8	834,9
Technical maintenance	65,9	44,8	59,5	101,9	156,4	128,5	120,5	90,6
Big technical maintenance	132,4	103,6	82,3	37,4	62,1	61,5	27,5	5,9
Civil maintenance	51,0	53,0	27,8	83,2	96,0	84,0	60,1	49,6
Big civil maintenance	208,9	199,5	131,4	446,1	179,3	161,6	213,9	189,3
Insurance, taxes	0,6	0,9	0,9	28,8	28,3	1,0	1,0	0,6
Other	54,9	58,5	59,6	58,3	39,2	0	0	0
Locks	**1.319,9**	**1.383,0**	**914,4**	**878,8**	**908,3**	**859,1**	**808,2**	**756,5**
Equipment costs	720,5	872,3	576,4	496,3	474,3	489,3	497,9	496,5
Technical maintenance	61,6	79,8	58,0	116,3	94,1	98,8	52,0	109,2
Big technical maintenance	65,4	27,3	18,9	12,0	0,0	91,3	79,2	0
Civil maintenance	137,6	99,8	92,1	67,9	80,9	88,1	84,6	80,1
Big civil maintenance	299,5	268,1	148,7	163,7	253,1	87,1	92,7	69,0
Insurance, taxes	3,3	2,6	1,4	1,2	1,5	1,7	1,9	1,6
Other	32,0	33,0	19,0	21,3	4,5	2,6	0	0
Other	**0**	**0**	**0**	**2.173,3**	**2.919,7**	**2.893,6**	**3.731,3**	**4.724,3**
Gas, water, electricity				0	27,0	46,5	44,7	44,1
Equipment maintenance				26,2	14,5	18,8	0	8,6
Furniture and soft furnishing				1,1	4,4	4,7	4,5	4,0
Equipment costs				37,7	60,5	36,9	63,8	76,2
Cars, Vessels				0	128,4	163,3	90,9	0
Overhead				2.082,7	2.577,3	2.578,9	2.936,7	4.594,3
Interest, write-off				0	0	26,9	26,5	39,4
Other				25,7	0,6	17,6	271,2	-42,5
Reservations				0,0	106,8	0	293,0	0
Total	**3.554**	**3.060**	**2.440**	**4.867,8**	**5.539,6**	**5.461,1**	**6.214,7**	**6.792,1**

Source: Province of Friesland

With regard to the question whether the above figures reflect the true and necessary maintenance costs, the following information has been gathered. The PMC was upgraded to CEMT 5 in the period 1991-2001. In this period the canal banks were broadened and the canal was deepened. There was a separate budget regarding the costs involved with the upgrading. The upgrading budget covered also the elimination of (part of) existing outstanding maintenance. The second phase of the upgrading started in 2003 and involves a further deepening of the canal and replacement of certain parts of the canal banks. The fact that the PMC channel was upgraded has resulted in the fact that for example the dredging costs are very low in 2001: dredging did took place in that year but was part of the upgrading plan so the costs involved have not been registered as maintenance costs.

Big technical and civil maintenance costs refer to costs that are not made on a yearly basis, for example the replacement of a large part of the canal bank. These costs are made according to a multi-annual plan. This leads to the fact that in some years these costs can be very low. This is done to save money so bigger works in a following year can be financed as one.

The personnel costs are included in the 'equipment costs', together with accommodation costs and various office costs. It was mentioned that the personnel costs are based on a registration of hours worked. During the last years several different registration methods of hours were used. One therefore cannot be sure if the equipment costs until the year 2001/2002 were representative. The item 'other' costs of the channel, bridges and locks differ from year to year because this item includes several elements and can therefore be seen as some kind of rest post. In the year 2003 we can see negative costs in the category 'other channel' costs. These costs comprise restitution payments that were financed in the year 2002. This has resulted in relative low channel maintenance costs in the year 2003 compared to the previous years.

The cost category 'Other costs' is determined by attributing 75% of these costs to the PMC channel. This percentage is based on historic data material. The costs in this category do therefore not reflect the real costs involved. Before 1999 the category 'other costs' did not exist.

Van Starkenborgh Channel

The total infrastructure costs of the Van Starkenborgh Channel (VSC) that are attributed to the shipping sector are listed in the next table.

Table 9.6 Total infrastructure costs Van Starkenborgh Channel (x 1000 Euro)

In K euro	1994	1995	1996	1997	1998	1999	2000	2001	2002
Infrastructure costs	**811**	**592**	**850**	**580**	**448**	**396**	**351**	**1.031**	**1.302**
Locks	182	120	119	114	193	170	163	389	181
Bridges	228	194	116	139	95	127	85	179	337
Embankments	93	119	147	190	58	1	82	124	31
Dredging	15	7	6	9	0	9	0	0	0
Roads, dykes	16	6	0	0	1	0	2	1	1
Construction works for shipping	9	37	0	0	11	0	0	0	8
Construction works for exploitation (remote control)	194	72	307	0	0	75	0	314	0
Renewal works	27	34	85	44	78	0	0	0	669

In K euro	1994	1995	1996	1997	1998	1999	2000	2001	2002
Other	47	5	69	64	11	13	19	24	75
Equipment costs	**179**	**188**	**245**	**197**	**190**	**210**	**157**	**214**	**130**
Service building	55	64	65	77	61	70	66	48	44
Cars, vessels, equipment	124	124	180	111	121	134	85	151	42
Other	0	0	0	9	7	6	6	15	44
Personnel Costs	**1.475**	**1.443**	**1.394**	**1.345**	**1.486**	**1.484**	**1.502**	**1.575**	**1.741**
Technical+Administrative	254	222	262	218	244	222	224	337	389
Service+Maintenance	1.184	1.183	1.086	1.091	1.192	1.208	1.241	1.200	1.285
Shipping inspection	36	33	43	34	34	31	23	31	53
Other	1	5	4	1	16	23	14	7	13
Total	**2.465**	**2.223**	**2.489**	**2.101**	**2.124**	**2.090**	**2.010**	**2.820**	**3.173**

Source: Province of Groningen

The costs for the locks comprise maintenance costs for locks and maintenance cost for posting spaces near the locks. The personnel costs for serving locks are not comprised in this figure, they are included under the heading ‘personnel costs, service and maintenance’. The increase in the year 2001 resulted from a replacement of a posting space near a lock.

The costs for bridges are relatively high in the year 2002. This is due to the fact that 2 bridges are at the end of their life-time and have to be replaced. No money is however available so maintenance costs rise. According to the person interviewed all the costs made for bridges should be attributed to the inland shipping sector because the channel was made for inland shipping: to improve connections for this sector. We think however that this is a difficult issue and will lead to endless discussions. We therefore prefer to split the costs equally between the road and shipping sector.

The embankment costs in the period 1994-1997 are higher compared to the period 1998-2002. This is due to the fact that the channel has been upgraded to CEMT 5[11]. Therefore the channel has been broadened, including new embankments that are not reflected in these figures. According to the Province of Groningen, the period 1994-1997 is representative for the embankment costs. The same accounts for the dredging costs: due to the upgrading of the channel, the channel has been deepened so no additional dredging costs had to be made. For dredging costs, the period 1994-1997 is representative.

The costs for roads and dykes have decreased since 1994 and are now very low. The reason for this is that these costs are transferred to another organization (the roads to municipalities and dykes to the ‘waterschap’). There are however still costs to be paid for roads and dykes but they are registered in another way because they are paid directly to the municipalities and ‘waterschap’ and are not attributed to the canal. According to the Province of Groningen the costs for dykes and roads in the period 1994-1995 can be seen as representative for the whole period 1994-2002.

[11] Upgrading of the channel started in 1991 and is now finished. Per 1-1-2002 ships of category CEMT 5 are allowed on the channel. Before this date they were not allowed (only with a special permit and under certain restrictions).

Construction works for shipping concern for example posting spaces (except the ones near locks) or the marking of bridges to improve passage speed. For the year 2003 (not official figures yet) the costs comprise € 254.000. According to the Province of Groningen one should make an average over the 10-year period to have a better idea of the costs.

Renewal works comprises big maintenance costs. In order to get a more fluent pattern of the costs these costs should be averaged.

The category ‘Other infrastructure costs’ comprises for example measures taken in the winter (to ‘fight’ the ice) and advertisement costs to publish coagulations.

The Equipment costs comprise the building costs (buildings from which the locks are served) and the costs for company cars and vessels. Due to a change in the financial administration the ‘other’ costs have increased in the year 2002. Due to another organization structure it is advised by the province of Groningen to look only at the total equipment costs.

The final cost component is the personnel costs. With regard to the technical and administrative costs, the same accounts as for the equipment costs: due to another organization structure the costs have increased in the years 2001 and 2002. The personnel costs of the shipping inspection have increased in the year 2002 because in that year the crew needed was finally complete. The VSC does not have a traffic guidance post because the number of vessels is too low for this. The ‘other’ personnel costs show an increase in the period 1998-2000. This is due to the upgrading of the channel that resulted in temporarily additional costs.

9.2.2 Estimation of marginal costs

IJsselmeer: ‘Oranjesluizen’ - junction Krabbegatsluizen/Houtribsluizen- Lemmer
For this part of the waterway only the average costs for one year are available. It is therefore not possible to calculate the marginal costs.

Prinses Margriet Channel (PMC)
In consultation with the Province Friesland the cost figures of the PMC have been adapted in such a way that they reflect the real, necessary costs in each year (see the table below). Adapted costs comprise for example the maintenance costs of bridges and locks: these costs are averaged. The same accounts for the taxes, interest/subsidies and other costs of the channel. The dredging costs are increased because the actual dredging costs are too low, according to the expert, due to the upgrading of the canal. Due to this upgrading the Beacon/Concrete costs have also been increased for the period 1998-2003 to € 50.000. The category ‘other costs’ was increased with € 2,5 million for the period 1996-1998: due to another way of registration these costs were not registered before 1999. Based on the adapted infrastructure costs of the PMC as showed below, the marginal costs are established.

Table 9.7 Total adapted infrastructure costs Prinses Margriet Channel (x 1000 Euro, incl VAT)

In K euro	1996	1997	1998	1999	2000	2001	2002	2003
Channel (expenditures)	**1.031**	**408**	**369**	**409**	**499**	**487**	**488**	**167**
Channel (costs)	***656***	***569***	***628***	***500***	***588***	***573***	***568***	***555***
Maintenance canal banks (expenditures)	124	79	*23*	60	135	98	80	75
Maintenance canal banks (costs)	*124*	*79*	*100*	*60*	*135*	*98*	*80*	*75*
Big maintenance canal banks (expenditures)	295	2	16	-2	42	81	80	1
Big maintenance canal banks (costs)	*64*	*64*	*64*	*64*	*64*	*64*	*64*	*64*
Dredging expenditures	18,6	0,2	17,6	84,8	38,9	0,5	19,7	24
Dredging costs	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Beacon/Concrete expenditures	54	46	24	32	38	31	35	34
Beacon/Concrete costs	*54*	*46*	*50*	*50*	*50*	*50*	*50*	*50*
Equipment (costs = expenditures)	279	245	279	191	204	226	239	231
Taxes (expenditures)	7	10	10	14	13	24	15	17
Taxes (costs)	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*
Interest/ subsidies/write-off (expenditures)	0	0	0	23	22	27	20	0
Interest/ subsidies/write-off (costs)	*12*	*12*	*12*	*12*	*12*	*12*	*12*	*12*
Other (expenditures)	254	27	1	8	6	0	0	-214
Other (costs)	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*
Bridges (expenditures)	**1.203**	**1.269**	**1.157**	**1.407**	**1.213**	**1.221**	**1.187**	**1.394**
Bridges (costs)	***1.192***	***1.315***	***1.304***	***1.186***	***1.167***	***1.233***	***1.212***	***1.442***
Equipment (costs = expenditures)	690	808	796	652	652	784	764	994
Technical maintenance (expenditures)	66	45	60	102	156	129	121	108
Technical maintenance (costs)	*98*	*98*	*98*	*98*	*98*	*98*	*98*	*98*
Big technical maintenance (expenditures)	132	104	82	37	62	62	28	7
Big technical maintenance (costs)	*64*	*64*	*64*	*64*	*64*	*64*	*64*	*64*
Civil maintenance (expenditures)	51	53	28	83	96	84	60	50
Civil maintenance (costs)	*64*	*64*	*64*	*64*	*64*	*64*	*64*	*64*
Big civil maintenance (expenditures)	209	200	131	446	179	162	214	225
Big civil maintenance (costs)	*221*	*221*	*221*	*221*	*221*	*221*	*221*	*221*
Insurance, taxes (expenditures = costs)	1	1	1	29	28	1	1	1

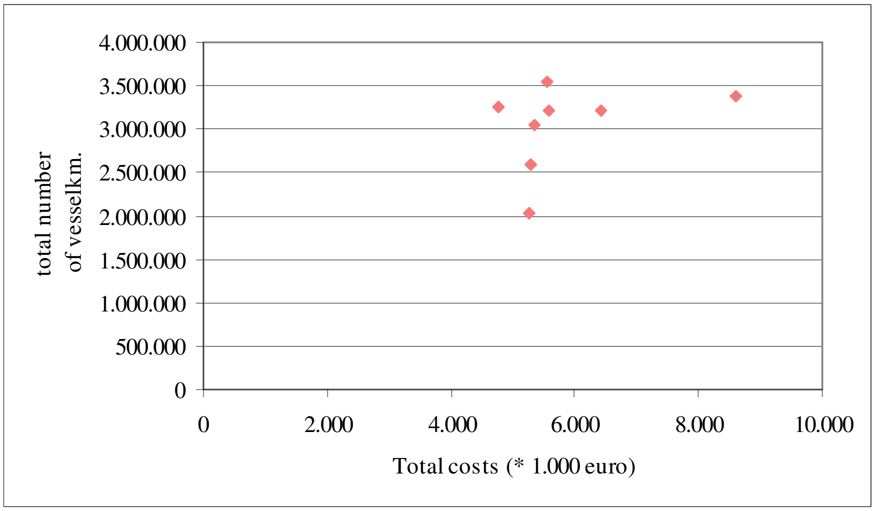
In K euro	1996	1997	1998	1999	2000	2001	2002	2003
Other (expenditures = costs)	55	59	60	58	39	0	0	0
Locks (expenditures)	**1.320**	**1.383**	**914**	**879**	**908**	**859**	**808**	**757**
Locks (costs)	***908***	***907***	***906***	***902***	***881***	***896***	***905***	***998***
Equipment (expenditures)	721	872	576	496	474	489	498	591
Equipment (costs)	*500*	*500*	*500*	*496*	*474*	*489*	*498*	*591*
Technical maintenance (expenditures)	62	80	58	116	94	99	52	109
Technical maintenance (costs)	*86*	*86*	*86*	*86*	*86*	*86*	*86*	*86*
Big technical maintenance (expenditures)	65	27	19	12	0	91	79	0
Big technical maintenance (costs)	*37*	*37*	*37*	*37*	*37*	*37*	*37*	*37*
Civil maintenance (expenditures)	138	100	92	68	81	88	85	95
Civil maintenance (costs)	*93*	*93*	*93*	*93*	*93*	*93*	*93*	*93*
Big civil maintenance (expenditures)	300	268	149	164	253	87	93	82
Big civil maintenance (costs)	*174*	*174*	*174*	*174*	*174*	*174*	*174*	*174*
Insurance, taxes (expenditures = costs)	3	3	1	1	2	2	2	2
Other (expenditures)	32	33	19	21	5	3	0	0
Other (costs)	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*
Other (expenditures)	**0**	**0**	**0**	**2.173**	**2.920**	**2.894**	**3.731**	**5.624**
Other (costs)	***2.500***	***2.500***	***2.500***	***2.173***	***2.920***	***2.894***	***3.731***	***5.622***
Total (expenditures)	**3.554**	**3.060**	**2.440**	**4.868**	**5.540**	**5.461**	**6.215**	**6.792**
Total (costs)	***5.256***	***5.291***	***5.338***	***4.761***	***5.555***	***5.596***	***6.416***	***8.616***

Source: ECORYS

Econometric approach

The relation between the number of vessel kilometres travelled through the PMC during the period 1996-2003 and the total (adapted) costs of the canal in that year is depicted in the next figure.

Figure 9.2 Relation between total (adapted) costs and total number of vessels for Prinses Margriet Channel (1996-2003)



By multiple regressions several types of functions have been estimated. First two linear costs functions were estimated:

TC = α*number of total vesselkm + TCC (1)
TC = α*number of freight vesselkm + β*number of recreational vesselkm+TCC (2)

Where: TC = total costs of PMC
α and β = coefficients to be estimated
TCC = total constant costs of PMC

The R^2 amounted to 0,12 for the first equation to 0,53 for the second equation. This can be seen as an improvement, however in the second equation the t-values of the estimated coefficients were too low, indicating that the estimated coefficients are statistically not significant. Both types of equations are therefore judged to be not suitable for estimating the marginal costs.

In a next step non-linear cost functions were estimated:

$TC = \alpha*q^3 + ß*q^2 + \gamma q$ + constant costs (3)
TC = αsin(number of freightkm) +ßsin(number of recr.km) + constant cost (4)

Where: q = total number of vesselkilometres
α, β and γ = coefficients to be estimated

Estimation of equation 3 resulted in a R^2 of 0,16. Further refinement of the equation by distinguishing between freight and recreational kilometres improved the R^2 significantly, the t-values of the estimated coefficients are however too low.

Finally, equation 4 showed a R^2 of 0,53. This was judged to be too low. Besides this, the t-values of the estimated coefficients are too low.
Based on the results above it was concluded that the marginal costs of the PMC could not be determined by using an econometric approach.

Engineering approach
The engineering approach is not used for the PMC to determine the marginal costs: no knowledge was available within the Provence with regard to the relation between costs and variables that influence these costs. The same as for the ARC accounts here: this is not the way used by the government to establish costs of a waterway.

Cost allocation approach
Starting point of the cost allocation approach is the division of the real costs into a user-dependent part and a non-user dependent part. This has been done together with the province of Friesland. This has resulted in the following:

Maintenance costs canal banks

- Maintenance and Big maintenance canal banks (not yearly)
  These costs are for the greatest part determined by their age and not by the intensity of traffic. Therefore only 20% of these costs are characterized as user-dependent costs. These costs are split between the freight (80%) and recreational vessels (20%).
- Dredging costs canal
  Dredging costs are only for a very small part influenced by the number of vessels using the canal. The user-depended part is estimated at 10% of the total dredging costs. All user-dependent costs are allocated to the freight vessels since these are the bigger vessels for which dredging is needed.
- Beacon/Concrete canal
  The maintenance costs for beacons/concrete are expected to have no relation with the number of vessels: they are qualified as being a 100% non-user dependent.
- Equipment costs canal
  These costs comprise the personnel costs that are made for maintenance work. Since the maintenance on the canal is characterized as being non-user depended for the greatest part, the same accounts for the equipment costs: 80% is classified as non-user dependent costs.
- Taxes/Interest/ subsidies/write-off/other costs canal
  These costs have no relation with the number of vessels using the canal: they are classified as 100% non-user dependent costs.

Maintenance costs for bridges
These costs are alleged to be non-user dependent for around 80%. The big maintenance costs are made according to a multi-annual plan that is not influenced by the number of vessels passing through the canal. The personnel costs (in the category Equipment costs) is also expected to have only a small relation with the number of vessels passing: because the channel is an important waterway the bridges have to be operational. A decrease (or increase) in the number of vessels will therefore have only minor implications for the number of people that operate the bridges. The user-dependent costs are split evenly between freight and recreational vessels

Maintenance costs for locks
Of these costs the greatest part, 80%, is expected to have no relation with the number of vessels passing. The maintenance costs for locks are for the greatest part determined by their age. Of the user-dependent costs 80% is allocated to freight vessel and 20% to

recreational vessels: freight vessels are in general much more heavier than recreational vessels so the forces on parts of the locks are also much more greater.

Other

Of this category 90% is classified as non-user dependent costs. As previously mentioned, the amount of these costs is determined by attributing 75% of these costs to the PMC channel. This percentage is based on historic data material. The costs in this category do therefore not reflect the real costs involved. They are therefore assumed to be for 90% non-user dependent costs.

Based on the above mentioned division between user-dependent and non-user-dependent costs and the share of the freight and recreational sector in the user-dependent costs, the total user-dependent costs are calculated that can be attributed to freight and recreational vessels. Taking into account the share of freight and recreational vessels in the total number of vessels on the PMC, the total user-dependent costs for freight and recreational vessels was calculated for the years 1997-2003. In a next step the change in these costs (the change compared to the previous year) was divided by the change (compared to the previous year) in the number of kilometres sailed by freight and recreational vessels in order to determine the marginal costs per kilometre travelled through the channel. The results can be found in the next table.

Table 9.8 Marginal costs per kilometre for Prinses Margriet Channel (Euro)

Year	Marginal costs freight vessel	Marginal cost recreational vessel
1997	-3,14	0,15
1998	3,27	0,12
1999	407,43	0,29
2000	2,57	0,24
2001	-0,11	0,00
2002	-0,09	0,81
2003	2,00	1,22

Source: ECORYS

The marginal costs per kilometre for a recreational vessel on the PMC ranges between € 1,22 and € 0 per km. For the freight vessels the results range between €-3,14 and € 407,43 per km. The negative marginal costs in 1997 arise due to a decrease in the costs and an increase in the number of freight-vessel kilometres. In the years 2001 and 2002 it is the other way round: costs increase and the number of kilometres decreases.

It was also tried to determine the marginal costs by looking at the change in the costs in relation to the change in vessel kilometres that took place in the previous year or that took place 2 years before[12]. As can be concluded from the table below this exercise did not lead to improved results.

[12] Although the choice for this particular period is arbitrarily, the time lag of 1-2 years corresponds with a peak in vessel traffic in 2000 (=T) and a peak in infrastructure cost in 2001 or 2002 (= T+1 or T+2). In general an increase in traffic level is followed by an increase in infrastructure costs 1 or 2 years later.

Table 9.9 Marginal costs per kilometre for Prinses Margriet Channel (Euro)

Year	Marginal costs freight vessel		Marginal costs recreational vessel	
	Km previous year	Km 2 years before	Km previous year	Km 2 years before
1997	0,27	0,39	-0,19	0,48
1998	-2,04	0,17	0,10	-0,13
1999	10,02	-6,24	0,13	0,11
2000	-48,92	-1,20	0,33	0,14
2001	1,73	-32,90	0,00	0,00
2002	-0,09	1,44	-0,33	0,26
2003	-0,97	-0,98	1,73	-0,70

Source: ECORYS

It can therefore be concluded that based on the cost allocation approach the marginal costs of the PMC have been determined, the results are however not satisfying. The main reason for this is the fact that the registration of the costs does not take place in a uniform format: cost administration methods are changed from year to year, the costs made for the upgrading of the channel have influenced the yearly maintenance costs and the working-hour administration program has been changed. This has probably prohibited the finding of a relative stable (in time) marginal cost figure.

Second best solution

Finally, as a second best solution, the average user dependent costs have been calculated. The result can be compared with the study in the Netherlands by CE towards the user dependent costs per vessel kilometre[13], in which the user dependent costs for inland shipping are estimated at € 0,47 - € 0,53 per freightvessel kilometre.
The results for the PMC can be found in the next table.

Table 9.10 Average user dependent costs Prinses Margriet Channel (Euro)

Year	Average user-dependent costs	
	Freight vessel	Recreational vessel
1996	0,45	0,21
1997	0,39	0,18
1998	0,36	0,16
1999	0,27	0,18
2000	0,28	0,18
2001	0,31	0,21
2002	0,34	0,23
2003	0,40	0,29

Source: ECORYS

The results for the PMC show results that on average are around € 0,10 lower per vessel kilometre compared to the figures for the whole of The Netherlands. This was not the result that was expected since the PMC figures are corrected for postponement of costs,

[13] 'De prijs van een reis', CE, september 2004

the upgrading of the canal etc. It can therefore be concluded that either the correction of the costs was not done properly or the average user dependent costs for the PMC are in fact lower compared to the average Dutch figure.

Van Starkenborgh Channel

Previously it is explained that the actual infrastructure expenditures of the VSC (see table 9.6) do not reflect the real necessary infrastructure costs of the VSC in time. In order to determine the marginal costs a correction has therefore been made for incidental and temporarily occasions, such as upgrading of the channel to CEMT 5, in order to arrive from expenditures to costs. The corrected figures are listed in table 9.11. These (adapted) infrastructure costs are the starting point for the determination of the marginal costs.

Table 9.11 Total adapted infrastructure costs to be attributed to inland shipping Van Starkenborgh Channel (x 1000 Euro)

In K euro	1994	1995	1996	1997	1998	1999	2000	2001	2002
Infrastructure expenditures	**811**	**592**	**850**	**580**	**448**	**396**	**351**	**1.031**	**1.302**
Infrastructure costs	**801**	**699**	**709**	**768**	**697**	**708**	**665**	**761**	**799**
Locks (expenditures)	182	120	119	114	193	170	163	389	181
Locks (costs)	*182*	*120*	*119*	*114*	*193*	*170*	*163*	*160*	*181*
Bridges (expenditures = costs)	228	194	116	139	95	127	85	179	*145*
- part of shipping sector (50%)	114	97	58	70	48	64	43	90	*73*
Embankments (expenditures)	93	119	147	190	58	1	82	124	31
Embankments (costs)	*93*	*119*	*147*	*190*	*137*	*137*	*137*	*137*	*137*
Dredging (expenditures)	15	7	6	9	0	9	0	0	0
Dredging (costs)	*15*	*7*	*6*	*9*	*9*	*9*	*9*	*9*	*9*
Roads, dykes (a) (expenditures)	16	6	0	0	1	0	2	1	1
Roads, dykes (a) (costs)	16	6	*11*	*11*	*11*	*11*	*11*	*11*	*11*
Construction works for shipping (expenditures)	9	37	0	0	11	0	0	0	8
Construction works for shipping (costs)	9	37	*30*	*30*	*30*	*30*	*30*	*30*	*30*
Construction works for exploitation(remote control), exp.	194	72	*307*	*0*	*0*	*75*	*0*	*314*	*0*
Construction works for exploitation(remote control), cost	*107*	*107*	*107*	*107*	*107*	*107*	*107*	*107*	*107*
Renewal works (expenditures)	27	34	85	44	78	0	0	0	669
Renewal works (costs)	*104*	*104*	*104*	*104*	*104*	*104*	*104*	*104*	*104*
Other (exp. = costs)	47	5	69	64	11	13	19	24	75
Total Equipment costs (b) (costs=expenditures)	**179**	**188**	**245**	**197**	**190**	**210**	**157**	**214**	**130**
Total personnel expenditures	**1.475**	**1.443**	**1.394**	**1.345**	**1.486**	**1.484**	**1.502**	**1.575**	**1.741**
Total personnel costs	**1.489**	**1.460**	**1.402**	**1.360**	**1.491**	**1.485**	**1.520**	**1.505**	**1.593**
Technical+Administrative (exp.)	254	222	262	218	244	222	224	*250*	*250*
Technical+Administrative (cost)	*254*	*222*	*262*	*218*	*244*	*222*	*224*	*337*	*389*
Service+Maintenance (exp.=cost)	1.184	1.183	1.086	1.091	1.192	1.208	1.241	1.200	1.285
Shipping inspection (expenditures)	36	33	43	34	34	31	23	31	53
Shipping inspection (costs)	*50*	*50*	*50*	*50*	*50*	*50*	*50*	*50*	53
Other (expenditures)	1	5	4	1	16	23	14	7	13

In K euro	1994	1995	1996	1997	1998	1999	2000	2001	2002
Other (costs)	*1*	*5*	*4*	*1*	*5*	*5*	*5*	*5*	*5*
Police costs	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (expenditures)	**2.465**	**2.223**	**2.489**	**2.101**	**2.124**	**2.090**	**2.010**	**2.820**	**3.173**
Total (costs)	**2.469**	**2.347**	**2.356**	**2.325**	**2.378**	**2.403**	**2.342**	**2.480**	**2.522**

(a) We assume that the costs made for the roads have no relation with inland shipping. These costs however do not need to be split up between roads and dykes because the costs for the dykes are fixed costs (see under cost allocation approach)

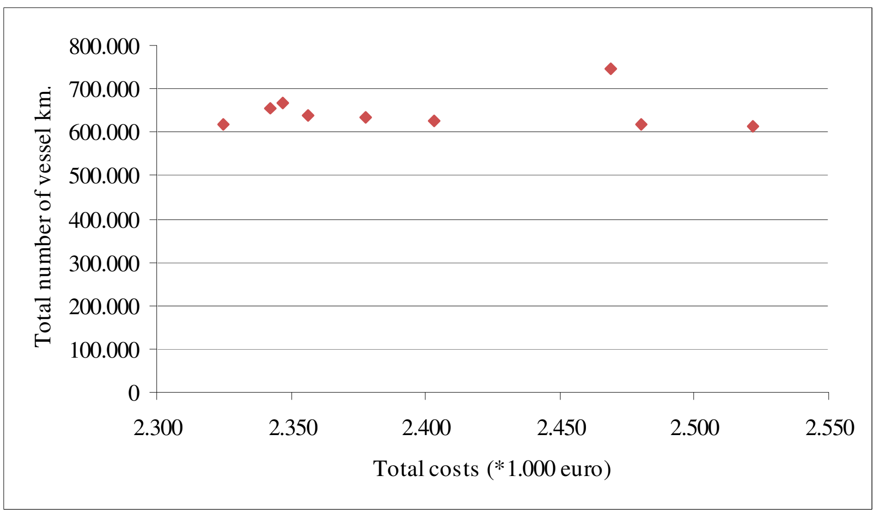
(b) Due to a change in the financial administration and another organization structure it is advised by the Province of Groningen to look only at the total equipment costs.

Source: ECORYS

Econometric approach

The figure below shows the relation between the amount of vessel kilometres travelled through the VSC during the period 1994-2002 versus de total (adapted) costs of the canal in that year. From the figure it can be concluded that there appears to be no relation between the two variables.

Figure 9.3 Relation between total (adapted) costs and total number of vessels in Van Starkenborgh Channel (1994-2002)



This has been checked using multiple regressions. First a linear regression analysis, assuming constant variable and constant marginal costs, was used : $TC = TVC + TCC$ or $TC = \alpha q$ + constant costs

Where: TC =Total costs of the VSC

TVC = Total variable costs of the VSC

TCC = Total constant costs of the VSC

q = number of vessel kilometres

The results were, as expected, not what we wanted. The R^2 amounted only 0,002. Taking into account the different type of vessel kilometres (recreational and freight), resulting in the function:
TC = α*number of recreational vessel km + ß* number of freight km + const costs, did not improve the results. The R^2 did improve but the estimated coefficients α and ß were statistically not significant.

Other regressions, assuming non-proportional marginal costs were also estimated:
$TC = \alpha q^3 + \beta q^2 + \gamma q + cst$ (a)
$TC = \alpha \sin(q\ freightkm) + \beta \sin(q\ recr.km) + cst$ (b)

Where q = number of total vessel kilometres
Cst = constant costs
α, ß, γ = coefficients to be estimated

The estimation of these two costs functions was also not satisfying. The R^2 improved to 0,38 for equation (a), but this is considered to be still too low. A further distinction between the number of recreational and freight kilometres did not lead to satisfying results either. The estimation of equation (b) resulted also in a very low R^2 of 0,03.

It can be concluded that based on the econometric approach the marginal costs could not be estimated.

Engineering approach
For the same reason as for the ARC and the PMC, the engineering approach is not used for the VSC to determine the marginal costs: no knowledge was available within the Provence with regard to the relation between costs and variables that influence these costs.

Cost allocation approach
The department of Transport of the Provence of Groningen has reacted on a discussion note regarding the division between the share of costs that vary with the number of vessels and the share of costs that are fixed. This has resulted in the following:

Maintenance costs for locks
The person interviewed estimates that the fixed maintenance costs for locks are to be around 80% of the total maintenance costs. This is around the same as for the ARC channel and the PMC channel. The user-dependent costs are for 70% attributed to freight vessel and 30% to the recreational vessels. This is around the same as for the ARC and PMC channel.

Maintenance costs for bridges
As mentioned previously the total costs for bridges are split evenly between the inland shipping sector and the road sector. Of the remaining costs for the inland shipping sector 20% is characterized by the person interviewed as user-dependent costs. These costs comprise for example speed reducing constructions in the water near the bridges. The user-dependent costs are split evenly between freight and recreational vessels.

Maintenance costs for canal banks

Around 80% of the maintenance costs for canal banks is estimated to be fixed and 20% to be vessel-dependant. The latter are equally divided between recreational freight vessels. The banks of the VSC are for the greatest part so called steel-dam-walls (like the ARC) and their wear and tear is determined by age. Other material used is tropical hard wood and stones.

Dredging costs

Dredging costs are classified as being fixed for 90%. The user-dependent part, 10%, is all attributed to freight vessels since these are the bigger ships that need more depth in order to be able to sail.

Maintenance costs for roads, dykes

Only the maintenance costs for dykes are expected to have a relation with the number of vessels using the channel. The costs for the dykes are expected to be fixed costs: they are not influenced by the number of vessels using the channel. The main variable that influences the maintenance costs for the dykes is the age of the dyke.

Construction works for shipping

Of these costs 20% are classified as user-dependent costs. The main part of these costs, 80%, is expected to have a relation with the number of freight vessels and 20% with the number of recreational vessels.

Construction works for exploitation

As mentioned previously these costs comprise mainly investment costs for remote control. They are therefore classified as being fixed for 100%.

Renewal works costs

The costs of the renewal works are almost completely determined by the lifespan of certain parts of the channel (doors of locks, speed reducing devices, etc.) and not so much by the intensity of the traffic on the channel. Therefore 90% of these costs are classified as fixed and only 10% as user-dependent. The user-dependent costs are equally divided between freight and recreational vessels.

Other maintenance costs

If the number of vessels on the VSC changes, these costs will remain more or less the same: (ship)wrecks will have to be removed, measuring of depth is needed, ice needs to be broken, traffic signs are needed etc,. Therefore 80% of these costs are classified as non-user dependent costs. Of the user dependent part of the costs, 60% is attributed to freight vessels and 40% to recreational vessels.

Equipment costs

The service building costs and the other costs (telephone costs, mariphone) are classified as having no relation with the number of vessels. Of the costs for cars, vessels and equipment, 80% is classified as having no relation with the number of vessels: if the amount of inland shipping decreases there is still a need for cars, vessels and equipment. Of the user-dependent part, 80% is attributed to freight vessels and the remaining 20% to recreational vessels.

Personnel costs
All personnel costs are expected to be fixed for the greatest part. If the number of vessels declines for example the locks will remain operational because the VSC is an important inland waterway. With regard to the shipping inspection it can be mentioned that for the whole of the Province Groningen there is only 1 vessel available. This number is expected not to change when the number of vessel changes on the VSK.

Based on the above mentioned division between user-dependent and non-user-dependent costs and the share of the freight and recreational sector in the user-dependent costs, the total user-dependent costs are calculated that can be attributed to freight and recreational vessels. Taking into account the share of freight and recreational vessels in the total number of vessels on the VSC, the total user-dependent costs for freight and recreational vessels was calculated for the years 1995-2002. In a next step the change in these costs (the change compared to the previous year) was divided by the change (compared to the previous year) in the number of kilometres sailed by freight and recreational vessels. The results can be found in the next table.

Table 9.12 Marginal costs per kilometre Van Starkenborgh Channel (Euro)

Year	Marginal costs freight vessel	Marginal cost recreational vessel
1995	0,28	0,14
1996	0,07	0,45
1997	0,58	0,48
1998	3,29	-0,01
1999	0,51	0,28
2000	196,88	0,17
2001	-0,95	-0,12
2002	-2,30	-1,52

Source: ECORYS

For both the recreational and freight vessels we see negative marginal costs in the year 2001 and 2002, due to increasing costs on the one hand and a decrease in the number of vessel-kilometres on the other hand. The negative sign for the year 1998 for recreational vessels results from a (very small) decrease in the costs (compared to the previous year) that are attributed to recreational vessels. According to the Province of Groningen there is no relation between the size of the vessel and the damage to the canal. This is because vessels that are too big for the canal are not allowed. This was also checked when the marginal costs were estimated: if the kilometres travelled by larger vessels are contributed a more heavy weight that the kilometres travelled by smaller vessels the resulting marginal costs do not improve.

It can be concluded that the results of the whole exercise are not satisfying. The Province of Groningen has been asked to look at the results to try to make further improvements in the available figures (maybe reservations were made in the year 2000 to have additional funds for the year 2001 or expenditures in the year 2002 resulted in lower expenditures for 2003). This however has not led to improved figures. The only remark made was that costs made in a certain year are not always registered in that year: if the bills are not paid yet in the (fiscal) year that the costs were made, the costs show up in the next year.

Finally the marginal costs were determined by using not the change in the number of kilometres travelled in the relevant year but by using the change in kilometres that took place in the previous year and that took place 2 years[14] before. The results are listed below. Based on these results the conclusion can be drawn that these calculations do not improve the results that were found if the (change in) number of kilometres of the relevant year is used.

Table 9.13 Marginal costs per kilometre Van Starkenborgh Channel (Euro)

Year	Marginal costs freight vessel		Marginal costs recreational vessel	
	Km previous year	Km 2 years before	Km previous year	Km 2 years before
1996	0,06	-	-0,56	-
1997	0,41	0,37	0,36	-0,44
1998	-0,47	-0,33	0,00	0,00
1999	1,15	-0,16	-0,61	-0,29
2000	-0,95	-2,15	-0,22	0,49
2001	-290,31	1,40	0,08	-0,10
2002	-0,27	-83,63	-0,09	0,06

Source: ECORYS

Second best solution

Again as a second best solution, compared to the marginal costs, the average user dependent costs have been calculated. The result can be compared with the CE-study in the Netherlands towards the user dependent costs per vessel kilometre[15]. As mentioned before, these costs were in this study estimated at € 0,47 - € 0,53 per freight vessel kilometre.
The results for the VSC are listed below.

Table 9.14 Average user dependent costs Van Starkenborgh Channel (Euro)

Year	Average user-dependent costs	
	Freight vessel	Recreational vessel
1994	0,67	0,23
1995	0,72	0,25
1996	0,80	0,28
1997	0,82	0,30
1998	0,85	0,28
1999	0,84	0,28
2000	0,81	0,27
2001	0,89	0,31
2002	0,91	0,32

Source: ECORYS

[14] Although the choice for this particular period is arbitrarily, the time lag of 1-2 years corresponds with a peak in vessel traffic in 2000 (=T) and a peak in infrastructure cost in 2001 or 2002 (= T+1 or T+2). In general an increase in traffic level is followed by an increase in infrastructure costs 1 or 2 years later.

[15] 'De prijs van een reis', CE, september 2004

The conclusion with regard to the user dependent costs per freight vessel kilometre for the VSC is the same as the one for the Amsterdam Rhine channel: the user dependent costs per kilometre on the VSC are higher than the costs calculated for the whole of The Netherlands. Possible reasons for the difference can be that:

- in the study of CE the actual costs are used, no correction has been made to arrive at the necessary costs as has been done for the VSC.
- In this study we have looked in detail at the different costs items and for each item we have tried to establish the user dependent part in the total costs. In the study of CE the method used was more rough: only total national figures were used and the division of the costs between user dependent and non-user dependent costs was not done on such a detailed level as in this study.

Conclusions

Finally the following conclusions can be drawn for both the Van Starkenborgh Channel (VSC)and the Prinses Margriet Channel (PMC):

- The marginal costs could not be determined with the econometric or engineering approach;
- The cost allocation method could be applied, however the results are not satisfying: for some years negative marginal costs arise and the results are not stable in time;
- The fact that the results are not satisfying is not blamed on the method (cost allocation) itself but on the method of cost registration. In the first place it is the expenditures that are registrated and not the (necessary) costs. In order to arrive from expenditures to costs, adaptations in the expenditure figures had to be made which is by definition not an objective exercise because is influenced by the expert decisions. Secondly the registration of the expenditures can be improved: expenditure registration methods change during the years and expenditures made in a year are not always registrated in that year.
- The average user dependent costs (for both freight and recreational vessels) do show a stable development in time although for the PMC these costs are lower and for the VSC these costs are higher, compared to the average Dutch user dependent costs that were calculated in a different study for the year 2002 (CE, 2004). This last study however uses rough national expenditure figures (not costs) and the division of the expenditures into a fixed and variable part was done on a rough scale only. This makes comparison difficult.

10 Case study 3: Basin Rhone-Saone

10.1 General information

The French inland waterways network counts 8.500 km, and 1.000 transport companies among which, 900 companies have less than 6 employees. From the end of the 90s, the French inland waterways transport tends to decrease.

The basin Rhone-Saone is an essential waterway link for both professional vessels (ships from 1 500 tonnes to 3000 tonnes, and convoys from 1 600 tonnes to 6 000 tonnes) and recreational vessels, connecting the river Rhone and the Mediterranean. In term of load capacity, the traffic volume in 2002 is 126.601 tonnes operated by 74 vessels versus 67 vessels in 2001, representing a slight increase of 1% in transport capacity.

10.2 Infrastructure costs

The Basin of Rhone-Saone route can be split into five main segments:

1. Canal of Rhone-Rhin (CRR), between junction Canal Rhone-Rhin and Saone, from Monbéliard to Damparis;
2. Petite Saone (PS) between junction Canal Rhone-Rhin and Corre, from St Jean de Losne to Corre;
3. Grande Saone (GS) between Canal Rhone-Rhin and South of Lyon, from St Jean de Losne to Lyon;
4. Petit Rhone (PR) between the Arles and the Ecluse de Saint Gilles;
5. Grand Rhone.

Because of lack of information related to Grand Rhone, we concentrate the study on the segments 1-4 for which data is on transport, traffic and costs is available.

The following figure presents the map of the Rhone-Saone.

Figure 10.1 Map Basin Rhone-Saone

Infrastructure characteristics:

The next table shows for each segment and for the entire basin of Rhone-Saone, relevant waterway characteristics as length, CEMT accessibility, and number of locks, its dimension and maximum velocity:

Table 10.1 Infrastructure characteristics Rhone-Saone

	Basin R-S	**CRR**	**PS**	**GS**	**PR**	**GR**
Length	> 860 km	175 km	192 km	170 km	60 km	330 km
Vessel size	From 7.8m x 2.9m to 13.8m 3.9m for barges, and 750 tons. From 38.5m x 5.05m to 95m x 11.40m for auto-engines, and 2500tons to 5000tons.	-.	-.	-	-	-.

	Basin R-S	CRR	PS	GS	PR	GR
Number of locks	126	69	21	3	n/a	13
Locks dimension:						
• Width		5.20 m	5.10 m	12 m	-	190 m
• Length		39.50 m	40 m	185 m	-	12 m
Velocity (m/h):						
• On river		10	15-30		15	30
• On channel		6	6 to 15		15	30

A small increase in number of freight vessels and load capacity was noticed in the period 2000-2002, the number of recreational vessels has been quite stable since 1999. As for marginal infrastructure costs calculation of recreational and freight vessels, according to statistics survey carried out by "La Direction Inter-Régionale Rhone-Saone de VNF", the number of passing vessels registered by lock records an increase for both recreational and freight vessel (see next table).

Table 10.2 Total number of recreational vessels passing through locks

Year	2002	2003	2004
Segment: CRR	466	1.024	301
• Exincourt	75	73	57
• Deluz	141	73	61
• Tarragnoz	85	356	62
• Rancenay	82	345	59
• St Symphorien	83	177	62
Segment: PS	865	906	824
• Rupt sur Saone	122	84	134
• Savoyeux	123	83	-
• Heuilley	620	739	690
Segment: GS	4.340	7.677	8.350
• Ormes	1.863	1.961	2.512
• Dace	2.477	2.441	2.660
• Couzon	-	3.275	3.178

Source: VNF (Voies Navigables de France)

Table 10.3 Total number of freight vessels passing through locks

Year	2000	2001	2002	2003
Segment: CRR	6.871	5.376	6.582	7.042
• Exincourt	521	741	538	610
• Deluz	756	736	794	809
• Tarragnoz	1.586	-	1.478	1.649
• Rancenay	1.056	997	1.126	1.140
• St Symphorien	2.952	2.902	2.646	2.834
Segment: PS	16.734	16.751	15.809	16.465
• Rupt sur Saone	5.013	5.271	5.067	5.214
• Savoyeux	5.876	5.547	5.205	5.465
• Heuilley	5.844	5.933	5.537	5.786
Segment: GS	8.890	10.454	9.978	10.086
• Ormes	3.768	4.859	4.541	4.559
• Dace	2.220	2.738	2.419	2.509
• Couzon	2.902	2.857	3.018	3.018
Segment: GS	7.470	7.620	7.049	7.452
• Pierre Benite	2.269	2.331	2.184	2.337
• Bourg des Valance	2.330	2.356	2.213	2.330
• Vallabrègues	2.871	2.933	2.652	2.785

Source: VNF (Voies Navigables de France).

10.2.1 Cost drivers

This section describes the cost allocation approach, which has been used to determine marginal infrastructure cost with regards to shipping activities. The expenditures registrations resulting from VNF enables to assess the marginal infrastructure costs value.

The validity of the results is subject to discussion however, because:
- Actual expenditures don't always reflect real infrastructure costs, and
- VNF could not provide information on how to distinguish various elements of infrastructure costs related to shipping activities.

Indeed, there are no distinctions between costs attributed to different inland waterways functions, in particular to shipping activity in France. Every year VNF receives budget from the authorities and via other incomes as hydraulic tax, tolls and state-owned receipts to maintain and to carry out other investments on inland network. Subsequently, VNF allocates these subsidies to different general construction works, renovation and repairs or construction following priorities or emergent needs.

Furthermore, according to the survey carried out by Conseil Régional des Ponts et Chaussées[16], the desirable financial level to maintain and to exploit inland waterways over the French inland network is around EUR 69 million for 6677 km each year. It is equivalent to EUR 9 million per year for the Basin of Rhone-Saone, whereas, the observed expenditures between 2000 and 2004 amount to EUR 3 million per year. The actual budget of infrastructure is thus 3 times lower than the estimated budget, which seems necessary to maintain the Basin at a certain quality level.

In order to assess the share of costs that can be attributed to inland shipping and to determine the share of variable costs and allocation of these variable costs to vessel types, two assumptions are made:

1. 80% of the total infrastructure spending is intended for shipping activities. As was stated before functions of inland waterways are diverse (shipping activities, electricity and water consumption supply, flooding prevention, irrigation and tourist activities). No further proof was found on how to allocate infrastructure costs to the various waterway functions. The VNF suggested allocating 80% of spending to shipping activities.
2. Within the costs mentioned above, share of variable costs in total infrastructure costs is 10% (versus 90% fixed costs). 80% of variable costs can be allocated to freight vessels, 20% to recreational vessels (source VNF, Direction inter regional Rhone-Saone).

The following table shows actual costs related to shipping activities for each segment from 2000 to 2004, whereas only relevant variable costs are considered. The user-dependent costs related to freight vessels for a certain waterway segment are calculated as total infrastructure costs for that segment multiplied by 80% (percentage of costs attributed to shipping activities), multiplied by 10% (percentage of user-dependent costs) and by 80% (percentage of user-dependent costs related to freight vessels). By the same way, the user-dependent costs for recreation vessels can be obtained (i.e total infrastructure costs * 80% * 10% * 20%).

Table 10.4 Variable infrastructure costs (in EUR) that can be allocated to freight and recreational vessels

In Euro	2000	2001	2002	2003	2004
Segment: CRR					
• Freight vessels	36.652	32.170	51.234	50.710	47.957
• Recreational vessels	9.163	8.043	12.809	12.678	11.989
Segment: PS					
• Freight vessels	27.514	28.398	36.798	35.696	33.974
• Recreational vessels	6.878	7.100	9.199	8.924	8.493
Segment: GS					
• Freight vessels	107.961	89.113	85.781	64.865	103.782
• Recreational vessels	26.990	22.278	21.445	16.216	25.945
Segment: PR					
• Freight vessels	8.258	9.213	9.005	8.420	62.747
• Recreational vessels	2.064	2.303	2.251	2.105	15.687

Source: VNF (Voies Navigables de France)

[16] Programmation des investissements de voies navigables de France sur le réseau fluvial existant, Mr BOUARD, January 1998.

The following table shows total actual infrastructure spending broken down into different cost categories for each waterway section for the years 2000 to 2004.

For all segments one can observe that maintenance costs fluctuate strongly from year to year. To smooth yearly fluctuation in costs, high maintenance costs have been averaged over a 10-year period. The following table describes infrastructure expenditures as a result of averaging maintenance and repair or construction costs over 10 years period.

Table 10.5 Average infrastructure expenditures (in EUR)

Basin Rhone-Saone

	2000	2001	2002	2003	2004
Rhone-Rhin canal Segment					
Maintenance costs	494 589				
- service of maintenance companies		9 116	121 928	57 698	9 556
- embankment			75 944	32 100	9 900
- bridges				9 209	
- waterways		95 067		18 181	36 865
Functional maintenance costs		342 376	516 974	508 502	517 691
Dredging costs			37 253		19 120
Operational costs 1					
- locks	9 803	36 280	4 899	50 672	75 172
- bridges		19 817	15 040	46 503	25 746
- dam				28 512	
Operational costs 2					
- person and goods safety	11 901				38 194
Equipment costs	56 392				
- repair and renovation			28 499	40 972	40 000
- construction					27 757
TOTAL	***572 684***	***502 657***	***800 538***	***792 349***	***749 330***
Petite Saone Segment					
Maintenance costs	295 517				
- service of maintenance companies			114 508	13 589	13 589
- embankment			28 484	22 420	2 358
- bridges					
- waterways		43 615		31 985	12 721
Functional maintenance costs		317 835	326 081	340 673	355 843
Dredging costs	8 104	64 663	27 427	26 734	20 000
Operational costs 1					
- locks	3 201		37 751	98 378	38 191
- bridges					
- dam					
Operational costs 2					
- person and goods safety	8 079	17 612			
Equipment costs	115 002				
- repair and renovation			30 280	20 165	88 142
- construction			10 436	3 800	
TOTAL	***429 904***	***443 725***	***574 966***	***557 744***	***530 843***
Grande Saone Segment					
Maintenance costs	700 930				
- service of maintenance companies		6 402	5 698	50 000	52 202
- embankment		54 502	26 034	82 419	104 000
- bridges					
- waterways		101 394	45 512	58 582	178 944
Functional maintenance costs		556 212	417 779	427 377	415 830
Dredging costs	36 983	458 203	567 309	246 428	786 114
Operational costs 1					
- locks	6 141	79 157	59 586	32 544	20 091
- bridges			608		
- dam		12 348	23 147	42 585	
Operational costs 2					
- person and goods safety	919 207	16 620	67 273		16 930
Equipment costs	23 623				
- repair and renovation		23 623	74 063	66 609	47 475
- construction		83 931	53 323	6 971	
TOTAL	***1 686 884***	***1 392 392***	***1 340 331***	***1 013 515***	***1 621 586***
Petit Rhone Segment					
Maintenance costs	105 183				
- service of maintenance companies		30 151			
- embankment			8 696	10 696	
- bridges					
- waterways		14 467			820 257
Functional maintenance costs		94 760	96 081	96 047	93 000
Dredging costs			11 543	17 196	11 543
Operational costs 1					
- locks			16 755		48 000
- bridges					
- dam					
Operational costs 2					
- person and goods safety	19 268				
Equipment costs	4 573				
- repair and renovation		4 573	4 573	4 573	4 573
- construction			3 048	3 048	3 048
TOTAL	***129 024***	***143 951***	***140 696***	***131 560***	***980 421***

Source: VNF

The next section describes the estimation of marginal costs.

10.2.2 Estimation of marginal costs

As stated in the previous section, according to the VNF (Direction Inter régionale Rhone-Saone), 80% of infrastructure costs can be allocated to inland shipping functions (freight and recreational vessels), 10% of these costs are variable, whereas 80% of these variable costs can be allocated to freight vessels and 20% to recreational vessels. Following these principles the following table can be constructed which represents annual variation in variable costs for freight vessels and recreational vessels.

Table 10.6 Yearly change in variable costs by vessel type and waterway section

In EUR	2001-2000	2001-2002	2002-2003	2003-2004
Segment: CRR				
• Freight vessels	-4.482	19.064	-524	-2.753
• Recreational vessels	-1.120	4.766	-131	-688
Segment: PS				
• Freight vessels	885	8.399	-1.102	-1.722
• Recreational vessels	221	2.100	-276	-430
Segment: GS				
• Freight vessels	-18.847	-3.332	-20.916	38.917
• Recreational vessels	-4.712	-833	-5.229	9.729
Segment: PR				
• Freight vessels	955	-208	-585	54.327
• Recreational vessels	239	-52	-146	13.582

Source : VNF, Direction inter- régionale Rhone-Saone.

The change in number of passages for freight and recreational vessels is shown in the following table.

Table 10.7 Yearly change in traffic (number of freight and recreational vessels) by waterway section

Number of vessels	2001-2000	2001-2002	2002-2003	2003-2004
Segment: CRR				
• Freight vessels	-	-	558	-723
• Recreational vessels	-1495	1206	460	-
Segment: PS				
• Freight vessels	-	-	41	-82
• Recreational vessels	17	-942	656	-
Segment: GS				
• Freight vessels	-	-	3337	673
• Recreational vessels	1564	-476	108	-
Segment: PR				
• Freight vessels	-	-	-	-
• Recreational vessels	150	-571	403	-

Source : VNF, Direction inter- régionale Rhone-Saone.

Based on yearly variations in user-dependant costs and yearly variations in the number of freights/recreational vessels, the marginal infrastructure costs can be calculated as:

$$CM_{\inf rastructure} = \frac{\Delta TC_{\inf rastrucure}}{\Delta N - vessel\,type}$$

Applying this function results in the following marginal costs for freight vessels (due to the lack of data concerning freight vessels on the Petite Rhone section marginal costs could not be calculated) and recreational vessels:

Table 10.8 Marginal costs of freight vessels

	2003	2004
CRR	€ - 0,9	€ 3,8
Petite Saone	€ -26,9	€ 21,0
Grande Saone	€ -6,3	€ 57,8

Source: Mettle 2005

Table 10.9 Marginal costs of recreational vessels

	2001	2002	2003
CRR	€ 0,7	€ 4,0	€ -0,3
Petite Saone	€ 13,0	€ -2,2	€ -0,4
Grande Saone	€ -3,0	€ 1,7	€ -48,4
Petit Rhone	€ 1,6	€ 0,1	€ -0,4

Source: Mettle 2005

As was found also in the Dutch case studies, the marginal costs results for the French waterway sections are not satisfying in a way that cost figures fluctuate strongly and costs are sometimes negative (with extreme values in between minus €3,0 and minus € 48,4 for the Grande Saone).

Second best solution

Since the calculated marginal costs are not satisfying, the average user-dependent costs have been calculated as a second best solution. Total vessel kilometres performed on the Rhone-Basin amounted 945.670 kilometres in 2004. The total variable costs allocated to freight transport in 2004, EUR 248.460 in total, divided by the 2004 traffic performance of freight transport results in € 0,26 per freight vessel kilometre. The 2004 traffic performance figure for the total Rhone-Saone section has been used to estimate average sailing distance of freight traffic per section, and subsequently average user-dependent costs per section for the years 2000-2003. The results are given in the next table.

Table 10.10 Average user-dependent cost for freight vessels

	2000	2001	2002	2003
CRR	€ 0,21	€ 0,24	€ 0,31	€ 0,29
Petite Saone	€ 0,06	€ 0,06	€ 0,08	€ 0,08
Grande Saone	€ 0,50	€ 0,35	€ 0,35	€ 0,26
Petit Rhone	€ 0,13	€ 0,14	€ 0,15	€ 0,13

Source: Data analysis and treatment by Mettle/ECORYS

The level of average user-dependent costs for freight traffic differs from section to section. On the Grande Saone section costs/vessel-km are relatively high. This of course follows from the relatively high infrastructure costs on the Grande Saone, whereas traffic performance is relatively low. The Petite Saone is just the other way around: on this section costs/vessel-km are very low, which follows from modest infrastructure costs on the one hand and high traffic performance on the other hand. Overall the average user-dependent costs vary between € 0,06 and € 0,50 per freight vessel kilometre.

As stated in the beginning of this chapter the real infrastructure costs for the Rhone-Saone are three times higher as engaged expenditures. In that respect we assess the marginal and average infrastructure costs also three times the estimated values of marginal infrastructure costs and average costs mathematically.

Conclusions

As a result the following conclusions can be made regarding the Basin Rhone-Saone case study:

- the engineering and econometric methods proof to be impractical for calculating marginal costs. With N=4 (number of segments), and T=5 (time dimension from 2000 to 2004), statistically, the estimated parameters are biased whatever dynamic model is used;
- the cost allocation method was used only on a rough scale due to a lack of detailed information. The cost allocation method was performed on expenditure data, no correction has been made to arrive at costs data. It is only known that on a rough scale the infrastructure costs are three times higher compared to the current expenditures. The resulting marginal costs fluctuate strongly between different sections of the waterway but also in time within a section. The result is judged to be not satisfying;
- the calculated average user dependent costs differ also between the different waterway sections and vary between € 0,06 and € 0,50 per freight vessel kilometre. Within a waterway section the average user dependent costs are stable over time.

11 Case study 4: Austrian Danube

General information
The River Danube was declared at the Crete Conference in 1984 to be one of the most important Transport Corridors linking West Europe to Central and Eastern Europe and providing a bridge between Europe and Asia through its strategic location. The opening of the Rhine-Main-Danube canal in 1992 made the Danube more accessible and more economically profitable for Western countries.

The Danube is the second-longest river of Europe (after the Volga). It rises in Germany, then crosses Austria (it waters Vienna), Slovakia (it waters Bratislava) and Hungary (it crosses Budapest). It then forms the Serbo-Croatian border, crosses Serbia and waters Belgrade. The river then forms the border between Romania (North) and Bulgaria (South). It then enters Romania, forms a part of the border with Ukraine before entering the Black Sea through a large swampy delta.

Figure 11.1 Map of Danube route

This case study focuses on to waterway sections located in Austria, which is part of the upper Danube basin. The catchment's area of the Upper Danube is densely populated with ca. 8 Mio people. The water is used as water supply for the larger cities. The industry originates in the pre-alpine region and the Alps. The most important industrial agglomeration areas are Munich, Augsburg and Ingolstadt and the chemical triangle Burghausen.

Figure 11.2 Austrian Danube

In 2002 total transport via the Austrian section of the Danube amounted 12.315.500 tons, of which 51% was import, 13% export, 32% transit and 5% domestic transport. Vessels with Austrian flag account for 22 % of the volume, Germany 26 %, Netherlands, Slovakia and Ukraine 10 –11 % each. Nearly 45 % of the transport volume consists of iron ore and oil products.

Table 11.1 Domestic and border crossing freight traffic and transport via the Austrian Danube section (2002)

2002	Number of journeys	Transport volume in tons
Cross-border Import	5.339	6.311.835
Cross-border Export	1.594	1.554.834
Transit	4.111	3.889.034
Domestic	738	560.747
TOTAL	11.782	12.316.450

Source: Statistik Austria

Dry cargo carried by motor vessels or barges has the largest share (around 80%) in total transport (see next table), liquid cargo in motor vessels and barges account for the other 20%, whereas other cargo (general cargo and containers) is hardly being transported.

Table 11.2 Freight traffic and transport via the Austrian Danube section by vessel type and commodity (2002)

2002	Number of journeys	Transport volume in tons
Motor vessel (dry cargo)	4.732	4.558.311
Barges (Dry cargo)	4.931	5.368.646
Motor vessel (liquid cargo)	987	1.096.964
Barges (liquid cargo)	1.117	1.283.469
Other	15	9.059
TOTAL	11.782	12.316.450

Source: Statistik Austria

11.1.1 Waterway characteristics

Depth and bottlenecks
To date, following strategic bottlenecks still exist on the Upper Danube:

Table 11.3 Strategic bottlenecks on upper Danube

Waterway section	Water depth (at LNRL)	Depth
Straubing-Vilshofen (km 2318 - 2249)	2,00 m	1,60 m
Melk- Durnstein (km 2038 - 2008)	2,30 m	2,00 m
Vienna-Bratislava (km 1920 - 1875)	2,20 m	1,90 m
Gabcikovo-Budapest (km 1810 - 1640)	2,00 m	1,70 m

Source: Statistik Austria

The most critical section is located between Straubing and Vilshofen. As measured against the LNRL, water depth of this section is guaranteed (with 94% probability) at only 2.00 m. In-depth analyses for this section have been initiated by the German and Bavarian governments to evaluate the different technical options from an economic and ecological standpoint, and the information generated was used in the political decision making process.

A final solution on how to improve this particular section has, however, not yet been found. In the Wachau (Melk/Dürnstein) riverbed engineering measures carried out in 1986-1987 have improved water depths by restoring 2.50 m at LNRL. Since then, maintenance measures have been aimed with the goal of maintaining a water depth of 2.30 m.

Over the last decades, navigation downstream of Vienna at 2.00 m draught has not been possible for an average of 84 days, and at 2.50 m draught for an average of 155 days respectively. The Austrian Government has renewed its obligation to assure fairway conditions east of Vienna, which will allow a draught of 2.70 m. An environmental impact study has recently been initiated to evaluate possible solutions.

These activities are funded within the TEN-T Programme. The Nagymaros stretch (1697 km) just before Budapest, could also be considered as a critically shallow section; a draught of 2.50 m cannot be assured for 160 days/year. In 1992 the Hungarian Government had proposed a three-step programme to improve navigation on this stretch.

However, these plans have not been realised to date. Contrary to the Straubing-Vilshofen bottleneck, the Austrian and Hungarian bottlenecks on the Upper Danube can be upgraded to a possible draught of 2.70 m at LNRL with regulation measures (Source: via Donau).

The velocity of vessels depends on fairway characteristics, water depth, loading/draught of the vessel, engine power and of course heading. The following table shows an overview of maximum velocities of vessels on the Danube.

Table 11.4 Maximum velocity of vessels on the Danube

Danube	Heading	MGS Europa I (up to 1,350 to) V [km/h]	Large motor vessel (2,000 to) V [km/h]	Push convoy (motor cargo vessel + barge) V [km/h]	Large push convoy (push vessel + 4 barges) V [km/h]
Upper	Upstream Downstream	10 18	13 18	10 18	9 16
Lower	Upstream Downstream	11-12 20	13-15 20	11-13 20	9-11 18

Within the bottlenecks on the Upper Danube, velocity is reduced to 6-8 km/h in upstream direction and for Straubing/Vilshofen to 9 km/h in downstream direction.

Locks

There are locks at the hydroelectric power plants along the Danube: Jochenstein (German/Austrian cooperation) and nine power plants of Austrian Hydro Power AG (AHP) (Aschach, Ottensheim, Abwinden-Asten, Wallsee, Ybbs-Persenbeug, Melk, Altenwörth, Greifenstein and Freudenau). The average time for passing the locks is 45 minutes, the real passing time being 20 minutes, the run-in ad run-out time 10 minutes and the waiting time 15 minutes.

Ports

Last, there are eight ports, which have at least one basin (Linz (Public Port), Linz-Voest, Enns, Ybbs, Krems and Vienna (3 locations: Freudenau, Lobau, Albern)) and several small transhipment sites are situated directly along the river Danube.

The next section describes the costs related to the Austrian Danube.

11.2 Infrastructure costs

11.2.1 Cost drivers

According to the decisions of the Conference of European Ministers of Transport, the connection of Rhine-Main-Danube is considered as one of the five most important waterway projects in Europe. Thus it should meet at least the standard of Waterway Category IV. This category permits the passage of large motor cargo vessels with dimensions of up to 110 m length and 11.4 m width. Such vessels should have a draught of 2.50 m and a cargo capacity of 1.800 tons as well as a twin-barge pusher-tug assembly of up to 3.300 tons cargo capacity.

Regarding the Austrian section of the Danube, the infrastructure costs in average for the years 2001 to 2003 are the following –without taken into account special costs in case of nature disasters such as floods) are the following:

Table 11.5 Average yearly infrastructure costs for the Austrian part of the Danube, period 2001-2003

In million Euro	Cost of material	Personnel cost
Maintenance costs (embankment, quays, waterway, bridges, information systems etc.)	6,5	2,6
Dredging	2,1	(included in material cost)
Operational costs (locks)	0,9	1,8
Operational costs (shipping police/patrol)	1,9	1,5
Total average yearly infrastructure costs	11,4	5,9
	Total material and personnel cost = 17,3	

Source: Via Donau, infrastructure costs from 2001 to 2003.

11.2.2 Estimation of marginal costs

This paragraph determines the relation between the various cost categories and the number of vessels.

The infrastructure costs on the Danube are mainly linked to the climate conditions as they largely affect the water level and water velocity. Navigational conditions show few but very severe bottlenecks due to restricted width and depth of the navigable canal. The respective sections are mainly on the upper Danube (Straubing-Vilshofen, Wachau, Vienna-Bratislava, near Nagymaros).

The operation of locks and bridges may result in marginal costs as a result of the energy used for closing and opening a bridge or a lock and personnel operating these locks and bridges. To access some terminals some bridges need to be opened. For the operation of bridges it is assumed that this takes place with permanently employed staff and that energy costs for an additional bridge opening are therefore not negligible.

A very large number of dams, reservoirs, dikes, navigation of locks and other hydraulic structures have been constructed in the basin to facilitate important water uses; these include over 40 major structures on the main stream of the Danube River. These hydraulic structures have resulted in significant economic benefits but they have also caused, in some cases, significant negative impacts downstream. These impacts include, for example, increased erosion and reduced capacity. The river diversions have resulted in reductions in flow below the minimum level required for desired water use. It leads to various negative consequences on fisheries and maintenance of aquatic ecosystems.

Table 11.6 Annual infrastructure expenditures of inland waterways from 2001 to 2003

In million euro	2001	2002	2003
Material & personnel costs	9,0	9,1	9,2
Dredging costs	2,1	2,1	2,1
Locks operational costs	2,7	2,7	2,7
Shipping police and patrol costs	3,5	3,4	3,4
Total	17,3	17,3	17,4

Source: Via Donau

Only 10% of the maintenance costs (material & personnel costs) are allocated to the inland shipping sector (according to Via Donau). All the expenditures made for dredging and the operation of locks are estimated to have a direct relationship with shipping activities. As for the 30% of shipping patrol and police expenditure, Via Donau authorities assess that 30% of these costs are attributable to the shipping activities. The following table list the total costs allocated to the shipping activities.

Table 11.7 Infrastructure costs allocated to shipping activities

In million euro	2001	2002	2003
Material & personnel costs	0,9	0,9	0,9
Dredging costs	2,1	2,1	2,1
Locks operational costs	2,7	2,7	2,7
Shipping police and patrol costs	1,0	1,0	1,0
Total	6,7	6,7	6,7

Source: Via Donau

The question is what the relation is between the total costs allocated to the inland shipping sector and the number of vessels. According to Via Donau (Österreichische Wasserstraßen-Gesellschaft)[17], the percentage attributed to user-dependent costs is 1-5% of the entire infrastructure costs attributed to the inland shipping sector. The Dutch case study percentages of variable costs amount to 15-28%, which is much higher than the Austrian Danube percentages (1-5%). In order to arrive at more realistic figures, the average percentage for the variable costs is calculated by weighing the Dutch and (upper

[17] Source reference: email 16 February 2005, Via Donau.

bound of the) Austrian figures, which arrives at 13%[18]. No information could be given on how to allocate this 13% of variable cost to freight and recreational vessels. Yet, in order to allocate the variable infrastructure costs to freight and recreational vessels, the percentages determined by ECORYS (see chapter on Practical guidelines, section 19.2.3) are used:

Table 11.8 Share of total variable costs that can be allocated to freight and recreational vessels

Type of variable costs	Total variable costs that can be attributed to:	
	Freight vessels	Recreational vessels
Maintenance costs canal banks	60%-80%	20-40%
Dredging cost	100%	-
Operational costs locks	70%-80%	20%-30%
Patrol costs	70%	30%
Average	65%-85%	15%-35%

Source: ECORYS

Taking into account the previous shares of freight and recreational vessels, variable infrastructure costs to be allocated to freight and non-freight transport can be calculated. Corresponding figures are given in the next tables.

Table 11.9 User-dependent costs related to freight vessels

In 1000 EUR	Lower limit			Upper limit		
	2001	2002	2003	2001	2002	2003
Material & personnel costs	70,2	71,0	72,5	93,6	94,6	96,7
Dredging costs	273,0	273,0	273,0	273,0	273,0	273,0
Locks operational costs	241,2	241,2	247,5	275,6	275,6	280,8
Shipping police and patrol costs	94,2	92,8	91,5	94,2	92,8	91,5
Total	678,6	678,0	684,5	736,4	736,0	742,0

Source: Mettle, 2005.

In the same way, we determine the user-dependent costs related to recreational vessels based on the percentages used to allocate variable costs.

[18] Calculated as (((15%+28%)/2)+5%)/2 = 13%.

Table 11.10 User-dependent costs related to recreational vessels.

In 1000 EUR	Lower limit			Upper limit		
	2001	2002	2003	2001	2002	2003
Material & personnel costs	23,4	23,7	24,2	46,8	47,3	48,4
Dredging costs	0,0	0,0	0,0	0,0	0,0	0,0
Locks operational costs	68,9	68,9	70,7	103,4	103,4	106,1
Shipping police and patrol costs	40,4	40,4	39,2	40,4	40,4	39,2
Total	132,7	133,0	134,1	190,6	191,1	193,7

Source: Mettle, 2005.

Total variable costs for freight and recreational vessels in the period 2001-2003 are summarized in the next table.

Table 11.11 Total user-dependent costs related to different types of vessels (2001-2003)

User-dependent costs 1000 EUR	Freight vessels		Recreational vessels	
	Lower limit	Upper limit	Lower limit	Upper limit
2001	678,6	736,4	132,7	190,6
2002	678,0	736,0	133,0	191,1
2003	684,5	742,0	134,1	193,7

Source: Mettle, 2005

The next table shows the evolution in number of journeys, load capacity and transport performance of freight vessels from 2001 to 2003. For recreational vessel the total number of journeys in 2003 is presented.

Table 11.12 Annual journeys, load capacity and transport performance of freight and recreational vessels

	Freight vessels			Recreational vessels
	2001	2002	2003	2003
Number of journeys	12.316	11.782	13.618	8.500
Total load capacity in tonnes	11.633.673	12.316.450	10.737.355	-
Total performance in T-km	9.871.178	12.063.244	10.121.341	-

Source: Via Donau

A proxy for the marginal costs is obtained by dividing the change in these infrastructure costs allocated to different type of vessels by the change in the number of journeys travelled by freight vessels, resulting in marginal cost of €0,75 /journey to €1,12 /journey in 2002 and about €3,37 to €3,54 /journey in 2003 for freight vessels (see table below).

Table 11.13 Marginal infrastructure costs for freight vessels

	Δ in number of journeys	Δ in infrastructure costs (in 1000 €)		Marginal cost (€/ journey)	
		Lower limit	Upper limit	Lower limit	Upper limit
2002	-534	-0,6	-0,4	1,12	0,75
2003	1836	6,5	6,0	3,54	3,27

Source: Mettle, 2005.

Second best solution

A second best solution for marginal costs are the average user-dependant costs. This would lead to the following figures.

Table 11.14 Average user-dependent costs in 2001-2003

	Freight vessels			Recreational vessels		
	2001	2002	2003	2001	2002	2003
Lower limit						
Total infrastructure costs (1000)	678	678	684	103	133	134
Total kilometres sailed (€ * mio)	4,31	4,12	4,76	na	na	2,98
Average cost € per km sailed	0,16	0,16	0,14	-	-	0,05
Upper limit						
Total infrastructure costs (1000)	736	736	742	190	191	194
Total kilometres sailed (€ * mio)	4,31	4,12	4,76	na	na	2,98
Average cost € per km sailed	0,17	0,18	0,16	-	-	0,07

Source: Mettle, 2005.

For both lower and upper limit, the average user-dependent costs are similar. The average user-dependent costs for freight vessels that are calculated in the three Dutch case studies are € 0,27 (lower limit) to € 1,15 (upper limit) per freight vessel kilometre (see table 14.2 for an overview), versus € 0,13 - € 0,18 per freight vessel kilometre in Austrian case study. It can be concluded that the user dependent costs per kilometre on the Austrian Danube are smaller than the costs calculated for the Dutch studies.

Conclusions

Finally the following conclusions can be drawn:

- The costs allocation method is used to calculate marginal costs;
- The resulting marginal costs are the marginal costs per journey. They vary between € 0,75 and € 3,54 per journey for freight vessels;
- The average user dependent costs are calculated at € 0,13 - € 0,18 per freight vessel kilometre. These costs are lower than the costs calculated for the Dutch studies.

12 Case study 5: Main-Danube Channel

12.1 General information

The German channel covers a distance of 170 km between Bamberg and Kelheim. The Main-Donau channel constitutes the link between the Main and the Danube rivers. Goods traffic on the Main-Donau channel has decreased considerably in 2001 compared to the year 2000 due to the bad economic conjuncture, and maintenance works (locks repair) on the channel. In 2001, the total volume of goods transported on the Main-Donau channel amounts 7.496 million tons versus 8.501 million tons in 2000, which is a decline of around 13% in transported weight. In the same year traffic volume between the Main-Donau channel and the river Donau declined by more than 36%. On the other hand, traffic volume between the Rhine and the Donau increased by 3,2%.

Figure 12.1 Main-Danube Channel

At the Kelheim lock 7.134 freight vessels (transporting 5.765 million tons of goods) passed in 2001 versus 7.687 freight vessels in the previous year (a 4.2% decline). The following table highlights the changes in the number of freight vessels and goods volume for the period 2000-2001.

Table 12.1 Number of vessels and transport (tons) through the Kelheim lock

Main Donau Channel	2001	2000
Upper (towards Donau):		
• Total number of vessels	4.680	4.999
• Number of freight vessels	3.673	3.923[a)]
• Volume in tons	3.354.937	-
Lower (towards Rhine):		
• Total number of vessels	4.723	4.997
• Number of freight vessels	3.461	3.662[a)]
• Volume in tons	2.409.674	-
Total	9.403	9.996

Source: Wasser-und Schifffahrtsdirektion Süd;

a) Estimation by ECORYS.

The following table presents freight transport through the Main-Danube canal. Total freight transport amounts 8,5 million tons in 2000. In 2001 freight transport declines with 1 million tons.

Table 12.2 Total freight transport (tons * mln) on the Main-Donau channel (MDC)

	2001 in million tons	2000 in million tons
Through Viereth lock	7,2	8,0
Through Main-Donau channel	0,0	0,0
Through MDC-Donau	0,3	0,5
Total Main Donau Channel	7,5	8,5

Source: Wasser-und Schifffahrtsdirektion Süd

The next section describes the costs related to the Main-Danube channel waterway infrastructure.

12.2 Infrastructure costs

12.2.1 Cost drivers

The table below describes the annual expenditures on the Main-Danube channel from 2000 to 2004. The cost-allocation approach was used in order to determine the marginal infrastructure costs. The investment costs presented here reflect construction works to maintain the canal correctly[19]. Therefore these costs will be taken into account in the short-term marginal costs calculation for this particular case study.

[19] Referring to the questionnaire guideline and emails sent to the *Wasser-und Schifffahrtsdirektion Süd* and *Wasser-und Schifffahrtsdirektion Südwest*, the costs registered by administrators reflect actual yearly infrastructure costs to inland shipping.

Table 12.3 Annual infrastructure expenditures to the Main Danube channel (in EUR)

Main-Donau Channel (MDC)	2000	2001	2002	2003	2004
Investment costs (€ * 1000)	9.111	15.409	15.065	17.972	16.197
Maintenance costs (€ * 1000)	15.225	16.390	15.883	16.393	8.146
Administration costs (€ * 1000)	3.905	4.075	4.323	3.926	3.875
Total costs (€ * 1000)	28.241	35.874	35.271	38.291	28.218

Source: Wasser-und Schifffahrtsdirektion Süd

Based on the previous figures on transport and infrastructure costs, marginal costs for the Main-Danube channel have been estimated. This is subject of the next section.

12.2.2 Estimation of marginal costs

To determine the marginal costs of inland shipping, many cost elements must be displayed. The *Wasser – und Schifffahrtsdirektion Süd* has been asked to distinguish infrastructure costs into variable and fixed costs of inland shipping. However, information on the:

- share of costs that can be allocated to inland hipping,
- split between fixed and variable infrastructure costs;
- share of variable costs that can be allocated to freight and non-freight transport

does not exist at the *Wasser – und Schifffahrtsdirektion Süd*, nor could they give estimates on realistic assumptions[20].

In order to calculate marginal costs, Dutch case study results have been used. Based on the Dutch percentages, the following percentages have been used (see section Practical guidelines chapter 19):

- 71% of total infrastructure costs can be allocated to inland shipping;
- Average variable costs amount 21% (average of lower and upper bound 15% respectively 28%).
- 75% of these variable costs can be allocated to freight transport, the remaining to non-freight transport (average of lower and upper bound 65% respectively 85%).

The following table describes the user-dependent variable costs for freight and non-freight vessels.

Table 12.4 Total user-dependent costs allocated to freight and non-freight vessels

Main-Donau Channel (MDC)	2000	2001	2002	2003	2004
Freight vessels (€ * 1000)	3.158	4.012	3.944	4.282	3.155
Non-freight vessels (€ * 1000)	1.053	1.337	1.315	1.427	1.052
Total costs in EUR (€ * 1000)	4.211	5.349	5.259	5.709	4.207

Source: Mettle/ECORYS, 2005

20 Reference email: 24 February 2005 from *Wasser-und Schifffahrtsdirektion Süd.*

The following table presents the marginal infrastructure costs in 2001 due to an additional vessel passage through the Main-Donau channel.

Table 12.5 Marginal costs to freight and non-freight vessels in 2001

Main-Donau Channel (MDC)	Variation in number of vessels	Variation in user-dependent costs (€ * 1000)	Marginal cost per vessel-km[a)]
Freight vessels	- 451	854	- € 11,13
Non-freight vessels	- 142	285	- € 11,80

Source: Mettle/ECORYS, 2005

a) Assuming that vessel sails total length of Main-Danube channel of 170 km

Based on these estimated figures, marginal costs for both freight and non-freight vessels are negative in 2001, due to the increase in costs and the decrease in the number of vessels. These results are not satisfying.

Second best solution

Because the results of the marginal cost calculations are not satisfying, an alternative method is proposed to arrive at an indication of the marginal costs, which is assessing the average user-dependent costs. The Main-Donau channel covers a distance of 170 km. According to the number of vessels sailing through the Kelheim lock, the average user-dependent costs per vessel-kilometre are € 2,45 - € 3,31 for freight vessels respectively € 2,57 - € 3,47 for non-freight vessels. These figures are much higher than those found in the Dutch case studies and French case study (see table 14.2 for an overview of the results of all case studies).

Table 12.6 Average user-dependent costs in 2001

Main-Donau Channel (MDC)	Number of vessels		Average costs per vessel-km	
	2001	2000	2001	2000
Freight vessels	7.134	7.585	€ 3,31	€ 2,45
Non-freight vessels	2.269	2.411	€ 3,47	€ 2,57
Total	9.403	9.996	-	-

Source: Mettle 2005

Conclusions

Based on the above, the following conclusions can be drawn:

- the cost allocation method was used to determine the marginal costs of the Main-Danube Channel, due to a lack of data the econometric and engineering method could not be used;
- the marginal costs were determined for one year only, 2001, but are judged to be not satisfying;
- in a next step the average user dependent costs have been calculated. Compared to the other case studies these costs are however much higher.

13 Existing infrastructure charging mechanisms

13.1 Introduction

In the previous chapters we have tried to determine the marginal infrastructure costs for several inland waterways. In this chapter we look at the infrastructure charging mechanisms for using inland waterways that currently exist. The most important countries for inland waterway transport are The Netherlands, Belgium, France, Germany and Austria. Together they comprise around ten thousand kilometres of inland waterways. Also the situation in Hungary is addressed since information became available in the Danube case study.

13.2 Examples of infrastructure charging mechanisms

13.2.1 The Netherlands

In The Netherlands one does not have to pay for the use of the inland waterways owned by the central government[21]. One does have to pay for using ports and locks that are owned by local governments. In a recent study[22] it is estimated that freight vessels in The Netherlands have paid around € 16 million in 2002 for using these ports and locks. Dividing this amount by the total number of kilometres travelled on the inland waterways (owned by both central and local government) by freight vessels (66,9 million vessel-km) results in around € 0,24 per vessel-km that is currently paid for using the inland waterways in The Netherlands.

In the recently published 'Nota Mobiliteit' (30 September 2004) the Dutch government writes however that one intends to change this situation: due to the fact that more money is needed to finance the inland waterways for construction and maintenance and the fact that the European Union wants to achieve a situation where one has to pay for using (all kinds of) infrastructure, the Dutch government is currently looking in the project 'Gebruiksvergoedingen Goederenvervoer' how the pricing policy would be if all costs of use and maintenance of infrastructure are to be paid by trucks, train and inland waterway vessels.

The European Commission has proposed the River Information System (RIS) in order to harmonize different information systems regarding inland waterways. It would be possible (in the future) to use the RIS together with the travel scheme of vessels to determine the charges that a vessel has to pay for a trip.

21 With the exception of two bridges. These two bridges are however not part of important inland waterways.

22 'De prijs van een reis' (the price of a trip), CE, Delft, september 2004

13.2.2 Belgium

In Belgium one has to pay so-called 'Scheepvaartrechten' (shipping rights) when using inland waterways owned by the government. For freight vessels these rights amount to € 0,00025 per ton-kilometre. In the year 2000 the Scheepvaartrechten were decreased with 90% in order to stimulate inland shipping[23]. Recreational vessels do not have to pay for Scheepvaartrechten.

13.2.3 France

Inland waterways
When using the French inland waterways, a toll must be paid. The goods tolls grant right of access to the network according to the vessels' characteristics, the route and the type of goods transported. Tolls imposed can be separated in two parts:

- An access right to the network, which is not related to the tonne-kilometres performance;
- A variable part, which depends on the tonne-kilometres performance.

Both parts have different values, depending on the size of the vessel. Revenues generated are used entirely for maintenance and enhancement of the network. The various rates are listed in the table below.

Table 13.1 Tolls (per 1 July 2003)

	Public general goods transport including containers (in Euros)	Specialised goods transport and transport via sea-river vessels in Euros ()
Access right to the network:		
> 5,000 T	67,38	33,69
3000 - 4999 T	58,85	29,42
1700 - 2999 T	54,88	27,44
1100 - 1699 T	52,14	26,07
500 - 1099 T	46,95	23,48
200 - 499 T	32,62	16,31
< 199 T	18,29	9,15
Variable part as function of T/km:		
Small gauge : 0,0686 Euros (ct/Km)		
Large gauge : 0,0869 Euros (ct/Km)		

Source: Voies Navigables de France

"For public or private goods transport within the confines of the areas entrusted to VNF according to article 124 of the 1991 Finance law (no. 90-1168 of 29/12/90), the carrier pays a toll for any routes travelled on the river network. Toll rates are calculated as a

[23] Source: http://www.binnenvaart.be/nl_downloads/klanten/reglementering/bel_waterwegen/Algemeen

function of the vessels' characteristics, the route and the type of goods transported, the load, and whether the vessel belongs to the inland or maritime navigation regime.
The toll is payable in addition to taxes and contributions of all kinds paid by goods carriers".

Lock service

The special on-demand passage or lock service allows river vessels to cross navigation facilities at night and during certain national holidays outside of normal operating hours.

This service is available to users who have made prior requests. The terms and conditions are defined by each navigation service for a given waterways in question, and which pay the sum of the corresponding charges.

Table 13.2 Normal regimen (regular period)

	Simple rate (in euros)	Increased rate between 10 pm and 6 am* (in euros)
Large push tugs	28,26	42,39
Small push tugs	18,84	28,26
Sea-river / coasters	28,26	42,39
Push tows:		
• > 1.500 T	28,26	42,39
• 751 to 1.500 T	18,84	28,26
Motor barge/ push tugs		
• 751 to 1,500 T	18,84	28,26
• 501 to 750 T	14,13	23,56
• < 500 T	9,42	14,13
Passenger vessels		
• Large gauge	18,84	28,26
• Freycinet gauge	9,42	14,13
Recreational vessels	18,84	28,26

* The increased rate represents a 50% increase in the simple rate except for motor barges from 501 to 750 T.

Exceptional regimen

The exceptional regimen consists of a doubling of the simple rate. It is applicable to certain national holidays (Christmas, labour day, new year and 14 July) and certain nights before holidays (24 December, 31 December, 30 April, 13 July).

Possible evolution of charging mechanisms

These current charging mechanisms are not enough to cover all exploitation costs of the French inland waterways, taken into account the fact that the French network is particularly old and would require main investments in the coming years.

The French VNF, the public organisation related to the French Ministry for infrastructure, housing, transport, tourism and the sea, is responsible for managing, operating, modernising and developing the French inland waterways network.

They are currently thinking of modifying the current charging mechanisms by implementing two optional systems, within a timeframe of 2 years:

- The first one would consist of an annual unlimited subscription (equivalent to a tax disc system) through which operators would have unlimited access to the network once paid.
- The second optional system would be based on a contract with the operators, mainly for the largest waterways. The global idea would be to charge higher tolls to the operators but offering them in parallel a range of services providing added value to the inland transport. This contractual relationship between the VNF and the operators would be actually based on the current program developed by VNF entitled “intelligent waterways” (*voies d’eau intelligentes*) dealing with electronic data interchange and real time monitoring of vessels, including geopositioning. VNF is currently working on the potential of such contracts with operators, the main scope being to establish customer loyalty. The potential implementation of this possible new charging mechanism, based on value-added services, also highly depends on the acceptability of the operators which is currently assessed by VNF.

13.2.4 Germany

The average charging price for German waterways depends on the value of the transported goods. The federal ministry of transport settles these prices. However, no charging mechanism exists for the “international rivers” namely Elbe, Danube, Rhine and Oder. For Moselle, the pricing mechanisms are decided in agreement among France, Germany and Luxembourg.

Regarding the infrastructures, the local regions (Bundes Länder) are responsible for the tariff policies in the ports. For the port of Straubing (near the Danube) for instance the minimum port tax collected per vessel is 30.00 €. For the port Deggendorf, also near the Danube, the port taxes ranges from € 76.69 to € 102.26 depending on the size of the vessel.

The charges regarding locks are already included in the charges settled by the ministry.

The federal ministry is looking for potential modifications of this charging mechanism, which are currently not enough to cover all costs. The average price has been relatively stable during the past years. But the federal ministry has difficulty in increasing tariffs due to the high competition with road and rail transport.

Kanalabgaben in Germany

The level of Kanalabgaben plays an important role in inland waterway transport in Germany. In other IWT countries in Western Europe the trend is towards a decrease or elimination of such charges. In Belgium the Flemish inland navigation administration has decided to decrease the so-called ‘Scheepvaartrechten’ (shipping rights) when using inland waterways owned by the government. For freight vessels these rights amount to € 0,00025 per ton kilometre. In the year 2000 the Scheepvaartrechten were decreased with 90% in order to stimulate inland shipping. In the Netherlands similar charges do not exist at all. Also the Mosel Commission has concluded that charges will not be increased, however will remain next two years at the same level. Nordrhine-Westfalia is one of the pioneer regions demanding to lower the Kanalabgaben.

13.2.5 Austria

Austria does not collect neither toll for locks or taxes for the discharge of waste and waster oil. No remuneration is claimed for the use of the installations of public federal banks.

13.2.6 Hungary

In Hungary, no tax is perceived for the sailing the waterway, only port and pier taxes are charged (see next table).

Table 13.3 Charging in Hungary

	Measuring unit	Győr-Gönyü	MAHART -Csepel	FERROPORT-Csepel	DUNAFERR Dunaújváros	ÁTI Baja
Port tax	€/t/24h	0.01	0.02		0.02	
Pier tax	€/tonne	0.26	0.33	0.33	0.30	0.20

Taxes do not include VAT, which in Hungary is 25%.

14 Conclusions case studies

14.1 Methodology

In order to determine the marginal infrastructure costs there are three approaches presented in the theoretical framework:

- Econometric approach;
- Engineering approach;
- Cost-allocation approach.

The econometric approach starts with the real occurring costs and seeks for a costs function to estimate the marginal costs. The engineering approach starts with estimating the costs of a single infrastructure section based on a technical relationship between input and output, but which are not necessarily reflected in actual spending, and generalizes the results afterwards. The cost-allocation approach starts with the cost registration and tries to split up relevant costs into fixed and variable costs. In a next step the marginal costs are determined by looking at the change in the variable costs versus the change in the number of vessels.

Practicability

It can be concluded that regarding the practicability of the three approaches the econometric approach is theoretically preferred since it provides objective evidence of cost causation, not depending on the judgment of the researcher, except regarding issues as the type of function and the selection of variables. However, it proved to be a problematic approach. To get an adequate sample size with sufficient variability amongst the explanatory variables requires disaggregate data for individual stretches of infrastructure. In the case studies performed this was a difficult exercise. Sometimes data on costs were only available for a (too) short period (1 to 3 years), in other cases data were available for a longer period but registration methods had changed leading to strange swifts in costs. It became also clear that expenditures on maintenance and renewals are influenced by financial situation of the responsible organisation: there were cases where maintenance costs suddenly increased because there was not enough finance to replace parts of the infrastructure leading to higher maintenance costs. The other way around was also seen: postponement of maintenance leading to relatively low maintenance costs.

The engineering based approach was not practical at all: there was no knowledge available within the organisations to follow this approach.

Since both the econometric and engineering based approaches proved to be not that practical, the cost-allocation approach was the method most used.

The cost-allocation method however requires a thorough analysis of the available data, lots of interaction with the organisation providing the data and the making of decisions that are always influenced by the judgement of the researcher. Nevertheless this approach was considered to be the most practical, also because the need for data is less compared to the econometric method. With regard to the observed costs the same applies as for the econometric approach: the observed costs do not always reflect the true costs due to for example postponement of infrastructure costs.

Transparency
To guarantee consistent, harmonized application of marginal costs charges, a transparent methodology for calculating these costs must be available. Based on the results it must be concluded that the most practical approach, the cost-allocation method, is in theory transparent. If decisions are made and published regarding what kind of costs need to be registered, in what way and which part of the different costs items are fixed and which are variable, the approach is in theory transparent. An issue for discussion however will be what percentage of the different costs items vary with usage. From our case studies we can derive benchmark figures, however these remain subject to specific appraisal in individual cases. Another complication is that not all infrastructure costs of inland waterways are related to inland shipping. Costs made for flood protection and water management for instance cannot be attributed to inland shipping and therefore should not be taken into account.

Generalization
Our view is that the methodological approach of cost-allocation to determine the marginal costs of inland waterways has the potential to be used for inland waterways in other countries. A potentially major inherent drawback of the approach is that it is depending on a great deal of detailed data (for a short period) and modelling specific to the waterway concerned, which may not be readily available in other countries.

Before a common approach of the cost-allocation method can be introduced for the infrastructure costs in the EU member states, it is in our opinion necessary to introduce a common method of cost registration. This means that it should be decided how costs of waterways have to be registered, what kind of cost items have to be identified, what these cost items comprise etc. After that, a next step is to agree what percentage of the different costs items varies with usage.

Short term versus long term
This study focuses on short run marginal costs, assuming that capacity of the infrastructure is constant. Long-run marginal costs include also the capital costs of increasing capacity to accommodate an increase in output; they are difficult to measure. Linking charges to long-run marginal costs would lead to inefficiencies where excess transport capacity exists. After all net social benefits are increased by increasing output and utilizing otherwise idle capacity (capital costs are treated here as ‘sunken’ costs and could be ignored. In order to raise money to compensate for the capital costs a lump-sum taxation could be raised, see also chapter 2).

Although this study focuses on the short-term marginal costs an indication can be given of what happens if investment costs are included. This indication is based on a study, which has been performed for the Dutch inland waterways (CE, 2004). This study quantifies charges per vessel kilometre for two scenarios:

1. Variable infrastructure cost – those costs which vary with the level of traffic intensity whereas infrastructure capacity remains the same - will be charged;
2. Variable infrastructure costs added up with the fixed infrastructure cost, this scenario includes all infrastructure costs (including costs of infrastructure replacements).

The next table shows the increase in charging levels between both scenarios (scenario 1 index = 100) disaggregated into type of vessels.

Table 14.1 Charges “scenario 1” in proportion to charges “scenario 2”

Type of vessel	Variable costs (index = 100)	Fixed costs (variable costs index = 100)	Total costs (variable costs index = 100)
Professional vessels			
<250 tonnes	100	268	368
250-400 tonnes	100	368	468
400-650 tonnes	100	502	602
650-1000 tonnes	100	704	804
1000-1500 tonnes	100	789	889
1500-2000 tonnes	100	981	1081
2000-3000 tonnes	100	1053	1153
>3000 tonnes	100	1530	1630
Recreational	100	189	289

Source: CE, Onderhoud en beheer van infrastructuur voor goederenvervoer, deelstudie 2

From the previous table we can conclude that short and long term marginal cost differ a lot. Fixed maintenance and management cost for infrastructure that can be allocated to inland shipping is estimated as almost 3 times higher than variable infrastructure costs for the smallest vessel categories and more than 15 times higher for the biggest vessel type.

14.2 Result case studies

It can be concluded that the administration of costs by the responsible waterway authorities contacted during the case studies is not organized in such a way that one is able to easily determine the marginal infrastructure costs of inland waterways:

- The availability of cost figures differs. For the Amsterdam-Rhine channel the infrastructure costs are known for only the last 3 years. For the IJsselmeer route there were only average figures available. For the Rhone-Saone and Danube case study even less detailed data on infrastructure costs were provided.
- The costs that are registered do not reflect the real necessary costs. Due to budgetary reasons maintenance costs can be relatively low (leading to outstanding maintenance) or relatively high (more money for maintenance is needed because replacement is postponed resulting in higher maintenance costs). In the case that a canal is upgraded the costs of these upgrading are registered separate from the

maintenance cost. The maintenance costs are however influenced by the upgrading: broadening and deepening of the canal leads for example to lower regular dredging costs and lower maintenance costs for embankments.
- Costs made in a year are not always registered in that year: if the bills are not paid yet in the year that the costs were made, the costs will show up in the next year.

Based on the case studies we have the impression however that cost allocation definitely has the possibility to serve as the method to arrive at marginal costs or, as second best solution, to arrive at average user-dependent costs because this method can overcome problems with the availability of data (only the costs for 1 or 2 years is needed) and corrections in the data can easily be made in order to correct for 'administrative problems' (postponement of costs, registration of costs for other reasons such as upgrading of channels, etc.)

Second best solution: average user-dependent costs

As an alternative method to arrive at an indication of the marginal costs, the average user-dependent costs have been calculated. The average (freight) user-dependent costs are calculated as: Total user (freight) dependent costs / Total number of (freight) vessel kilometres. The results are compared with the results of a Dutch study[24] from 2004 in which the user dependent costs were estimated at € 0,47 - € 0,53 per freight vessel kilometre. In the table below the results for the different case studies are summarized.

Table 14.2 Average user-dependent costs in € /vessel-km for freight vessels in the different case studies

Year	ARC	PMC	VSC	CRR	PS	GS	PR	AD	MDC
1994	-	-	0,67	-	-	-	-	-	-
1995	-	-	0,72	-	-	-	-	-	-
1996	-	0,45	0,80	-	-	-	-	-	-
1997	-	0,39	0,82	-	-	-	-	-	-
1998	-	0,36	0,85	-	-	-	-	-	-
1999	-	0,27	0,84	-	-	-	-	-	-
2000	-	0,28	0,81	0,21	0,06	0,50	0,13	-	2,45
2001	1,15	0,31	0,89	0,24	0,06	0,35	0,14	0,17	3,31
2002	1,14	0,34	0,91	0,31	0,08	0,35	0,15	0,17	-
2003	-	0,40	-	0,29	0,08	0,26	0,13	0,15	-

ARC = Amsterdam Rhine Channel PMC = Prinses Margriet Channel
VSC = Van Starckenborgh Channel CRR = Canal Rhone-Rhine
PS = Petit Saone GS = Grande Saone
PR = Petit Rhone AD = Austrian Danube MDC = Main-Danube Channel
(1) Assuming that 20% of the infrastructure costs have a relation with the number of freight vessels travelling on the Danube

It can be concluded that the average user dependent costs for freight vessels on the Main-Danube Channel are very high compared to the Dutch, French and Austrian figures. One

[24] 'De prijs van een reis', CE, september 2004.

of the reasons for this can be the poor estimation of the total costs. In fact the Main-Danube Channel case study provides too limited information to draw a solid conclusion. With regard to the Dutch case studies it can be concluded that the figures for the ARC and the VSC are higher compared to the Dutch national average. Possible reasons for the difference can be that:

- in the study of CE the actual costs are used, no correction has been made to arrive at the necessary costs as has been done for the VSC.
- In this study we have looked in detail at the different costs items and for each item we have tried to establish the user dependent part in the total costs. In the study of CE the method used was more rough: only total national figures were used and the division of the costs between user dependent and non-user dependent costs was not done on such a detailed level as in this study.

The results found for the waterway sections of the Basin Rhone-Saone are relatively low compared to the Dutch figures.

Finally, no distinction is made in the case studies between the user-dependent costs and the type of ships using the waterway. This is done because the user-dependent costs are not influenced by the size of the ship, according to the experts that provided the data: because the waterway is built to accommodate certain ships in a CEMT-category these ships do no cause relatively more damage, resulting in higher maintenance costs, compared to smaller ships. This would be the case if ships of a higher CEMT-category than allowed would use the inland waterway. This however is forbidden and rarely takes place (in the exceptional case that a ship of a higher CEMT-category wants to use the inland waterway the authorities must be noticed in advance. They will than decide whether this is possible and what actions/restrictions must be taken).

14.3 Conclusions and recommendations

In our view the cost-allocation approach has the potential to be used in order to determine marginal costs of inland waterways. The variations in the marginal costs resulting from the case studies are not the result of the quality of the method as such, but are resulting from registration problems that administrative bodies are encountering when categorizing infrastructure costs/expenditures for waterways.

Based on the literature review and the marginal cost pricing approaches applied in the case studies, we would therefore recommend:

1. To introduce a common method of cost registration which addresses:
    a. Registration of waterway expenditures;
    b. Translation of expenditure into ‘yearly costs’;
    c. Cost items that have to be identified;
    d. Clear definition of these cost items;
    e. Percentage of costs that can be attributed to inland shipping (and what cost to for example flood protection, water management etc.);
    f. The share of the different costs items that vary with usage.
2. To monitor the degree of backlogging of maintenance costs, in order to compensate for postponed maintenance and level off high and low maintenance costs.

3. To further improve and apply the methodology of cost-allocation as most practical and transparent methodology for getting the prices right.

Part III Other marginal costs

15 Safety and accident costs

In the theoretical framework a method to determine the safety and accidents costs is presented. In this chapter we will present a simplified approach, based on the cost-allocation method. The application of this cost-allocation method is much easier, the data availability is better and it is not known whether the results of this approach are substantially different from results from a perfectly executed marginal case study (that includes risk avoidance).

Attribution of costs to parties involved

In general in a cost-allocation the total costs of society are determined and attributed to different cost drivers, which for instance for safety costs could be the type of vehicle, location, time of day, driver characteristics etc. For accidents costs the attribution of costs in multi-party accidents is rather difficult. Within the EU funded UNITE program the costs are allocated based on damage done to the other party. This however requires advanced accident statistics. Unfortunately studies have shown that the registration of accidents is poor in most countries, especially for inland waterway transport. Therefore in this simplified approach we will use the vehicle type that causes the accident, for which data is in most cases available.

Insurance premiums

Insurance premiums can be considered as internalization of external costs. The premium for self-protection should not be taken into account, but the premium for third party risk should be taken into account. However it is unknown what these premiums are exactly for the inland waterway transport and what the damage is to other vessels involved. Therefore we do not take these insurance premiums into account in this simplified approach.

We propose to use the following simplified approach, that is based on the case study within the UNITE project. This case study to container shipping on the Rhine in the Netherlands provided some data on accident costs.

1. Determine accident *risk*; this data should be based on national statistics or if possible on specific information for the waterway segment. Ideally speaking the data should distribute between the victim and injurer (including single ship accidents).

2. Determine risk *elasticity*; this is the relationship between number of accidents and number of vessels. Of course this relation depends heavily on aspects such as type of vessels, type of waterway, location and conditions. Within the UNITE case study the risk elasticity could not be determined and is set on 0.01 for both the victims and injurers.

3. Evaluate *monetary value*; the costs of the different accidents should be determined. Within the UNITE case study the following average costs have been determined.

Cost element	Amount	Internal/external
Damage to ship	€ 94.400 per incident	Internal
Damage to cargo	- not determined -	Internal
Damage to infra	€ 37.000 per incident	External
Human injury	€ 1.783.000 per death € 316.000 per heavy injury € 16.000 per slight injury	Internal for injurer, external for victim
Administrative costs	€ 9.0000 per hospitalized person	External
Liability insurance	50% of human injury costs victims	Internal

These costs could be used for other case studies if specific information is not available. If the costs are used for other countries than The Netherlands, they should be corrected for the Public Power Parity.

4. Determine *external part* of costs: the insurance costs for third party risks should be subtracted. Within the UNITE case study it is assumed that the premium amounts to 50% of the human injury or death costs for victims.

Example:

In 2000 there were 22 accidents on the Amsterdam-Rhine-Channel. In 14 accidents an inland shipping vessel was involved. We assume that in these accidents, 5 vessels were significantly damaged, in 2 accidents there was significant damage to the infrastructure and there were 2 heavy injuries (1 injurer and 1 victim). Besides this there was 1 accident that lead to damage to the cargo.

	Number of accidents	Cost per accident	Total safety costs (euro)	Internal costs	External costs
Damage to ship	5	94.400	472.000	472.000	
Damage to cargo	1	15.000	15.000	15.000	
Damage to infrastructure	2	37.000	74.000		74.000
Heavy injuries: injurer	1	316.000	316.000	316.000	
Heavy injuries: Victim	1	316.000	316.000	158.000	158.000
Administrative costs hospital	2	9.000	18.000		18.000
Total			1.211.000	961.000	250.000

The total costs are thus [damage to ship] 5 x € 94.400 = € 472.000, [damage to infra] 2 x € 37.000 = € 74.000, [heavy injury] 2 x € 316.000 = € 632.000, [administrative costs hospital] 2 x € 9.000 = € 18.000 and [estimate of damage to cargo] 1 x € 15.000 = € 15.000. This leads to total safety costs of around € 1.211.000 per year. The external costs of these costs are € 250.000 per year (corrected for damage to ships, damage to cargo and liability insurance). The marginal safety costs, taking the risk elasticity of 0,01, are thus around € 2.500 per vessel for the Amsterdam-Rhine Channel in the Netherlands.

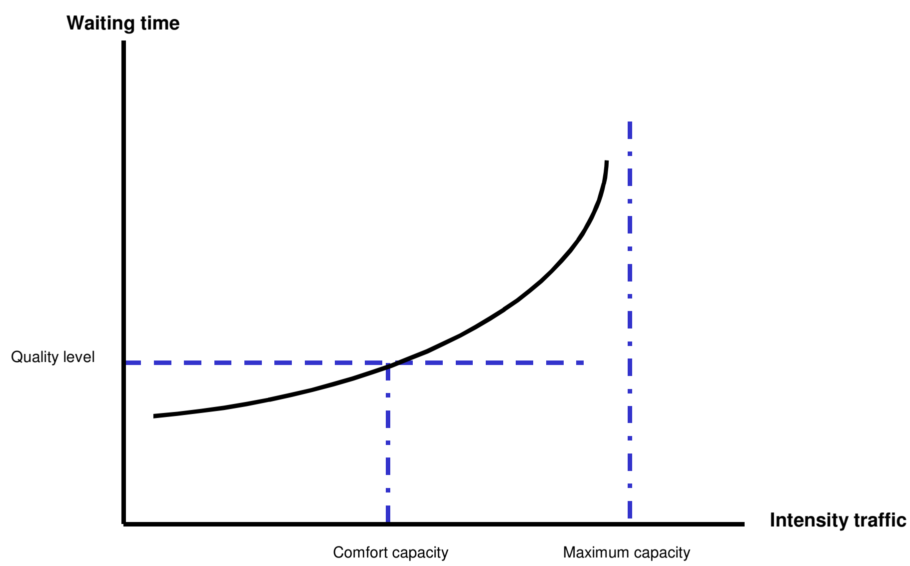
In theory this extra vessel entering the traffic flow causes around € 2.500 safety cost and theoretically should be charged for these extra costs. In common day practice the extra ship entering the traffic flow cannot be identified. For practical reasons one could suggest to recoup these costs from an average vessel using the waterway that year. Assuming an average payload weight of 1000 tonnes per ship, total transport performance of an average ship would amount 73000 tonnekilometres (1000 tonnes times the length of the ARC section of 73 kilometres). In this example the marginal safety costs would arrive at € 0,03 per tonnekilometre for the Amsterdam-Rhine Channel each year. In comparison, for the Rhine the UNITE-study calculated a marginal accident cost of € 0,002 per tonnekilometre.

16 Congestion costs

In the theoretical framework the difficulties of determining the congestion costs for inland waterway transport are discussed. There are almost no studies performed to these costs and in general the expected outcome is low. However, on a specific inland waterway segment with locks and/or bridges that need to be opened, congestion could occur. There are few examples of locks, which offer quantifications of the relation between the intensity of traffic and congestion at locks. ECORYS has developed a 'lock-model' for inland waterways in Belgium[25]. In this model the relationship is modelled between intensity, capacity of the lock and average waiting time. In this chapter the method to determine the waiting time is described, including the valuation of the waiting time. The determination of the waiting time consists of several steps:

1. Determining the comfort capacity; the theoretical capacity (assuming that during opening hours the lock is continuously in both directions fully used) will never be met, since there is a diversity of vessels types and the arrival pattern is in practice not optimal, there may be an imbalance in intensity per direction. The quality level of the lock is determined by the average waiting time of the lock. The comfort capacity is the capacity that corresponds with this quality level. This is presented in the following figure.

Figure 16.1 Relationship between intensity and average waiting time (defining the quality level and comfort capacity)



[25] ECORYS, Studie naar de effecten van een toename van de scheepvaart op de capaciteit van de waterwegen in Vlaanderen, Rotterdam, 2003.

2. Determining traffic flow and arrival pattern

The vessels differ a lot in size and form and this has an impact on the capacity (and waiting time) at the locks. Therefore it is important to determine number of vessels, sizes of vessels and arrival patterns are there any peak hours during the day), taking into account the opening hours of the lock.

3. Determining average waiting time

Within the model built by ECORYS the lock characteristics (opening hours, dimensions, time of lockage of vessels and arrival pattern) are held against the traffic forecasts. This leads to an average waiting time, which might be more than the quality level. This will lead to measures to increase the capacity (opening hours, additional chamber etc). The average time can be valued.

4. Valuation of waiting time

The waiting time can be valued with the value of time for inland waterway transport. It is rather difficult to determine this value of time. The value of time will be different for the different type of vessels and different types of cargo. Recently in the Netherlands a study was finished to determine the value of time[26]. This study concluded on a value of 78 Euro per vessel per hour for container shipments and 74 Euro for non-container shipments[27] (average 74 Euro).

Example:

The Royers lock in the Port of Antwerp is one of three locks that can be used by inland vessels to enter the Albert Channel. The lock has a length of 180 meter and a width of 23 meter and can process all types of inland vessels. In 2001, about 14 million tons of cargo has passed the Royers lock via 24,600 inland vessels (including empty vessels). These vessels are quite concentrated on certain hours of the day, 70% of the daily passages are concentrated in 12 opening hours, whereas the remaining 30% of the arrivals are distributed over the other 12 hours. The duration of a complete lockage cycle (both directions) takes 90 minutes (average free-flow waiting time is already 45 minutes per vessel assuming a uniform arrival pattern).

The model simulates the arrivals and lockage process on an average working day. The model runs result in an average waiting time of 70 minutes per vessel (of which 25 minutes due to congestion) in the busy period of a day and an average waiting time of 46 minutes per vessel in the quiet period of the day. This can even be split up in the average waiting times per type of vessel, but given the level of detail of the available key figures for valuation of waiting time, a further split up is not required. This leads to a total waiting time due to congestion of 7,300 hours per year for the lock, which can be valuated against an average value of 74 Euro. The

[26] Besides the value of time, also a value of lost time is presented. This is the value per percent change in the reliability. This value is set at 6,6, Euro per percent change for container shipment and 6,2 Euro for non-container shipments (average 6,3 Euro).

[27] Within the UNITE project the value of time for inland waterway transport in the Netherlands was determined on 218 Euro per vessel per hour (0,20 Euro per ton).

waiting time costs in 2001 for the Royers lock thus amounts to 540,000 Euro. Another example is the Lock at Asper on the Upper Scheldt. The lock has a length of 125 meter and a width of 14 meter and can process CEMT Va and smaller vessels. In 2001, about 9.3 million tons of cargo has passed Lock Asper via 20,600 inland vessels (including empty vessels). These vessels are quite equally spread over the opening hours, 40% of the daily passages are concentrated in 6 opening hours, whereas the remaining 60% of the arrivals are distributed over the other 10 hours. The duration of a complete lockage cycle (both directions) takes 40 minutes (average free-flow waiting time is 20 minutes per vessel assuming a uniform arrival pattern).

For this lock there is no real busy and quiet period (almost uniform distribution over the day). The model runs result in an average waiting time of 35 minutes per vessel in both the busy period and the quiet period of the day (of which 15 minutes due to congestion). This leads to a total waiting time due to congestion of 5,150 hours per year for the lock, which can be valuated against an average value of 74 Euro. The waiting time costs in 2001 for Lock Asper thus amounts to 381,000 Euro.

These two examples immediately highlight a weakness in the use of key figures for the valuation of waiting time. The valuation does not take into account the composition of the type of vessels, although the share of large vessels (CEMT V and larger) is much higher at the Royers lock than at Lock Asper. It would therefore be recommended to derive key waiting time valuation figures per vessel type, because it is obvious that one hour for a large vessel should have a higher valuation than one hour loss for a small vessel.

Disadvantage of this method is that not the marginal congestion costs are determined, but the average congestion costs. And these average congestion costs are already paid by the inland shipping companies: by doing business the shipping company has already taken into account the fact that there will be waiting times for using locks. It would therefore be unfair to let shipping companies pay these congestion costs again, now only as really out-of-pocket expenses. This would mean that they have to pay the congestion costs twice.

What we are looking for are the additional congestion costs that arise when one additional vessel enters the traffic flow. These are the real marginal congestion costs. A practical way to determine these costs is by using the ‘waiting-time lock model’ for two following years. The change in the total waiting-time costs in the t+1 year can attributed to the change in the number of vessels and these costs can be seen as the marginal congestion costs. A further improvement of the method would be if the valuation of waiting time could be more specified, taking into account the type of vessels.

Example:

Assuming that traffic at both locks will increase with 5% in the next year, and as a result of that waiting time will increase with 2,5%, total waiting time cost will arrive at around:

- EUR 554.000 for the Royer lock, an increase with around EUR 14.000
- EUR 390.000 for the Asper lock, an increase with around EUR 9.000

Dividing the increase in waiting time cost by the increase in number of vessels, results in marginal congestion costs of around:

- EUR 11 per vessel for the Royer lock
- EUR 9 per vessel for the Asper lock

In theory these extra vessels entering the traffic flow are causing around € 9 up to € 11 congestion cost per vessel. Theoretically the extra vessels should be charged for these extra costs. In common day practice the extra ship entering the traffic flow cannot be identified. For practical reasons one could suggest to recoup these costs from all vessels using the waterway that year. In this example the marginal congestion costs of € 14.000 for the Royer lock would be assigned to approximately 25.800 vessels, which results in € 0,54 marginal congestion costs per passage. For the Asper lock the € 9.000 marginal congestion cost would be assigned to around 21.500 vessels, resulting in € 0,42 marginal congestion costs per passage

17 Environmental costs

In part I the theoretical framework regarding the environmental costs is discussed. The main element in this discussion was the Impact Pathway Approach, which is a detailed work out of a bottom-up approach for calculating marginal external costs. The Impact pathway Approach has been developed within the EU funded ExternE project. In this chapter some practical guidelines are presented to use this approach.

Air pollution

In the theoretical framework five steps are mentioned, based on the Impact Pathway Approach, to calculate the air pollution costs. These steps include the determination of emission factors per vessel kilometre and the financial valuation of emissions.

For the determination of emission factors per vessel kilometre, the TREMOVE[28] data can be used. As mentioned in the theoretical framework the TREMOVE model provides data on passenger and freight transport for the EU-15 countries plus Switzerland, Norway, the Czech Republic, Hungary, Poland and Slovenia. There are 21 categories for inland waterway transport vessels. For each country the vehicle-kilometres per mode are given and the amount of inland waterway transport related emissions. The combination of these two leads to the emission factors.

Example:

In 2002 there were 14,47 million vehicle kilometres per year for dry cargo vessels from 400-650 ton. In the same year these vessels caused 1.186 ton Nox emissions. This leads to 81,96 ton per million vehicle kilometre of Nox .

The next step is to determine the financial valuation of emissions. For this purpose the following table can be used with the marginal external costs of emission in rural areas for the EU-15 countries. This table is based on the BeTA database (eventually results from the ExternE-project).

[28] See: www.tremove.org

Table 17.1 Marginal external costs of emissions in rural areas (€ per ton, prices 2002)

	SO_2	NO_x	$PM_{2,5}$	VOC
Austria	7.200	6.800	14.000	1.400
Belgium	7.900	4.700	22.000	3.000
Denmark	3.300	3.300	5.400	7.200
Finland	970	1.500	1.400	490
France	7.400	8.200	15.000	2.000
Germany	6.100	4.100	16.000	2.800
Greece	4.100	6.000	7.800	930
Ireland	2.600	2.800	4.100	1.300
Italy	5.000	7.100	12.000	2.800
Netherlands	7.000	4.000	18.000	2.400
Portugal	3.000	4.100	5.800	1.500
Spain	3.700	4.700	7.900	880
Sweden	1.700	2.600	1.700	680
United Kingdom	4.500	2.600	9.700	1.900
EU-15 average	**5.200**	**4.200**	**14.000**	**2.100**

Source: TREMOVE database

The valuation of CO_2 emissions is not known for all EU-15 countries. We have used a valuation of 50 Euro per ton, which is the most recent estimate for the Netherlands.

The combination of the emission factors and the valuation of emission leads to the external costs of air pollution. For SO_2 en $PM_{2,5}$ the urban effects are different from the effects in rural areas. The exact effects depend on the number of inhabitants of the urban area. In the following table some valuations are mentioned for different sizes of the city.

Table 17.2 Marginal external costs of emissions in urban areas (€ per ton, prices 2000)

	$PM_{2,5}$	SO_2
100,000 inhabitants	33,000	6,000
200,000 inhabitants	66,000	12,000
300,000 inhabitants	99,000	18,000
400,000 inhabitants	132,000	24,000
500,000 inhabitants	165,000	30,000
1,000,000 inhabitants	247,500	45,000
Several million inhabitants	495,000	90,000

Source: TREMOVE database

Example:

We know that the NO_x emission factor of dry cargo vessels (450-600 ton) is 81,96 ton per million vehicle kilometre. Combined with the table mentioned above (4.000 Euro per ton NO_x in the Netherlands) this means that the costs are 0,33 Euro per vehicle kilometre in rural areas.

In the following table the results for the Netherlands are presented for the dry cargo vessels.

Table 17.3 Emission costs per type of vessel in the Netherlands (Euro per vessel kilometre)

	Rural area					Urban area				
	SO_2	NO_x	PM	VOC	CO_2	SO_2	NO_x	PM	VOC	CO_2
Dry Cargo 400-650 ton	0,03	0,34	0,07	0,01	0,21	0,09	0,34	0,49	0,01	0,21
Dry Cargo 1500-3000 ton	0,09	1,28	0,28	0,03	0,79	0,31	1,28	1,98	0,03	0,79
Tanker 400-650 ton	0,02	0,34	0,06	0,01	0,23	0,08	0,34	0,46	0,01	0,23
Tanker 1500-3000 ton	0,14	1,98	0,45	0,05	1,23	0,49	1,98	3,16	0,05	1,23
Push barge400-650 ton	0,12	1,67	0,36	0,04	1,03	0,43	1,67	2,51	0,04	1,03
Push barge 1500-3000 ton	0,12	1,67	0,36	0,04	1,04	0,42	1,67	2,58	0,04	1,04

Source: TREMOVE database

Noise costs

In the theoretical framework the five steps of the Impact Pathway Approach are mentioned to determine the noise costs. A simplified approach is a cost-allocation approach and can consist of four steps.

1. Determine cut-off value below which the nuisance is regarded as negligible. In general noise with a low frequency (such as rail transport or inland waterway transport) is less annoying than continuous noise (such as road transport). Therefore the cut-off value is, equally to rail transport, set at *60 dB(A)*.

2. Determine the number of households and people that are exposed to a certain noise level, using different noise level groups. These statistics need to be collected for each country specifically.

3. Determine financial valuation; this valuation is situation specific and can be determined by using a revealed preference method or a stated preference method. There are different studies performed to determine the willingness to pay for noise reduction. However these studies show a large range in results. In a EC Workshop on 14 December 2001 (State-of-the-art in noise valuation) a valuation between € 5,00 and € 50,00 per household per dB per year is proposed. We suggest to use the median value of this range, being *€ 23,50 per dB per household* per year, or approximately € 10,00 per person.

4. Allocate to vessel classes, using for instance the number of vehicle kilometres per vessel type and weighting factors for different vessel types.

To determine the total noise costs within and outside city limits the number of households within and outside city limits that are disturbed must be known. If this information is missing a default value could be used. For instance in the Netherlands it is known that 80% of the noise costs fall within urban areas and 20% outside. This of course depends on the urbanization level of the country. It is however in most cases assumed that the inland waterway transport does not cause any noise costs, since very few people live that close to inland waterways. Below an imaginary example is presented, just to show the different steps in the calculation.

Example:

For a specific inland waterway segment the number of households that suffer form noise disturbance is determined. The results are that 45 households suffer from 55-60dB, 25 households from 60-65 dB and 10 households from >65 dB. The cut-off value is 60dB. This means that 5 households suffer from an average of +2,5 dB and 10 households from an average of + 7,5 dB. This is valued at 25 households x 2,5 dB x 23,50 Euro + 10 households x 7,5 dB x 23,50 Euro = 3.232 Euro per year.

However, to arrive at real marginal costs – the additional noise costs that arise when an additional vessel enters the traffic flow – one should estimate the yearly change in noise level and attribute the corresponding costs to the yearly change in the number of vessels. A practical way to determine these costs is to apply the previous calculation example for two following years. The change in the monetarised noise cost in the t+1 year can be attributed to the change in the number of vessels and these costs can be seen as the marginal noise costs.

Part IV: Practical guidelines

18 Infrastructure costs versus expenditures

18.1 Introduction

In the previous part it is concluded that the cost allocation approach is a practicable and transparent method in order to determine marginal infrastructure costs. Due to the current method of cost registration, application of the cost allocation method is however not always easy. Before describing the method of calculating the total marginal costs using the cost allocation approach in the next chapter, the following section provides practical guidelines that can be applied in order to overcome the problem of registering actual infrastructure **expenditures** instead of yearly infrastructure **costs**. It must be noted that the guidelines proposed in this chapter will be preceding a more elaborated methodology which will be developed on behalf of the Commission in the study “From infrastructure expenditure to infrastructure costs”, also headed by ECORYS. This future methodology will provide a real practical and policy solution for proper registration of infrastructure costs. The guidelines we present in the next section result from the case study experiences laid down in the previous chapters, they however do not present ‘the’ standard method to correct actual expenditures in order to arrive at necessary costs. Therefore these guidelines can be applied, for the time being, to translate yearly expenditures on infrastructure into yearly infrastructure costs.

18.2 From yearly expenditures to yearly infrastructure cost: practical guidelines

For a number of reasons maintenance costs being registered by administrators do not always reflect the actual yearly infrastructure costs. When infrastructure expenditure figures are available (preferably for three to four years but at least for two years), infrastructure administrators should perform the following data checks, and if necessary should adapt figures accordingly, in order to translate yearly expenditures into yearly cost:

1) *Has the waterway been upgraded to a higher CEMT category during the years for which the cost figures are available?*
   If the waterway infrastructure has been upgraded, maintenance costs must be increased since upgrading of infrastructure will result in lower regular maintenance costs for the relevant year(s) the waterway has been upgraded. This will be of relevance especially for dredging costs and embankment costs.

Example

The Prinses Margriet Channel was upgraded to CEMT 5 in the period 1991-2001. In this period the canal banks were broadened and the canal was deepened. There was a separate budget regarding the costs involved with the upgrading. The upgrading budget covered also the elimination of (part of) existing outstanding maintenance. The fact that the PMC channel was upgraded resulted in the fact that for example the dredging costs fluctuated strongly between years in the period 1991-2001: dredging did took place in those years but was part of the upgrading plan so the costs involved had not been registered as maintenance costs. As a result the dredging costs were increased to the level they would have been had the channel not be upgraded. This new 'cost level' was determined by the province Friesland.

2) *Have there been tight budgetary restrictions resulting in backlogging of maintenance?*
   Budget restrictions are expected to result in relative low actual maintenance expenditures. It should be determined, with what factor the expenditures should be upgraded to arrive at the actual costs, which are necessary to prevent backlogging.

Example

In the case of the Amsterdam-Rhine channel, the maintenance costs had all been raised with 20%. This percentage was estimated by the Province Utrecht According to the Province Utrecht these should be the maintenance costs that would have been made if enough money had been available.

3) *Have any reservations been made?*
   It has to be determined whether or not reservations are made in one year that result in lower expenditures in the next year. If reservations have been made waterway authorities/administrators have to assess the actual amount of these reservations first. Subsequently, actual expenditures have to be corrected from year to year.

Example

Big technical and civil maintenance costs refer to costs that are not made on a yearly basis, for example the replacement of a large part of the canal bank. These costs are made according to a multi-annual plan. This leads to the fact that in some years these costs can be very low. This is done to save money so bigger works in a following year can be financed as one. In the case of the Prinses Margriet Channel the big technical maintenance costs were therefore averaged during the relevant time period.

4) *Are infrastructure costs always been registered in the 'right' year?*
   Sometimes bills are not being paid in the (fiscal) year the costs were actually made, however these costs show up in the next year. Therefore cost figures collected should be checked on yearly fluctuations (see also point 5).

Example

In the case of the Prinses Margriet Channel cost were analysed for the period 1996-2003. It showed that the cost category 'other costs' was only registrated for the period 1999-2003. Before 1999 these type of costs were made for the channel but registrated in another way. It was therefore decided (in accordance with the Province Friesland) to increase the cost category 'other costs' with € 2,5 million each year for the period 1996-1998.

5) *Are maintenance costs subject of strong fluctuations from year to year?*
Maintenance and renewal costs, which show relatively strong cost fluctuations from year to year, should be averaged over the years. High maintenance costs made in one year should be averaged over a 10-year period.

Example In the case of the Amsterdam-Rhine channel the maintenance costs for locks showed a sudden increase in the year 2002. After consulting the Province Utrecht it became clear that in this year big maintenance costs were made for one specific lock. In accordance with the Province Utrecht it was decided to spread these costs over a period of 10 years.

6) *Has there been a change in the cost registration method as a whole or in the costs registration of certain cost units?*
If this is the case it must be determined whether cost fluctuations between years are caused by this methodological modifications, and if so a correction must be made.

Example In the case of the Prinses Margriet Channel it was found out that the personnel costs are based on a registration of hours worked. During the last years however several different registration methods of hours were used resulting in costs fluctuations from year to year. In accordance with the province Friesland it was decided that only the most recent figures could be seen as representative.

7) *Has there been a shortage of personnel?*
If this has occurred in certain years, expenditures for personnel should be increased with the amount that is necessary to employ these people in order to arrive at the necessary costs.

Example In the case of the Van Starkenborgh Channel it was found that during the period 1994-2002 the personnel costs related to shipping inspection were stable except for the year 2002. Enquiry showed that in the year 2002 the inspection crew needed was finally complete resulting in higher personnel costs in that year. As a result, and in consultation with the Province Groningen, the personnel costs for the period 1994-2001 were increased to compensate for the fact that in this period there was a shortage of personnel.

In order to be able to answer all these questions a contact person within the cost registration organization that has full knowledge regarding the relevant inland waterway and its characteristics is necessary. The ‘translation’ of infrastructure expenditures into costs should preferably be made on an annual basis, but at least once every 5 to 8 years.

When the expenditures on the inland waterway are translated into the necessary costs, one can start to calculate the total (short run) marginal costs of using an inland waterway. A practical way of doing this is described in the next chapter.

19 Marginal cost calculation

19.1 Total (short run) marginal costs

This chapter describes the method for calculating the various constituent elements of the marginal costs of inland shipping. The percentages and cost figures that are listed in this chapter are intended as guidelines. They can be used if the information needed is lacking. It is however preferred that local figures are used.

The total (short run) marginal costs for inland shipping comprise the marginal infrastructure costs plus the marginal accident costs plus the marginal environmental costs and the marginal congestion costs.

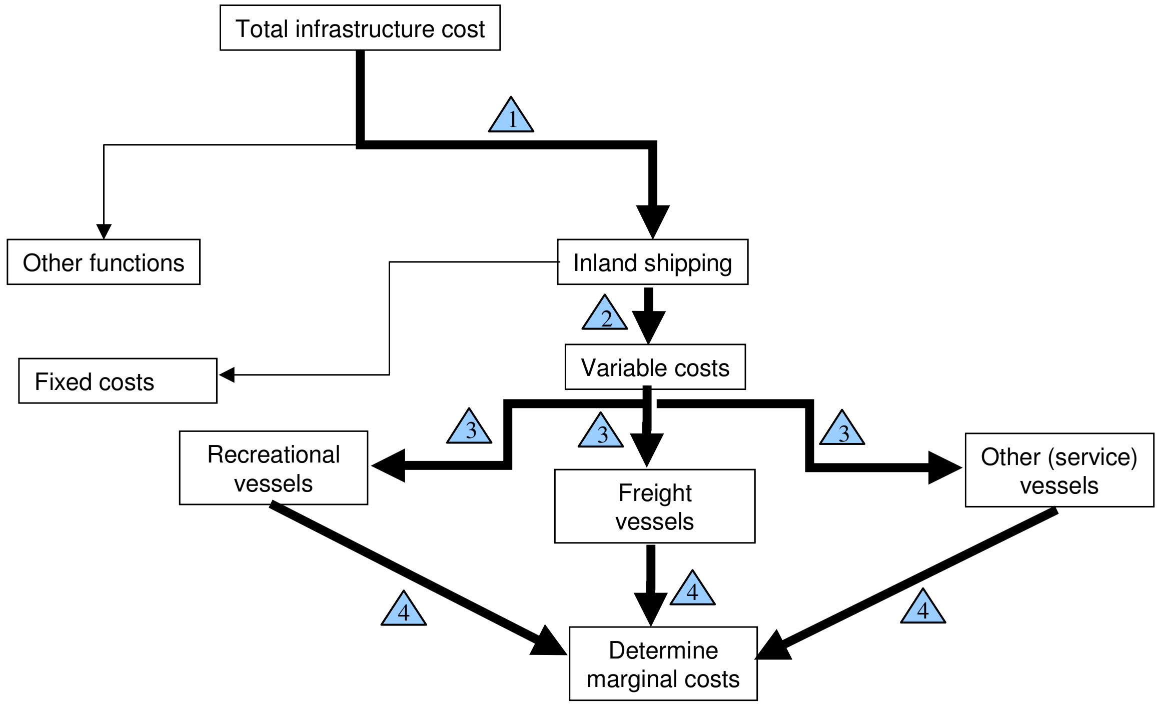
Total (short run) marginal costs for inland shipping =

Marginal infrastructure costs + marginal accident costs + marginal environmental costs + marginal congestion costs

19.2 Marginal infrastructure costs

In order to determine the marginal infrastructure costs of inland shipping using the cost allocation method, the following 'decision tree' must be followed: starting with the total costs – at least for a 2-year period - made for an inland waterway:

Figure 19.1 Decision tree for determining marginal infrastructure costs attributable to inland shipping



Source: ECORYS

Note: blue triangles refer to steps 1 – step 4 described hereafter

19.2.1 Step 1: Allocation of total infrastructure costs to waterway functions

Determine the total infrastructure costs of inland waterways that are related to the function' inland shipping'

First of all, it has to be determined which share of total costs registered for an inland waterway is made for (freight) vessels and which share is made for other functions (i.e. protection of land against floods, drinking water function etc.).

In The Netherlands the costs made for inland waterways that have a direct relation with inland shipping are known since the costs made for other functions (costs for dykes, pumps, etc necessary to protect the land against floods) are costs being registered by other organizations (the so-called Waterschappen or Hoogheemraadschappen). When these costs are added up, the costs of inland waterways made for inland shipping comprise 71% of the total costs made for inland waterways[29]. In the French case study it was estimated (by the VNF) that around 80% of total infrastructure spending is intended for shipping activities.

[29] Source: 'De prijs van een reis', CE, September 2004.

Table 19.1 Calculation of total infrastructure costs of inland waterways for inland shipping

Total infrastructure costs of an inland waterway made for inland shipping =

% of total inland waterway costs made for inland shipping[1)] x total infrastructure costs of the relevant inland waterway

1) Share of total inland waterway costs made for inland shipping is 71% to 80% in the case studies

It also has to be determined whether the resulting inland waterway costs are representative: do the registered expenditures reflect the real necessary costs? In the previous chapter practicable guidelines are given to determine the necessary costs.

19.2.2 Step 2: Distinction of shipping related costs into variable and fixed costs

Divide the infrastructure costs of inland waterways made for inland shipping into variable and fixed costs

In this second step the total infrastructure costs of inland waterways calculated in the previous step have to be split into fixed and variable costs. Fixed infrastructure costs are costs that are not influenced by the number of vessels using the infrastructure. Variable costs vary with the number of vessels using the infrastructure. If no information is available regarding fixed and variable costs, the next figures can be used. These figures are based on the Dutch case studies.

Table 19.2 Division of infrastructure costs of inland waterways into fixed and variable costs

Type of costs	Fixed costs	Variable costs	Remarks
Maintenance costs canal banks (including personnel costs)	80%-90%	10%-20%	
Dredging cost	80%-90%	10%-20%	
Beacons, concrete	100%	-	
Construction works for shipping	80%	20%	
Maintenance costs radar	100%		
Maintenance costs bridges	80%	20%	If the bridges do not have to be opened for vessels these costs should not be taken into account (and be attributed to cars and trucks)
Other maintenance costs	80%-100%	0%-20%	Depending on what these costs comprise the share should be determined.
Operational costs locks	70%-80%	20%-30%	
Operational costs traffic post	-	100%	
Patrol costs	50%	50%	
Taxes, interest, write-off, other costs	100%	-	
Average	72%-85%	15%-28%	

Table 19.3 Calculation of variable infrastructure costs attributable to inland shipping

Variable infrastructure costs of an inland waterway made for inland shipping =

% of variable costs[1)] x total infrastructure costs of an inland waterway made for inland shipping[2)]

1) = 15-28% in this example

2) = Result of step 1

19.2.3 Step 3: Allocation of variable costs to vessel type

Divide the variable costs between freight and non-freight (i.e. recreational) vessels
In this third step the variable costs calculated in the previous step have to be assigned to freight and non-freight (i.e. recreational) vessels (the fixed costs are not taken into account when determining marginal costs). If the waterway is only used by freight vessels or only by recreational vessels, 100% of the variable costs can be allocated to freight vessels or non-freight vessels respectively. However, a mix of freight and non-freight vessels navigating the waterway is more everyday practice. In this case variable costs should be attributed to freight and recreational vessels. For the different variable costs categories found in the case studies the percentages that can be used to allocate variable costs to freight and non-freight vessels are listed in the next table.

Table 19.4 Allocation of variable infrastructure costs to freight and non-freight vessels

Type of variable costs	Total variable costs that can be attributed to:	
	Freight vessels	Recreational vessels
Maintenance costs canal banks	60%-80%	20-40%
Dredging cost	100%	-
Construction works for shipping	80%	20%
Maintenance costs bridges	50%	50%
Other maintenance costs	60%	40%
Operational costs locks	70%-80%	20%-30%
Operational costs traffic post	100%	-
Patrol costs	70%	30%
Average	65%-85%	15%-35%

Now the variable costs can be calculated that can be attributed to the different types of vessels[30]. In doing so one has to reckon with the shares of the different types of vessels navigating the waterway. If the waterway is used by 1 freight vessel and 100 recreational

[30] No distinction has to be made between sizes of freight vessels (CEMT category). Because it is forbidden for vessels to use inland waterways that are classified a lower CEMT category than the CEMT category of the vessel, it cannot be said that bigger vessels cause more damage than smaller ships. The waterway is constructed in such a way that bigger ships can pass without causing more damage compared to smaller ships.

vessels one cannot simply allocate 65% to 85% of all variable costs to that one freight vessel, which represents only 1% of total traffic. A correction must be made which can be done in the following way:

Share of freight vessels in total traffic (1%) is multiplied by the share in variable costs (maximally 85% in this example), resulting in 0,0085. The same is done for the recreational traffic, thus share in traffic (99%) multiplied by the share in variable costs (at least 15% in this example) results in 0,1485. The amount of variable costs attributable to freight vessels is now 0,0085/(0,0085 + 0,1485) = 5,4%. Multiplying this percentage with the total variable costs gives the variable costs attributable to that one freight vessel. The table below shows the percentages of variable costs attributable to freight vessels for different shares of freight vessels in total traffic.

Table 19.5 Allocation of variable infrastructure costs to freight and non-freight vessels, depending on the share of freight vessels in total traffic

Type of variable costs	Share of freight vessels in total traffic: 15%		Share of freight vessels in total traffic: 50%		Share of freight vessels in total traffic: 85%	
	Freight vessel	Recreational vessels	Freight vessel	Recreational vessels	Freight vessel	Recreational vessels
Maintenance costs canal banks	21%-41%	59%-79%	60%-80%	20-40%	90%-96%	4%-10%
Dredging cost	100%	-	100%	-	100%	-
Construction works for shipping	41%	59%	80%	20%	96%	4%
Maintenance costs bridges	15%	85%	50%	50%	85%	15%
Other maintenance costs	21%	79%	60%	40%	90%	10%
Operational costs locks	29%-41%	59%-71%	70%-80%	20%-30%	93%-96%	4%-7%
Operational costs traffic post	100%	-	100%	-	100%	-
Patrol costs	29%	71%	70%	30%	93%	7%
Average	25%-50%	50%-75%	65%-85%	15%-35%	91%-97%	3%-9%

The above can be summarized as:

Table 19.6 Calculation of variable infrastructure costs attributable to freight vessels

Variable infrastructure costs of an inland waterway made for freight vessels =

% of variable costs attributable to freight vessels[1] x variable infrastructure costs of an inland waterway made for inland shipping[2]

1) = 5,4% in this example

2) = Result of step 2

19.2.4 Step 4: Determine marginal infrastructure costs

Based on the previous steps the marginal costs per type of vessel can be determined. This is simply done by dividing the change in variable costs that is attributed to a certain type of vessel (recreational, CEMT II, etc) by the change in the number of kilometres sailed by that type of vessel.

Table 19.7 Determination of marginal infrastructure costs

Marginal infrastructure costs per vessel km =
(variable costs in year t+1 – variable costs in year t)
÷ (number of vessel km in year t+1 – number of vessel km in year t)

If the marginal costs of several years are available a marginal cost function can be estimated which represents the relationship between marginal costs and time. If no information is available regarding the marginal infrastructure costs, or the marginal cost calculations do not result in plausible figures, the average user dependent costs can be calculated as a second best solution. Table 14.2 lists the average user-dependent costs for freight vessels resulting from the different case studies. If the average user dependent costs are available for a certain time period an average user-dependent cost function can be estimated indicating the development of these costs in time.

19.3 Marginal accident costs

The marginal accident costs comprise the external costs for society. The internal costs such as insurance costs and damage costs to ships and cargo are not taken into account. It is assumed (in accordance with the UNITE case study) that the insurance premium covers 50% of the human injury or death costs for victims.

Table 19.8 Determination of marginal accident costs

Marginal (external) accident costs per passage on a river/canal =
(total damage costs per year to infrastructure + total costs per year of victims injuries/deaths x 0,5 + total administrative costs per hospitalized person)
x risk elasticity
÷ number of tonne-kilometres

In order to determine the marginal accidents costs the following costs figures can be used in case there is no specific information available. These cost figures are determined for The Netherlands. If the figures are used for other countries, they should be corrected for the *Purchasing Power Parity*[31].

Table 19.9 Average costs figures

Average damage costs to infrastructure = € 37.000 Victim dead = € 1.783.000 Victim serious injury = € 316.000 Victim slight injury = € 16.000 Administrative costs per hospitalized person = € 9.000 Risk elasticity = 0,01

If no information is available regarding the number of accidents and the damage to infrastructure etc, the results of UNITE can be used. In the UNITE case study for container transport on the Rhine marginal (external) accident costs have been calculated. They were estimated to amount to approximately € 0,002 per ton-km.

19.4 Marginal environmental costs

19.4.1 Air pollution

To calculate the marginal air pollution costs the emission factors per vessel kilometre are multiplied by the monetary valuation of the different emission types.

Table 19.10 Determination of marginal air pollution costs

Marginal (external) air pollution costs per vessel kilometre per type of emission = **emission factor per vessel kilometre per type of pollutant** **x monetary valuation of emissions**

[31] Purchasing power parity (PPP) is the exchange rate at which the goods in one country cost the same as goods in another country. The purchasing power parity exchange rate will be different depending on what goods are chosen to make the comparison. Typically, the prices of many goods would be looked at, weighted according to their importance in the economy.

Table 19.11 Emission factors per vessel kilometre

Vessel type	SO2	Nox	PM	VOC	CO2
	ton / M vtgkm	ton / M vtgkm	ton / M vtgkm	ton / M vtgkm	ton / M vtgkm
Dry Cargo -250 ton	3,33	56,67	3,33	3,33	3.333,33
Dry Cargo 250-400 ton	2,94	57,98	3,99	2,94	2.941,18
Dry Cargo 400-650 ton	4,98	81,96	4,98	4,01	4.284,73
Dry Cargo 650-1000 ton	7,00	121,99	8,00	6,00	6.364,55
Dry Cargo 1000-1500 ton	9,00	167,02	10,99	8,02	8.694,18
Dry Cargo 1500-3000 ton	17,02	304,00	20,01	14,99	15.848,45
Dry Cargo +3000 ton	16,39	304,92	19,67	14,75	16.393,44
Tanker -250 ton	0,00	54,55	0,00	0,00	0,00
Tanker 250-400 ton	2,04	57,14	4,08	2,04	2.040,82
Tanker 400-650 ton	4,62	81,54	4,62	4,62	4.615,38
Tanker 650-1000 ton	6,83	121,74	8,07	6,21	6.211,18
Tanker 1000-1500 ton	8,91	167,18	10,94	7,89	8.651,40
Tanker 1500-3000 ton	27,07	472,49	31,88	24,02	24.672,49
Tanker +3000 ton	26,67	473,33	32,22	24,44	24.444,44
Push barge -250 ton	22,94	397,25	26,15	20,18	20.642,20
Push barge 250-400 ton	23,36	397,81	26,28	19,71	20.437,96
Push barge400-650 ton	23,81	396,83	25,40	20,63	20.634,92
Push barge 650-1000 ton	23,14	398,35	26,45	19,83	20.661,16
Push barge 1000-1500 ton	22,93	396,82	26,11	20,06	20.700,64
Push barge 1500-3000 ton	23,06	396,87	26,03	19,93	20.757,83
Push barge +3000 ton	46,15	821,15	55,77	40,38	42.307,69

Table 19.12 Monetary valuations of emissions

Marginal external costs of emissions in *rural* areas (€ per ton, prices 2002)

	SO_2	NO_x	$PM_{2,5}$	VOC	CO_2
Austria	7.200	6.800	14.000	1.400	
Belgium	7.900	4.700	22.000	3.000	
Denmark	3.300	3.300	5.400	7.200	
Finland	970	1.500	1.400	490	
France	7.400	8.200	15.000	2.000	
Germany	6.100	4.100	16.000	2.800	
Greece	4.100	6.000	7.800	930	
Ireland	2.600	2.800	4.100	1.300	
Italy	5.000	7.100	12.000	2.800	
Netherlands	7.000	4.000	18.000	2.400	
Portugal	3.000	4.100	5.800	1.500	
Spain	3.700	4.700	7.900	880	
Sweden	1.700	2.600	1.700	680	
United Kingdom	4.500	2.600	9.700	1.900	
EU-15 average	**5.200**	**4.200**	**14.000**	**2.100**	**50**

Source: TREMOVE database

For SO_2 en $PM_{2,5}$ the urban effects are different from the effects in rural areas. The exact effects depend on the number of inhabitants of the urban area. In the following table some valuations are mentioned for different sizes of the city.

Marginal external costs of emissions in *urban* areas (€ per ton, prices 2000)

	$PM_{2,5}$	SO_2
100,000 inhabitants	33,000	6,000
200,000 inhabitants	66,000	12,000
300,000 inhabitants	99,000	18,000
400,000 inhabitants	132,000	24,000
500,000 inhabitants	165,000	30,000
1,000,000 inhabitants	247,500	45,000
Several million inhabitants	495,000	90,000

Source: TREMOVE database

19.4.2 Noise

In most cases it is assumed that shipping on inland waterways does not cause any noise costs since very few people live that close to inland waterways. In theory noise costs can be calculated as follows:

Table 19.13 Determination of marginal noise costs

Marginal noise costs =
Number of households or people exposed to a noise level > 60 dB(A) due to inland shipping
x valuation of noise per household or person per dB(A)[1)]
÷ total number of vessel kilometres by type
1) Valuation of noise = € 23,50 per dB per household or € 10 per person

Actually the result does not reflect the marginal costs but the average noise costs. To arrive at real marginal costs one should estimate the yearly change in noise level and attribute the corresponding costs to the yearly change in the number of vessels. A practical way to determine these costs is to apply the previous calculation example for two following years. The change in the monetarised noise costs in the t+1 year can be attributed to the change in the number of vessels and these costs can be seen as the marginal noise costs.

19.5 Marginal congestion costs

The marginal congestion costs can be calculated in the following way:

Table 19.14 Determination of marginal congestion costs

Marginal congestion costs per vessel =
(total waiting time in year t+1 x value of waiting time[1)]) **– (total waiting time in year t x value of waiting time)**
÷ (number of vessels in year t+1 – number of vessels in year t)
1) Value of waiting time: € 78 per hour for container shipments and € 74 for non-container shipments

List of literature

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List of organizations contacted

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  - Rijkswaterstaat Directie Oost-Nederland
  - Rijkswaterstaat Directie Noord-Nederland
  - Rijkswaterstaat Directie IJsselmeergebied
  - Adviesdienst Verkeer en Vervoer

- Province of Friesland

- Province of Groningen

- SVD Utrecht

- German Ministry of Transport (Bundesministerium für Verkehr, Bau- und Wohnungswesen - Wassershiffahrt Direktion)

- Wasser- und Schifffahrtsdirektion Süd

- Via Donau

- Voies Navigables de France