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CATRIN

Cost Allocation of TRansport INfrastructure cost

D12 – Conclusions and recommendations

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VTI; University of Gdansk, ITS Leeds, DIW, Ecoplan, Manchester Metropolitan University, TUV Vienna University of Technology, EIT University of Las Palmas; Swedish Maritime Administration, University of Turku/Centre for Maritime Studies

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Table of Contents

List of Tables

List of Figures

1 Introduction

The CATRIN project aimed at producing qualified research with the ambition to support the European transport policy, specifically to assist in the implementation of transport pricing. The project has thus both a strong research element and an element of short-term policy relevance. While this latter element requires a certain degree of simplicity the project emphasize that simplicity has to be created from the understanding of complexity. We have the ambition to have our research published in international scientific journals. We have involved different disciplines and does not focus on one single cost allocation approach but acknowledge that different viewpoints need to be taken in different situations. The project also recognizes that cost allocation (or pricing principle) recommendations need to be given in a short-term and a long-term perspective. The former stresses immediate implementation with a degree of uncertainty. The project will in a long-term perspective outline how these uncertainties can be resolved to suite the European transport policy for the future. Finally, our policy focus also means that CATRIN stresses the importance of dialogue with infrastructure managers.

1.1 The project

The objectives of the project are:

- to identify (possibly) generic organisational differences across modes and countries, i.e. to certify whether the responsibility for pricing of infrastructure use and spending on maintenance and investment is vested in one organisational body (such as at many airports) or a separate responsibility for different ministries or agencies (which seems to be the case for roads)
- to establish cost recovery practices – i.e. whether infrastructure is supposed to recover its own costs or not – across modes and countries,
- to ensure a wide coverage on policies and practices in new Member states,
- to identify the primary pricing principles that can guide policy makers under different organisational structures and different cost recovery rules;
- to this end current knowledge of marginal costs for infrastructure use must be summarised and knowledge gaps identified.
- In order to fill gaps in the knowledge of marginal costs, we will in addition to econometric knowledge, seek to develop and examine engineering evidence regarding the variability in costs depending on vehicle characteristics,
- and as one part of this endeavour, a European Road Damage Experiment to clarify the accuracy of the fourth power rule for the European Transport Policy of the 21st century will be outlined,
- a engineering approach will be used to predict the relativities between different vehicle and track types in railways,
- use methods developed in the road sector to examine some of the marginal costs in aviation.
- Based on all this CATRIN will develop applicable proxies to marginal cost based pricing,
- and to explore these developments in a number of real world cases,
- and refine them into recommendations on infrastructure cost allocation procedures for use in infrastructure pricing decisions on all modes of transport,
- as a part of this we will propose a set of financing and organisational alternatives for Baltic icebreaking services,

- and to discuss all these procedures with infrastructure managers and to assess the possibility to implement the principles.

The project started in May 2007 and ended in May 2009 and has been carried out in nine work packages. The organisation of the work packages is depicted in the figure below. Each of the work packages has published one or more deliverables which are presented in table 1[1].

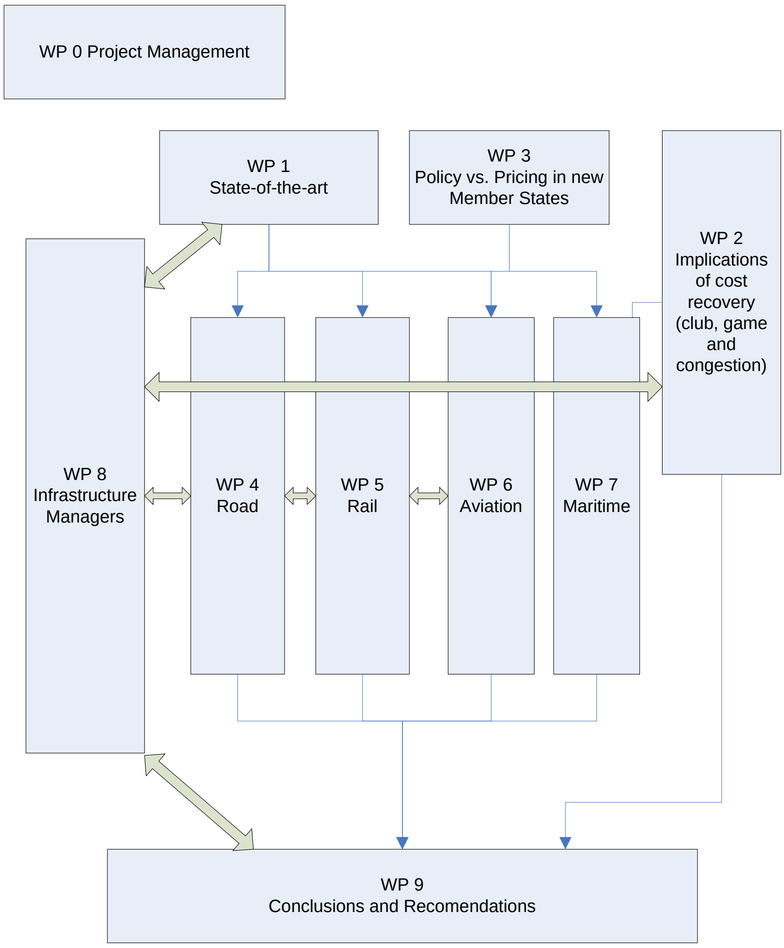

Figure: 1 Work packages in the CATRIN project

[1] Can be downloaded from http://www.catrin-eu.org/

Table 1 Deliverables for further reading

Deliverable		Work package
No.	**Title**	
D1	Cost allocation Practices in the European Transport Sector	WP 1
D2	Blueprint for Case Studies	WP 1
D3	Charging for joint and fixed costs (club, game and congestion)	WP 2
D4	To be a new Member State – what does it mean for pricing policy.	WP 3
D5	Data availability for research on Cost Allocation in the new Member States	WP 3
D6	Road Cost Allocation for Europe	WP 4
D7	Outline of a European Road Damage Experiment	WP 4
D8	Rail Cost Allocation for Europe	WP 5
D9	Allocation of infrastructure cost in the air transport sector	WP 6
D10	Allocation of infrastructure cost in the maritime sector	WP 7
D11	Infrastructure managers views on infrastructure cost allocation	WP 8
D12	Conclusions and Recommendations	WP 9

1.2 This report

This final reports draw on the work presented in all of these deliverables and is organised in four parts.

- Part I gives a background to why the question of "cost allocation of transport infrastructure cost" is raised by public bodies and what different views that can be taken on the question (section 2 and 3).
- Part II summarises the research on marginal costs in each of the four modes (section 5 to 8) considered in the project and includes an introduction to the issue (section 4). For rail and road we have a common structure; the marginal cost estimates (x.1), the current regulation (x.2), and possible short-term implications (x.3) as well as the long-term development issues (x.4). We have identified other issues in aviation and maritime infrastructure.
- Part III focus on the further issue of implementation and discuss cost recovery (section 9), the consequence for New Member States (section 10) and the view of Infrastructure managers (section 11).
- Part IV or the last section (section 12) summariesies our conclusions and gives recommendations.

PART I

Background

2 Market failures in the provision of infrastructure services[2]

The invisible hand of markets is widely held to provide for the efficient supply of a range of goods and services. This means that markets are able to meet the customers' demand by investing in new facilities. Competition ascertains that profits are not supra normal so that customers do not have to pay too much for their purchases. The competitive pressure also induces producers to manufacture at lowest possible costs. It is, however, not reasonable to believe that infrastructure services can be made available for travel and transport by way of free competition between atomistic suppliers in the same way as for many other goods and services.

Two dimensions of efficiency are in focus in this chapter. The first is to ensure that existing resources – roads, railways, ports and airports – are used in an efficient way. It is well known that marginal cost pricing will achieve this objective: Charging for infrastructure use according to the incremental costs for admitting more vehicles, ships or airplanes to use them will make certain that there is neither too much nor too little traffic. The second efficiency dimension concerns new production facilities – new infrastructure. It is equally well known that this should take place whenever the expected revenue from charging future users plus the net non-monetary benefits exceeds the expected costs for construction and future maintenance[3].

2.1 Natural monopoly

A natural monopoly is at hand when it is cheaper to have one single firm supply in all customers on a market rather than having several firms competing for demand, represented by D_1 in Figure 2.

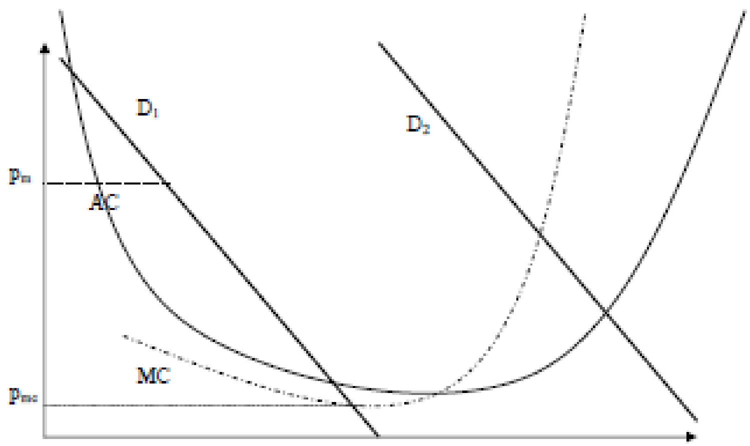

Figure: 2 Illustration of the dilemma where a policy which enhances efficient use is not sufficient to recover the full costs.

The reason for this is that average cost (AC) are falling within the pertinent range of demand and therefore marginal costs (MC) is lower than AC. It costs a lot to have the original facility

[2] Based on D3 - Nilsson et.al. (2008)
[3] A third efficiency concerns cost efficiency which is not at focus here.

built, so the more customers, the lower is the cost per customer (the decreasing part of the AC curve). The addition of new users will moreover result in fairly low additional costs, which in the figure is manifested by a MC curve below the AC curve. The presence of a single firm creates a welfare dilemma. A monopolist can be expected to charge a high price (for instance at p_M in the figure). This will recover costs and also facilitate a sizeable profit. But the monopolist's profit maximising policy is in conflict with efficiency since the high price will scare travellers away from using the facility; the infrastructure will not be used to capacity even though it would be cheap to admit additional vehicles.

It has already been indicated that an efficiency enhancing policy would call for a price at marginal cost (p_{mc} in the figure). This would, however, not be sufficient to recover the full costs of supplying the service for a natural monopoly. In particular, revenue would not cover the costs for constructing new facilities when this is needed. This is at the core of the cost recovery issue: in a natural monopoly industry, a welfare enhancing policy does not guarantee that proceeds from (efficient) charging of infrastructure use are sufficient to cover the costs for (efficient) maintenance and expansion of infrastructure. To establish efficiency, it is therefore necessary to combine optimally low prices and an efficient investment policy with subsidies. It is important to emphasise that the cost recovery issue is related to the relationship between costs and demand. With the specific cost situation at hand in Figure 2, but with higher demand – for instance as depicted by D_2 – the firm could combine efficient pricing (at marginal cost) with cost recovery. Although not explicitly shown in the figure, this situation with high demand would call for an efficient pricing (a price set where mc intersects the demand curve) which not only recovers all costs but which actually would generate a profit.

2.2 Public good

Two features distinguish a public from a private good; non-rivalry and non excludability. The consumption of private goods result in rivalry since one customer's purchase makes it impossible for another person to buy and consume the same good. The consumption of a public good is not rivalrous in this sense; although one person listens to a radio broadcast it is feasible for anyone else to benefit from the same transmission. The second distinction is related to the possibility to stop someone from consuming the respective goods. For private goods, excludability can be implemented through ownership; the seller keeps the good under lock until it is sold whereafter the customer can consume it. Once the radio broadcast is sent out it is, on the other hand, not feasible to exclude anyone from listening to it, meaning that it also has a non-excludability feature.

The presence of public good qualities in goods and services makes it difficult for a producer to ascertain full cost recovery. Since it is not possible to charge every user or to stop anyone from listening once a show is on the air, there is a risk that this type of service is never produced. This is so even though consumers value the service at far higher levels than it would cost to produce then. The (potential) efficiency problem with public goods is therefore that of under supply.

As illustrated by the radio broadcasting example, there are several ways to make goods with public good features available for consumption. The historical approach has in many countries been to have the public sector to supply the market. This has been paid for by taxation or by way of license fees for all owners of radioreceivers. Alternatively, and increasingly common, radio broadcasts are paid for by commercials, i.e. by private companies paying for having information about their products spread in parallel with the "core" programmes. Infrastructure has some public good features. In situations with low use relative to capacity, additional users will not affect the possibility of existing vehicles to use the facilities. This non rivalry aspect is obviously present during off peak, for instance during nights. In congested periods, infrastructure use is equally rivalrous as any private good.

It is relatively straightforward to charge for the use of ports, airports and railway infrastructure, meaning that these infrastructures are not a public good in the excludability sense; relatively few vehicles make use of port facilities etc. so that simple charging schemes are technically easy and cheap to implement. For road infrastructure, exclusion has historically only been feasible by toll booths which is an administratively costly way to exclude those that do not want to pay. It is, however, increasingly common that more sophisticated electronic devices are used to charge for use and to exclude or penalise those that do not pay.

2.3 Externalities

The textbook definition is that an externality represents the (positive or negative) consequence of one person's or firm's consumption or production on the consumption or production of other persons or firms that the first party not necessarily takes into account. As a result of a negative externality, there may be too much (or too little with positive externalities) consumption or production of this type of commodity.

This long definition hides a range of features related to infrastructure use. A trip on a road by a vehicle imposes accident risks on other users. It gives rise to exhaust when burning fuel, it is noisy and it causes some wear on the road. In congested situations, more vehicles will increase the travel time for all existing vehicles in the system.

The same line of reasoning also has a bearing on other modes of transport. There are some accident externalities in rail, air and maritime services. Also ports, airports and railway lines may be used close to capacity meaning that there is congestion. Moreover, any use of transport infrastructure making use of fossil fuel generates greenhouse gases. A functioning market is in principle able to internalise wear and tear and will handle congestion. This is so for private production of weekend relax services as well as air transport. Both holiday resorts and airlines have high fixed cost relative to marginal costs; it is expensive to build a hotel or to buy a new airplane, while adding guests or travellers is cheap as long as rooms or seats are available. Holiday resorts and airlines therefore charge less during off peak (perhaps somewhat more than marginal costs) than during the holiday season or when rooms and seats are expected to be fully occupied. The peak period guests therefore pay most of the bill for the original construction and purchase. The same is, however, not automatically true of environmental and accident externalities, which do not spread via some sort of market. There is therefore a risk that transport is cheaper and consequently more extensive than what would be warranted from a social perspective. Society has access to several means to cap consumption. One way to do so is to regulate – in the extreme to forbid – activities which give rise to (negative) externalities. The other mechanism is to impose a charge on the activity which generates the externality; the charge should then approximate the external costs. This is referred to as Pigou taxation. The traveller would then have to internalise the negative side effects and may as a consequence reduce this activity.

For the present report it is important to note that the Pigou taxes used to internalise external costs will have financial consequences for society; the surcharge is motivated as a tool for enhancing efficiency but it will also generate income for the treasury.

2.4 Equity

From a social perspective, and even if the market was producing and allocating goods and services in an efficient way, the outcome may still be questioned if the allocation is not seen to be equitable. It is reason to sort out what this may mean when applied to the transport sector, and in particular to the issue of cost recovery.

Equity or fairness are two intertwined concepts with several dimensions. In the economic literature two stand out. A government program is considered horizontally equitable if similar individuals are treated similarly. The principle of vertical equity says that individuals who are in a position to pay more than others should then do so. In many countries one political objective is that opportunities and standards of living for individuals and firms should be similar in all regions. This may be seen as a horizontal equity aspect. In the transport context it may be interpreted to mean that all travellers should have access to infrastructure of decent standard, irrespective of if there are many or few users. This means that more and better infrastructure than motivated by efficiency reasons should be built in regions where few inhabitants live.

A vertical equity dimension may be that governments sometimes charge fees to users in spite of that the marginal cost is low. This is in conflict with the efficiency arguments discussed in the context of natural monopolies and public goods. Examples include toll-roads, ports and airports. The equity argument may be that those who make use of the facility obviously benefit more than non-users. If users are believed to be better off than tax payers, they should – according to this argument – be paying for their consumption. In the extreme, it may be argued that a whole mode of transport should be covering its costs. For this reason, user fees are seen as an equitable way of raising revenue to finance public facilities.

In the literature, an extensive discussion addresses the trade-off between equity and efficiency, and there are two standard objections against the general use of equity objectives. The first concern is that an equitable policy may mean that less will be available to allocate to those most needy than if an efficient use of resources could be implemented. The second concern, which has particular significance for the transport sector, is that equity issues, if important, should be dealt with by way of general economic tools such as general taxation and subsidies. It is, according to this line of argument, not cost efficient to adjust policies within a specific sub-sector of the economy in order to account for equity concerns. If inhabitants of a certain region should be treated favourably for equity reasons, this should be implemented in higher general allocations to that part of the country. Road investments should be forced to compete with other policies to improve the situation of people in the region.

There is also an equity argument between countries. Assume that it is efficient to charge the use of a certain piece of infrastructure – a road or railway tunnel, a port or an airport – below average costs. The citizens of that country would then have to foot the bill for that share of costs which is not paid for by users. If this infrastructure primarily is used for international traffic, this may be seen as unfair. Irrespective of the arguments, it is a fact that policy making is affected by both equity and efficiency concerns.

3 To deal with market failure in infrastructure provision[4]

Infrastructure is of paramount importance to make economies function in a smooth way. Although not all infrastructures are provided directly by governments, a government has the ultimate responsibility that smooth and efficient transport is guaranteed. In this section we present an overview over the issue in each of the modes.

3.1 Roads

With some exceptions, road services are provided by the public sector. To be precise, the availability of roads is arranged by governments while governments have a choice between using in-house resources or to procure maintenance and construction from private firms. This may be seen as a way to handle the natural monopoly aspects of road infrastructure supply. Since it is not cost efficient to have several roads competing for the same customers, the public sector provides the services in order to avoid high prices charged by a commercial monopoly operator.

A further common feature of road service provision is the institutionalised separation of charging of users and, on the other hand, the spending on infrastructure. One ministry and its road agency are responsible for taking care of existing roads and for the construction of new. Another ministry, the Treasury, is responsible for charging by way of fuel taxation and indirect taxes on road users. This division, specific for the road sector, can possibly be explained by the revenue generating potential of charging road users.

The proceeds from taxation of fuel and ownership exceed the amounts spent on infrastructure in most (while not in all) European countries. Road user taxation is therefore a potent mechanism for raising revenue for any government. From the efficiency perspective, it may be reason to challenge these pricing and spending policies, and in particular the generation of a financial surplus. Taxes which (more than) recover costs are not compatible with the natural monopoly qualities of road infrastructure and the necessity to charge only at the (low) marginal cost level. Why should road users then pay so much?

One counter argument is that marginal costs are not always low. Parts of the road network are congested during parts of the day and week. Additional users will then imply high marginal costs. However, the main charging mechanism – fuel taxation – is the same irrespective of if demand is high or low relative to existing capacity. A substantial efficiency problem is therefore the inability to differentiate charges according to the precise demand/capacity situation at hand. Congestion tolls in London and Stockholm only represent a first go towards a policy of more price differentiation.

There are at least two arguments in favour of "high" taxation of road users; externalities and general taxation concerns. The externality issue arises since the natural monopoly discussion only addresses costs for building and maintaining the infrastructure. Adding external accident and environmental costs on top of these direct costs provides a complementary motive for expecting that an efficient policy would recover the full costs of road infrastructure provision[5]

[4] Based on D3 - Nilsson et.al. (2008)

[5] Much research has been done on this, and in very broad terms the following observations seem to be coming back: i) Passenger vehicles using rural, non-congested roads seem to be more than paying for their social costs, understood in its widest sense. Possibly excluding London and Stockholm, this is not so in cities where both health issues and congestion would require a higher level of taxation. Also main intercity arteries may be so

The general theory of taxation and spending in the public sector provides a second argument in favour of revenue in excess of costs in the road sector. The theory has landed in a fairly simple rule: levy more taxes on goods and services with lower price sensitivity – lower price elasticity – than on commodities where the reaction to a price increase is swift and large. This provides a complementary explanation to the use of road sector taxation as a source of general tax revenue.

There are additional principles from the public finance theory policy which have bearing on taxation in the road sector. Diamond & Mirrlees (1971) for instance demonstrate a very general result saying that – excluding Pigou taxes levied to internalise external effects – intermediate products should not be taxed. For the transport sector this means that commercial vehicles should only be paying for the externalities they give rise to- They should not be requested to pay financially motivated charges.

The standard way for markets to answer the question about the efficiency of an investment policy is to assess whether future financial proceeds generated by an investment would motivate the initial spending. No such tests can be performed in a sector with a monopoly service provider. Rather than comparing financial revenue and costs, the accepted methodology is to apply social Cost Benefit Analysis (CBA) to assess the merits of investment in new, and maintenance of existing roads. This is a technique to account for consumer benefits which do not materialise in the price of the commodity, in particular not on a monopoly market. The question is therefore whether enough resources are allocated over the public budget to allow for spending on roads in an efficient way. The answer to the question would be important in that increases of, or savings in the road budget would reduce or increase, respectively, the financial net of the sector. Put in other words, today's financial surplus would be smaller if more was being spent on construction and maintenance of road infrastructure, and vice versa. It is, however, difficult to provide a straightforward answer since there seem to be few examples of CBA being used in sectors other than infrastructure.

3.2 Railways

During the introductory years of railways, and when the industry was an economically and financially vibrant part of many national economies, different railway companies were competing with each other. In contrast to roads, railways seem to have mainly been vertically integrated with operations and infrastructure services provided as a single package. By the middle of the 20th century, private railways had been merged into national, vertically integrated monopolies. Typically they were state owned. The process of consolidation was a result of an increasingly fierce competition from road transport. Railway operators could therefore no longer charge prices that would make it possible to recover not only costs for operating the services but also the high costs for infrastructure investment and for taking care of the network.

In the late 1980's, Sweden was first to split infrastructure from operations. One bearing idea was the belief that the industry's natural monopoly features primarily are embedded in infrastructure rather than in the operation of train services. Today, most European countries have followed this path.

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congested so that higher taxes on passenger traffic may be warranted. ii) On top of the arguments for passenger vehicles, heavy vehicles inflict substantial damages on the road when using them. Fuel taxation fails to account for the fact that the higher the weight per axle, the more substantial is the destructive power of a vehicle.

In contrast to roads, the charging of track use is at least administered by the provider of the infrastructure services. The poor financial results for the consolidated railway sector have however continued. In some countries, the industry seems to be required to cover its own financial costs. The consequence of high charges is rapidly falling market shares for rail. Based on the discussion in the previous section, this seems to provide a strong indication of a combined market and government failure. Marginal costs are low but infrastructure charging is so high so that passengers are induced to go by car and freight by truck. The financial situation in other countries seems to be that train operations can cover their costs, sometimes with subsidies from different tiers of the public sector, while infrastructure still requires substantial subsidies, not least in order to spend on new, or to facilitate substantial upgrading of existing railway lines. Based on the natural monopoly logic, this seems to be a reasonable way to reduce the risk for market failure: subsidies guarantee that existing tracks are being used. In these countries, the failure of the market to provide the appropriate level of services is avoided.

However, this does not necessarily mean that the current level of subsidy is optimal. First, railways generate externalities in the form of noise, accidents and air pollution and, secondly, railways are, on the other hand, at least partly congested. Track capacity is not sufficient to meet demand on certain high-volume lines and during peak periods. This may not be a major problem as long as all traffic is carried out within and by one single company. The gradual opening up of the industry for entry will however make it increasingly pertinent to handle track scarcity by other means to construct the annual time table than administrative rules. The introduction of pricing instruments would obviously have consequences for the financial net of the industry.

Taken together, this seems to imply that there indeed is an efficiency motive for not discontinuing railway operations due to a poor financial result. The huge investment costs sunk in railway infrastructure can not be recovered by charging users. Line closure and investment in new capacity has to be considered on a case by case basis by the use of the same analytical tools as in the road sector, i.e. CBA.

3.3 Airports

Most airports are operating with a degree of natural monopoly: it is not viable to have several adjacent airports compete head on with each other. To a degree, this conventional wisdom seems to be challenged by the growth of low cost airlines. One part of their strategy is to operate from non-hub airports with modest landing fees and little congestion. At least in some countries, major airports are therefore challenged by fringe competitors. This does not stop the major airports from being virtual monopolies. In many countries, the downside of this is dealt with by having the airport within the public sector, the underlying idea being that this is a means for ascertaining that prices do not reach monopoly levels. Elsewhere, particularily in England, airports have been privatised but are subject to regulation in order to prevent them from acting as monopolists.

There also seems to be a degree of cross subsidisation within the industry. In some countries, parts of the revenue from hubs are dedicated to make up for losses at secondary airports. Based on a belief that an airport is a vital tool to attract business, secondary airports may also be subsidised by the local communities where they are located.

Given these caveats, airports seem to make a decent living. The revenue from take-off and landing charges and charges from handling passengers, luggage and freight, in combination with income from parking and vending licences, means that the industry is not a financial burden to society in general.

In the same way as for roads, there still is an issue with respect to degree of internalisation of the external costs for air traffic. This has repercussions for the competitive situation for competing modes. The financial implications of full internalisation of externalities are, however, unclear. One reason is that much of air transport is undertaken over the air space of other countries. It is therefore not obvious how a complete internalisation would affect revenues. This is even more so to the extent that externalities are handled by way of cap-and-trade instruments.

3.4 Ports and other maritime facilities

For centuries, ports have been economic units of major importance in international trade. The important role of ports has not decreased. On average, sea transport is currently growing at an annual rate of three percent. This development means that well functioning ports are important for governments, in Europe as well as in other parts of the world.

Ports offer infrastructure services, vessel related services and cargo related services. The respective activities are often carried out by different firms which are coordinated by the port authority. Three different organizational models are used.

- The *landlord port* where the port authority owns and manages the port infrastructure. Private firms provide port services and own their assets – the superstructure (buildings etc.) and equipment (cranes).
- The *tool port* where the authority owns both infrastructure, superstructure and equipment. Private firms provide services and rent port assets through concessions or licences.
- If a port authority is responsible for the port as whole this is referred to as the *services port*.

Countries that have adopted an Anglo-Saxon approach to charging for port services have a clear commercial orientation in which users (mainly shippers) bear all costs generated in the production of various services provided by the ports. According to this doctrine, the port should be profitable or at least generate revenue to cover its costs so that no tax subsidies are required. The continental approach to charging is less commercially orientated. Instead, ports are considered as being part of the society’s overall infrastructure, much like roads and railways.

The cost structure of a port is like most other infrastructure; it costs a lot to have it built and equipped with cranes etc. Up towards the capacity limit, the additional expenses for admitting vessels are low, but at some level of demand interactions between the different users start to induce disturbances. The scale economies are even higher when it comes to navigation aides, where there are virtually no marginal costs to admit additional users.

The situation of underpricing of emissions from naval vessels seems to be the same as for airlines. In the same way as for airports, competition between cities creates a check on the ability to utilise natural monopoly powers. Market power therefore seems to be of secondary importance only. There are, however, situations where ports are subsidised in order to stop services from being discontinued, which then may be in line with the natural monopoly qualities of the services. This does not seem to result in a general outcry for national subsidies, but the support grows out of concern over employment opportunities etc at the local level. Another observation is that there seems to be no outside pressure to increase the cost recovery ratio of ports as an aggregate.

Overall we therefore conclude that there is no reason to be concerned about cost recovery issues in the maritime sector. The industry seems to be thriving and able to pay whichever charges they are asked to pay. There is competition between ports which has two consequences; to cap monopoly pricing and to induce local communities to provide subsidies to stop their own ports from losing all services.

PART II

Marginal Cost and Modal Focus

4 Marginal infrastructure cost

Before going into the study of marginal cost in each mode we present a common background in this section regarding definitions (4.1), the principle of short- and long run marginal cost (4.2) as well as a short engineering outlook (4.3) and a section on detailed econometric methodology used (4.4).

4.1 Definition of cost items[6]

4.1.1 Investments, renewals, maintenance, operation

The distinction between investments, renewal, maintenance and operation is important both for the question which parts of expenditures have a service life of more than one year and are capital costs, and for the comparison of national practice and studies regarding the nature of expenditures considered. In particular the distinction between maintenance and renewal and between maintenance and operation differs across countries and studies, indicating that these categories are sometimes overlapping and fluent. In EUROSTAT (2003) a classification is given for investment expenditures and maintenance expenditures on certain types of infrastructure. In general the two types of expenditures are defined as:

- Investment: Expenditure on new construction and extension of existing infrastructure, including reconstruction, renewal and major repairs of infrastructure
- Maintenance: Expenditure for keeping infrastructure in working order.

In European standards (EN 13306:2001) 'maintenance' is defined as *'combination of all technical, administrative and managerial actins during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function'*. Both maintenance and renewal is thus a part of the general maintenance term. Unfortunately, there are no universal definition of the terms investment expenditure and maintenance expenditure that makes it possible to distinguish between on one hand investment and renewal and the other maintenace and operation. For this reason, cost comparisons should always be accompanied by a clear definition of what is included and excluded in the definition. For CATRIN we use the following basic classifications (see table 2). However, it should be clear that more often the resarcher has to accept the classification used by the auhoritry that stores data.

4.1.2 Infrastructure expenditures versus infrastructure costs

Infrastructure expenditures are periodical (e.g. annual) monetary flows. In contrast to expenditures, infrastructure costs take into account the service life and opportunity cost (benefits of an alternative use of money) of investments. Infrastructure costs contain thus the capital costs and the non-capitalised part of annual expenditures for infrastructure.

All spending on assets which have an expected life of more than one period (one year) should be capitalised. Capital costs comprise the consumption of this fixed capital. In principle, it should be measured by adding two components; the change in value of a piece of equipment at dates t and t+1; and the interest foregone during this period by tying up capital in this piece of asset. For most standard-type assets, secondary markets provides a proxy for the value of an asset over time. Since secondary markets for in particular roads and railways are non-existent, the measurement of capital cost in infrastructure is particularily challenging.

[6] Based on D1 - Link et.al (2008)

Depreciation based on rule-of-thumb may provide more or less good proxies for the capital costs.

Table 2 CATRIN classification

Measure	Purpose	Other name	Example
New construction, enlargement and upgrading (part of EUROSTAT investment)	To improve the level of service.	-	Increase the capacity or improve the safety standard of a road section
Renewal (part of EUROSTAT investment)	Bringing the infrastructure back to its original condition. Replacing large sections of more than one layer of the (road) construction but without improving the level of service. Often at the same time replacing drainage, street lighting, signing and safety fence	Periodic maintenance, Structural repair, structural maintenance	Repair, reinforcement and resurfacing Track renewal
Maintenance (part of EUROSTAT maintenance)	Preventive measures against deterioration of the infrastructure or corrective measures to repair minor damages	Routine maintenance, Construtional maintenace, Preventive maintenance, annual maintenance	Crack sealing, patching, shoulder maintenance etc Tamping, ballast cleaning etc
Operation (part of EUROSTAT maintenance)	To keep the infrastructure open for traffic	Ongoing maintenance (running expenditures)	Snow removal, cleaning, grass cutting. signals

4.1.3 Running expenditures (costs)

Running expenditures are annual monetary flows with a lifetime of less than one year (e.g. production and consumption occur in the same period). Consequently, they are equal to running costs.

4.1.4 Fixed and variable costs

Fixed costs are those which remain the same (in total) over a wide range of output levels while variable costs as those which vary with changes in output. Accounting texts use a more precise definition according to which variable costs change in direct proportion to changes in output. However, the distinction between variable and fixed costs is highly dependent on the time horizon considered: In the long run all costs are variable, meaning that even the largest investment may be modified to change fixed costs, given a long enough time. Note, that the terms fixed cost and capital cost and the terms variable cost and running cost cannot be used synonymously since parts of capital cost and running cost might be either fixed or variable. The distinction between fixed and variable costs is important for pricing purposes: Fixed costs are irrelevant for efficient pricing while variable costs are a starting point for deriving marginal costs.

4.2 Short- and long-run marginal cost

Since the variability of costs depends on the time horizon considered, short-run and long-run marginal costs have to be distinguished:

- **Short-run marginal costs** are related to the use of already existing infrastructure. Capacity is given and cannot be adjusted to changes of demand in the short-run.
- **Long-run marginal cost** is the change in variable cost caused by producing an additional unit of output, plus the estimated additional capacity costs per unit, based on the additional capacity that will have to be constructed if sales at that price are expected to continue or to grow over time. Since theoretically all costs are variable in the long run, no fixed costs do exist and the total costs as the basis for the mathematical derivation of (long-run) marginal costs include these future increases of capacity.

Let us shortly consider the relationship between the long-run and short-run cost curves. It is clear that the long-run average cost (LRATC) curve must always be below any short-run average cost curve (SRATC) as the latter is the constrained solution of the long-run minimization problem. At a certain point the short-run cost curve will be tangent to the long-run cost curve. At this point the long-run (LRMC) and short-run marginal costs (SRMC) are equal.

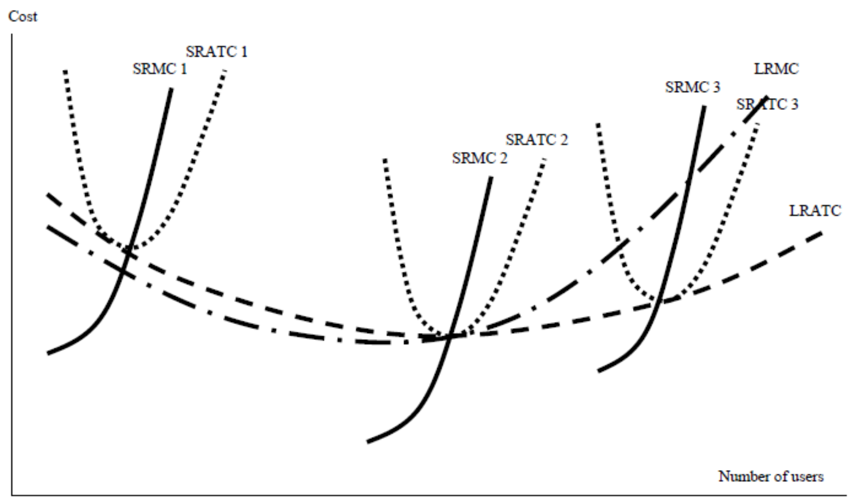


Figure: 3 Long and short run cost curves with three different sizes of the production unit

At a capacity utilisation below this tangent point of short- and long-run average costs curves the SRMC will be below the LRMC which mirrors the fact that we have overcapacity in the design of the facility. A pricing rule based on the SRMC will encourage use of the unused capacity already built. With a higher level of demand congestion and scarcity will arise which raises the SRMC - often very sharply - above the LRMC. The SRMC pricing rule will reduce the number of users that enter the facility.

4.2.1 (Over)utilisation of infrastructure

The use of a piece of transport infrastructure, consumes the capacity of that asset. Where that capacity is fixed in the short run, greater utilisation of the capacity leads to congestion, which usually manifests itself as the reduction of traffic speeds to below free-flow speed and/or the occurrence of queuing at junctions. Depending on characteristics of access to infrastructure, over-utilisation of infrastructure leads to congestion costs (non-scheduled transport) or scarcity costs (scheduled transport).

Congestion costs occur when the presence of one vehicle increases the journey time of another one. This phenomenon may happen for two distinct reasons as traffic builds up. Firstly, increased traffic density obliges drivers to drive more slowly because the gap between vehicles is reduced. Secondly, queuing may occur at junctions or other bottlenecks. Each vehicle on a congested piece of infrastructure both imposes and bears congestion costs.

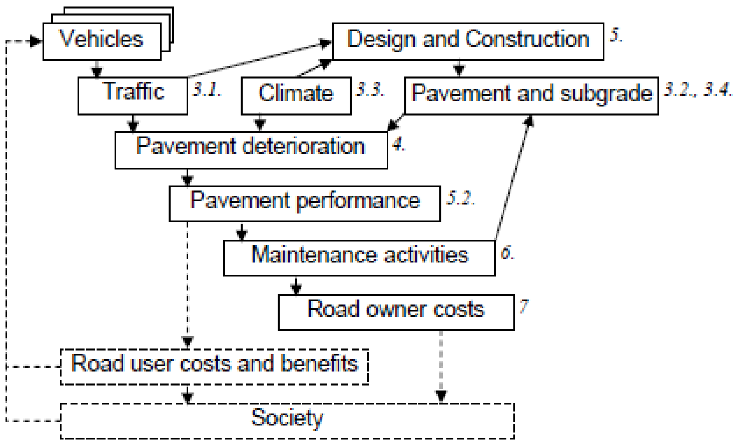
Where infrastructure managers control access to the network on a planned basis (e.g. rail, airports), shortages in capacity on the network manifest themselves in a different form – scarcity. For example, on the rail network scarcity represents the inability of a train operator to obtain the path they want, in terms of departure time, stopping pattern or speed. The inability of the train operator to provide the service it estimates will best meet its 'customers' demands represents a cost to society equal to the social value of that train service.

4.3 Engineering outlook[7]

Before going into the discussion on detailed econometric methods to estimate marginal costs it is useful to have a brief engineering overview of the issue of infrastructure wear and tear.

The figure below depicts an engineering overview in of the road sector; starting with factors that lead to deterioration such as traffic, climate and the pavement and subgrade itself. Then, models for pavement deterioration and subsequent needs for maintenance are depicted. Finally, the costs of different maintenance activities are investigated. This chain of consequences leading to costs for maintaining our road infrastructure is the key to understanding the mechanisms behind road user marginal costs.

Figure: 4 Vehicles generating costs for maintaining road network. Arrows indicate direction of consequence



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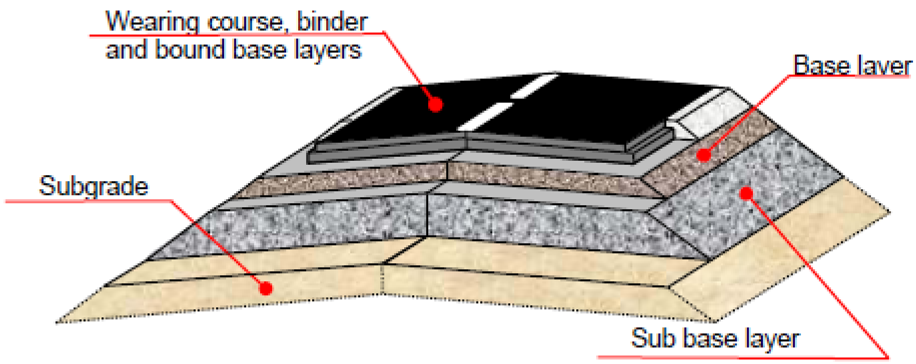
[7] Based on D7- Hofko et.al. (2008) and D8 – Wheat et.al. (2009)



In assessing track degradation two key modes of maintenance activity are relevant: rail damage which is caused by the action of the contact forces at the wheel-rail interface, and includes wear and fatigue of the rail surface; and track settlement damage which is caused by the vertical load of vehicle passages and results in uneven settlement of the track in the ballast. Rail damage is usually corrected by grinding (mainly using large automated grinding vehicles) and track settlement has to be corrected periodically by tamping, again usually using large dedicated vehicles. The influence of the behaviour of specific vehicles, in term of rail damage, can be assessed using a method based on the 'Tgamma' number which represents the energy dissipated at the contact patch area as a consequence of micro slip between wheel and rail. This index is then used to interpret whether the vehicle is damaging the rail due to wear, rolling contact fatigue (RCF) or more commonly, a combination of both. The track settlement damage is usually assessed using a logarithmic law based on the vertical load amplitude and characterized by two different rates, one immediately after installation or tamping and another, longer term, settlement during extended use.

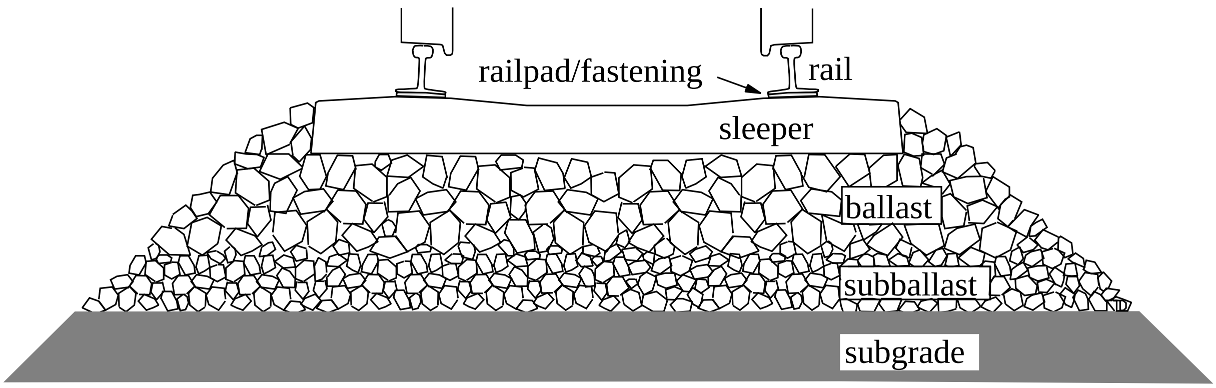


Figure: 5 Track infrastructure layout (from Dahlberg T. in Handbook of Railway Vehicle Dynamics, ed. Iwnicki S., Taylor and Francis 2006)

4.4 Econometric methods[8]

Econometric studies estimate cost functions and derive marginal costs from the results. To illustrate the method, consider a variable cost function which has double log functional form and two traffic types A (passenger) and B (freight):

$$\ln(C_i) = \alpha + \beta_1 \ln(Q_{Ai}) + \beta_{11} \ln(Q_{Ai})^2 + \beta_2 \ln(Q_{Bi}) + \beta_{21} \ln(Q_{Bi})^2 + \gamma \ln(I_i) \qquad (1)^9$$

[8] Based on D8 – Wheat et.al. (2009)

Where

- C_i is the maintenance and, if applicable, renewal or operational cost per annum for section or zone i;
- Q_i is outputs for section or zone i ; here in terms of traffic with vehicles of different types (A and B). Above is also a squared term included;
- I_i is a vector of fixed input levels for section or zone i – these include the infrastructure variables

The econometric approach focus on two of the 'boxes' in figure 3 above, traffic and costs, while the intermediate detailed steps of the engineering approach is captured in the infrastructure variable. Given that we succeed in the estimation of the function in (1) the marginal cost can be derived as the product of the average cost (AC) and the usage elasticity ε. In the example above we included the square of the traffic variable Q_A which means that the elasticity with respect to vehicle type A is non-constant if β_{11} is non-zero.

$$\varepsilon_A = \frac{dC}{C}\frac{Q_A}{dQ_A} = \frac{d\ln C}{d\ln Q_A} = \beta_1 + 2\beta_{11}\ln(Q_A) \tag{2}$$

The average cost is simply the cost C divided by the relevant output variable Q. However, the average cost will depend on the traffic volume Q. Therefore the marginal cost will usually depend on the traffic volume.

$$MC = \varepsilon AC = \varepsilon\frac{C}{Q_A} = \left[\beta_1 + 2\beta_{11}\ln(Q_A)\right]\frac{C}{Q_A} \tag{3}$$

Two additional observations should be highlighted.

- First, while the theoretical specification above includes different outputs in terms of different vehicle types, the reality is more problematic. This is because in reality, the correlation between different outputs is so strong that the econometric model has difficulty in distinguishing between the effects from different vehicle types.
- Secondly, input prices are often assumed to be constant between sections or areas and thus are not included in the studies.

In addition to the double log functional form, some studies have used the Box-Cox functional form. This is given by replacing the log (ln) transformation of variables by the Box-Cox transformation given by:

$$w^{(\lambda)} = \frac{w^{\lambda} - 1}{\lambda} \tag{4}$$

where w is the variable to be transformed and λ is a parameter to be estimated. This transformation is flexible since it nests both the log transformation ($\lambda \to 0$) and the linear transformation ($\lambda = 1$). This means that there is a natural statistical test of the appropriateness of the double log functional form. As with the double log model, both usage elasticities and marginal costs can be derived from this model post estimation. However, even in models

[9] Including an error term

without second order terms for traffic (that is, ignoring the squared terms in equation (1)), the Box-Cox models allow usage elasticities to vary with traffic levels since:

$$\varepsilon_A = \frac{dC}{C}\frac{Q_A}{dQ_A} = \frac{d\ln C}{d\ln Q_A} = \hat{\beta}_1(Q_A{}^{\hat{\lambda}})/(C^{\hat{\lambda}}) \qquad (5)$$

As with the double log models, marginal costs are computed as the product of the estimated elasticity and fitted average cost.

There is sometimes a need to scale the estimated usage elasticity by the proportion of costs considered in the study. This assumes that the excluded costs are not variable with traffic. As such, all other things equal, the usage elasticity will fall as more of the excluded costs are subsequently considered. More formally, the elasticity is equal to the ratio of marginal cost to average cost. As we include more of the originally excluded costs into the cost base marginal cost will (by assumption) stay constant, but average cost will fall. In particular the relationship between average cost under the restricted cost base (AC^R) and average cost under the 100% of the cost base (AC^F) is given by

$$AC^F = \frac{AC^R}{p} \qquad (6)$$

Where p is the proportion of cost considered in the study. This in turn implies:

$$\varepsilon^F = \frac{MC}{AC^F} = \frac{MC}{AC^R / p} = \varepsilon^R p \qquad (7)$$

Based on our results, and especially the railway case studies, we observe that marginal costs vary considerably between and within countries for road and rail. These differences are driven by many factors such as infrastructure quality and traffic density. Inspection of the underlying data of the first component of marginal cost, average cost, reveals that average cost is very variable both between and within case study countries. This is intuitive as we would expect average cost to be impacted strongly by the infrastructure quality and traffic density differences across countries. However we estimate much less variation in the usage elasticities across countries and within countries. As such it is difficult to generalise our results on marginal cost. Instead we note the relationship:

Marginal cost = Average cost x Usage elasticity (8)

5 Rail[10]

Previous studies in rail infrastructure costs can be categorised into top-down and bottom-up studies. Top-down studies consider elements of total cost and use statistical or judgemental techniques to determine what elements or proportions of elements are variable with traffic. Bottom-up approaches utilise established engineering relationships to model directly the extra damage caused by more traffic and then apply unit costs of remedial work to determine the marginal cost.

The disadvantage of the engineering approach is that it models elements of work in a piece meal fashion and may miss important linkages within the system. As such it may under estimate marginal cost. It also relies on the availability of robust measures of unit costs for remedial work and may rely on judgement which limits their applicability. Ultimately undertaking robust engineering bottom-up modelling of the railway system is a time and resource consuming task. This contrasts to the econometric approach which uses realised cost data. As such it ‘lets the data speak’. However the econometric approach to date has been unable to disaggregate marginal cost between vehicles to any large degree. Also the econometric approach is not insusceptible to the influence of researcher judgement or the quality and consistency of the underlying data.

With the advantages and disadvantages of each approach in mind, we consider that there are two ways of developing the previous research in this area. First the results of either approach can be used to validate the results of the other. This addresses the concern that both approaches are not insusceptible to judgement or problems with data quality. Second the two approaches could be combined so that the econometric approach is used to determine what amount of cost is variable with traffic with the engineering models then allocating this cost to different vehicles depending on the damage characteristics of each.

In the remainder of this section we summarise the result from the case studies on railway marginal cost (5.1), discussing current regulation (5.2) and short term policy implication (5.3) and long term research questions (5.4).

5.1 Elasticity and Marginal Costs Estimates

Following the discussion in the previous section (4) we split the presentation into elasticity and marginal cost.

5.1.1 Usage Elasticities

The research in the rail work package considered in detail appropriate ways to compare results across countries. After a thorough appraisal of the candidate ways to compare ‘average’ usage elasticities it was determined that several measures had relative merits and demerits and so it was decided to present a wide range of measures and consider the general patterns emerging. All the case studies outlined in the table below have considered maintenance only cost for at least a single tonnage measure. The table shows the various (scaled) summary measures for the total usage elasticities[11] for each case study.

[10] Based on D8 – Wheat et.al. (2008)

[11] The Total Usage Elasticity is termed to describe the proportionate impact on costs from a proportionate increase in all traffic types. For models which consider more than one traffic measure, it is given by the sum of the usage elasticities for each traffic measure.

Table 3: Summary measures for the total usage elasticity from each study – maintenance only cost, scaled where appropriate

Study	Preferred functional form	Mean Tonnage density (Tonne-km / Track-km)	Whole Sample Averages: Unweighted Mean	Weighted Mean	Median of sample
France	Box-Cox	7,300,000	0.35	0.39	0.32
Sweden	Box-Cox	7,650,000	0.23	0.25	0.23
Switzerland	Box-Cox	13,100,000	0.23	0.22	0.22
Austria	Box-Cox	10,600,000	0.40	0.55	0.37
Great Britain	Double-log	4,810,000	0.27	0.25	0.24
Pooled International	Double-log	8,135,000	0.33	0.23	0.29
Study	**Evaluated at sample mean of data**	**Evaluated at average infrastructure quality and 3,650,000 tonne-km per track-km**		**Evaluated at average infrastructure quality and 12,775,000 tonne-km per track-km**	
France	0.40	0.28		0.53	
Sweden	0.25	0.22		0.25	
Switzerland	0.22	0.19		0.22	
Austria	0.35	0.29		0.36	
Great Britain	0.08	0.06		1.00	
Pooled International	0.28	0.38		0.18	

Note: We choose to evaluate the total usage elasticity at both 3,650,000 and 12,775,000 tonne-km per track-km because these provide the approximate lower and upper bound of the average tonnage densities across countries.

Remarkably, the vast majority of estimates are between 0.2 and 0.35. For those results that are outside this range, there exists plausible explanations as to why this is so. We have more confidence in this finding than the range reported in GRACE, given the number of alternative metrics that we have considered in making this judgement. We have also found that the average total usage elasticity is increasing with traffic density when infrastructure quality is fixed at the average level in the country. However we have found little evidence that it differs with infrastructure quality.

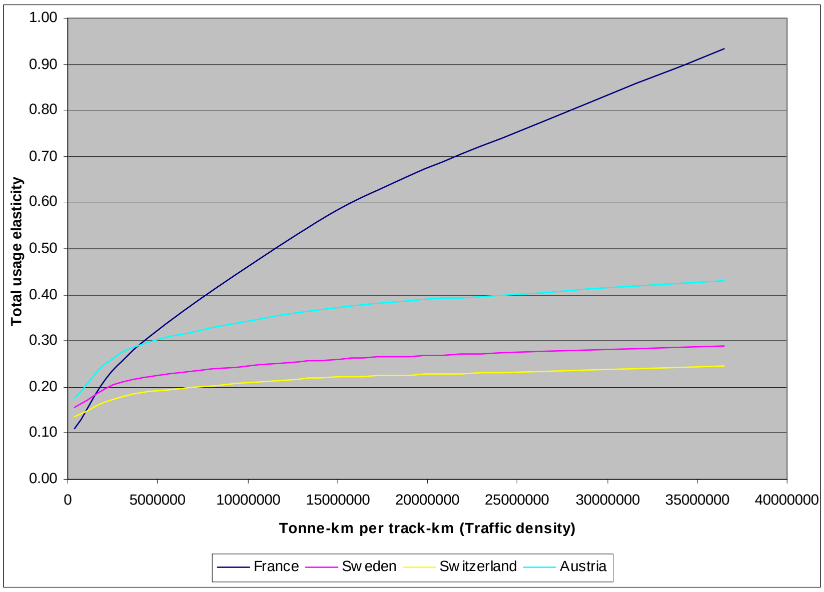


Figure: 6 Total usage elasticity against traffic density for Box-Cox models (average infrastructure quality)

The results are less conclusive regarding the difference between passenger and freight train. For all countries the passenger usage elasticity was found to be over two times that of the freight usage elasticity. It should be noted that *a priori*, even if marginal costs are believed to be the same for passenger and freight (per gross tonne-km), we would not expect the elasticities to be the same. This is because the usage elasticity value depends on the relative traffic mix between passenger and freight. All other things equal there should be a higher elasticity for passenger relative to freight as the ratio of passenger to freight tonne-km increases.

Two studies, Switzerland and Great Britain, have examined the sum of maintenance and renewal. The estimates for the usage elasticities derived from these models are 0.28 from the Swiss model and 0.49 from the British model. The British study looked at only 67% of maintenance costs, the main element being permanent way maintenance and also only track renewals, which accounts for approximately 30% of renewals expenditure. Given that these two categories are likely to be the most variable with traffic, it is no surprise that the estimated elasticity for Great Britain is so high relative to that for Switzerland which examined all maintenance and renewal that could be allocated to track sections. With a reasoning on the proportion of fixed costs and the above in mind, it seems reasonable to suggest that the studies actually point towards the usage elasticity for the sum of maintenance and renewal costs being between 0.28 and 0.35. However there is obviously a great deal of uncertainty associated with these estimates given that only two studies have considered renewals.

5.1.2 Marginal cost

The table below gives the summary marginal cost estimates for each study. Similar to the consideration of measures of 'average' usage elasticities, we present several different measures for each case study. The table shows that different measures can, in some cases, give radically different marginal cost and this show the importance of comparing a range of measures.

Table 4 Summary measures for maintenance only marginal cost, € per thousand gross tonne-km

			Whole Sample Averages		
Study	Preferred functional form	Mean Tonnage density (Tonne-km / Track-km)	Unweighted Mean	Weighted Mean	Median of sample
France	Box-Cox	7,300,000	2.70	1.39	1.80
Sweden	Box-Cox	7,650,000	11.52	0.46	0.86
Switzerland	Box-Cox	13,100,000	0.84	0.32	0.50
Austria	Box-Cox	10,600,000	2.60	1.20	1.50
Great Britain	Double-log	4,810,000	2.51	1.73	1.56
Pooled International	Double-log	8,135,000	4.36	2.17	2.53

Study	Evaluated at sample mean of data	Evaluated at average infrastructure quality and 3,650,000 tonne-km per track-km	Evaluated at average infrastructure quality and 12,775,000 tonne-km per track-km
France	2.01	2.25	2.00
Sweden	0.54	0.52	0.24
Switzerland	0.39	0.92	0.39
Austria	0.88	1.46	0.79
Great Britain	1.07	3.16	1.78
Pooled International	3.55	5.98	1.18

The whole sample weighted mean has commonly been reported by the existing literature. The range from the CATRIN studies is 0.32€ per thousand gross tone-km (€TGKM) to 2.17€TGTKM. This range has a greater maximum and a greater minimum than that found in GRACE, but overall is comparable. This finding is to be expected because this measure utilises the whole sample and since many countries in CATRIN were also considered in GRACE we would expect our models to give similar answers. Further we find that we have more balance in the distribution of this measures from the five studies compared to GRACE where there were several studies with very low weighted average marginal costs and only one country (Great Britain) with high marginal costs. This is due to the addition of the Pooled International and French case studies that both have high average and marginal costs. The whole sample unweighted mean can give radically different estimates than other measures from study to study. This maybe because all studies estimate very high marginal costs for very low tonnage density sections. Depending on the number of these sections they could have a large impact on the result of this measure.

Perhaps most useful for comparison purposes are the two marginal costs evaluated at average infrastructure quality and at the same tonnage levels. This is because these measures hold traffic density constant across studies and attempt to control for differences in infrastructure quality (be it only relative to the means in each study – which will be different from study to study). We still find some differences in estimates between studies. This is partly due to the different shapes of the marginal cost curves estimated. In particular the marginal cost curves from the Box-Cox models decay relatively slowly with traffic density, while the marginal cost curve for Britain is U-shaped and decays very quickly for the international model. A further explanation is our approach to controlling for infrastructure quality is limited and variations in average infrastructure quality may explain the differences.

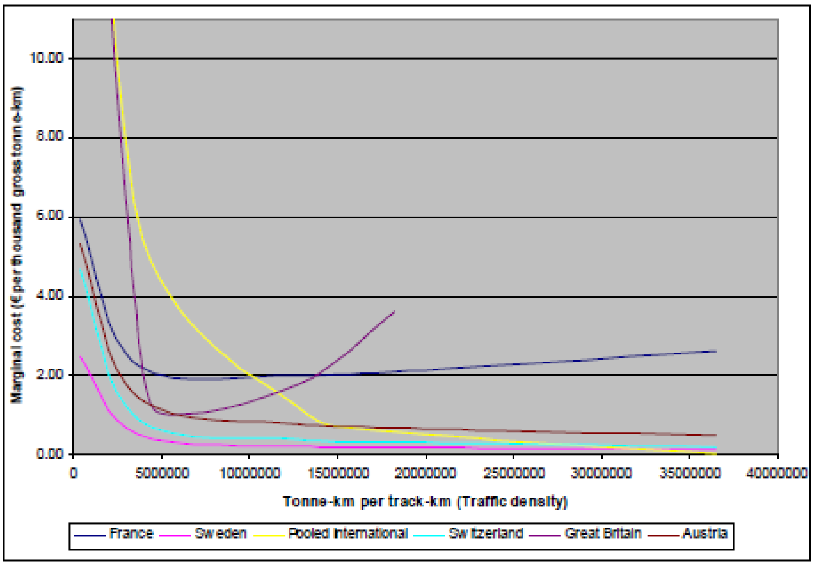


Figure: 7 Plot of marginal cost for all studies holding infrastructure characteristics and quality at sample mean levels

The estimates using the whole sample weighted average measure for the studies that considered maintenance and renewal costs were 0.71 and 8.12 Euro per thousand gross tonne-km for the Swiss and British case study respectively. This is a very big difference and reflects both differences in the estimated usage elasticities and differences in average costs. Our view is that the British estimate seems high partly because we believe the estimate for the usage elasticity is high (even though we can explain some reasons for the elasticity being so high, that is, the restricted cost base, even net of this effect, it still seems high). It is difficult to draw too many conclusions from the above given the small number of studies undertaken. What is clear is that there is more consensus between usage elasticities than between marginal costs.

By decomposing marginal cost into average cost and the usage elasticity we can see the reasons for the large variation in marginal costs across countries and within countries. Average cost differs considerably between and within countries driven by differences in infrastructure quality and traffic density. In contrast usage elasticities do differ by traffic density but in a much more predictable manner

5.1.3 Differentiating charges by vehicle type

The engineering studies found large differences between the damage on the infrastructure for some vehicle types even when normalised by gross tonne-km. Therefore it could be argued that costs would be better reflected by differentiating the charges by vehicle type.

It should be pointed out that the engineering studies carried out in this project were based on a limited number of case studies and so caution must be taken in generalising these results. However the engineering study does indicate that the econometric estimates of passenger traffic being of up to seven and a half fold greater marginal cost than freight traffic maybe too dramatic. Indeed the engineering models seem to be showing that the exact traffic and track mix is important and certain mixes could result in freight traffic being more damaging than passenger.

The latest engineering tools were used in this work to assess the damage levels on the infrastructure; vehicle models were prepared and run on measured track data for specific track sections. For each track section this produced relative damage levels for each vehicle type for the two main damage mechanisms: track settlement damage (requiring tamping or ballast replacement) and rail damage (requiring grinding or rail replacement). Example results for track settlement for each vehicle are shown in the following figure. These relative factors are per gross tonne and so they can be viewed as relative damage of each vehicle per gross tonne-km. For the Ostkustbanan route from Stockholm to Uppsala, the high speed locomotive results in the highest damage and the tare freight wagon is lowest and the difference in settlement damage per tonne-km between the two vehicles is 33%.

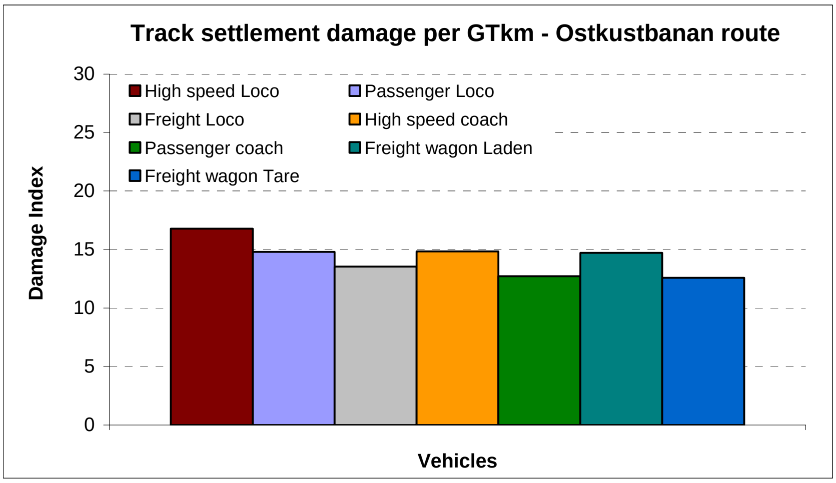


Figure: 8 Track settlement damage per GTkm by vehicle

The results for rail wear damage are given in following figure for the same track section. This shows a wider variation of relative damages by vehicle, with a high speed locomotive doing approximately double the damage of a laden freight wagon.

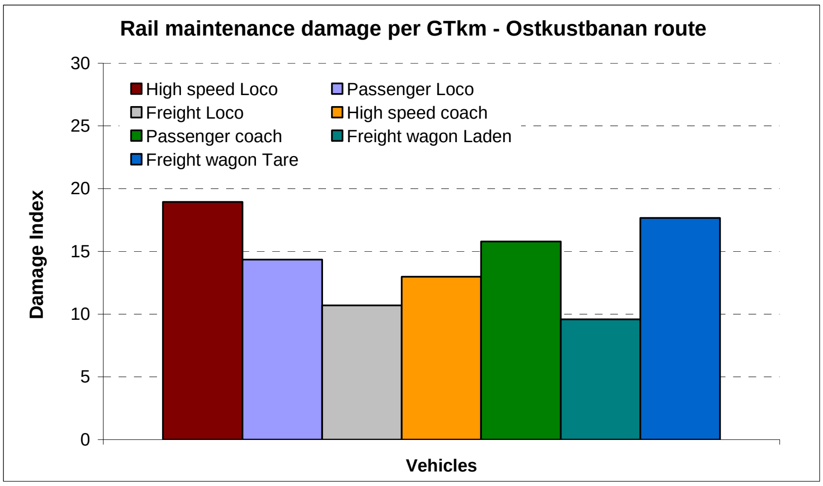


Figure: 9 Rail damage per GTkm by vehicle

These results show that, especially for rail damage, the damage caused by different vehicles can vary considerably even when normalised by tonnage. This indicates the proposal to use the engineering models to allocate variable cost, derived from econometric models, to different vehicles.

5.1.4 Scarcity

Wherever capacity is scarce, there is a strong argument for charging reservation fees to reflect the opportunity cost of slots, in terms of net revenue, unpriced user benefits and net external benefits. Ideally this would represent the net benefit of the second best use of the slot, which can only be known when all possible uses have been examined and the optimum determined. This is hardly practical as a way of setting tariffs when future demand for slots may come from unknown new entrants. More practical is setting a tariff according to the opportunity cost of the slot to the existing dominant operator. This is particularly the case when, as is the case on almost all routes in Britain, the dominant operator is a franchised passenger operator, with long term franchise and access agreements and for which detailed information on costs and demand is available to the franchising authority and the regulator. In other circumstances calculation of the charge will be more rough and ready, but – as long as care is taken not to set the charge so high as to lead to capacity being left unused – introduction of such a charge, reflecting the opportunity cost of taking slots away from the dominant operator, is likely to have a socially beneficial effect on timetable planning and the use of scarce capacity. An example derived from Britain illustrates how a relatively simple pattern of peak and off peak charges per slot may be derived, whilst Italian practice illustrates how a weighting may be applied to reflect the fact that trains travelling at a speed different from the optimal for the route in question consume more capacity than a single train of the dominant type.

However, such charges do not directly reflect the cost of the capacity provided under long term framework agreements which entitle the operator, or their customer, to a certain amount of capacity in the long run. In this case the long run avoidable cost of the capacity in question should be reflected in a fixed charge to the customer concerned. Where open access competition exists, such a fixed charge might be problematic in terms of affecting the terms of competition between the incumbent and new entrants. But in the case of a monopoly franchise there is no such complication. Such a charge would be particularly relevant where a regional authority is responsible for franchising passenger services, whilst the national government subsidises infrastructure in general. Without such a charge, the regional authority has no reason to consider the costs of providing capacity when setting out its long term plans for the services in question.

Both the above developments in track access charging would increase the revenue of the infrastructure manager, reducing the burden on national taxpayers and easing the financial problems that infrastructure managers have when funding from the state is inadequate for its needs.

5.2 Current Regulation

The Directive 2001/14/EC provided the general framework for setting rail infrastructure charges for the use of domestic and international services. The directive determined that charges must be based on "costs directly incurred as a result of operating the train service". They may include:

- Scarcity, although where a section of track is defined as having a scarcity problem, the infrastructure manager must examine proposals to relieve that scarcity, and undertake them unless they are shown, on the basis of cost benefit analysis, not to be worthwhile;
- Environmental costs, but these may only add to the revenue raised from train operators in total where these are levied on other modes;
- Recovery of the costs of specific investments where these are worthwhile and could not otherwise be funded;
- Discounts but only where justified by costs; large operators may not use their market power to get discounts;
- Reservation charges for scarce capacity, which must be paid whether the capacity is used or not;
- Non discriminatory mark ups but these must not exclude segments of traffic which could cover direct cost.
- Compensation may be paid for uncovered costs on other modes through a specific time-dated compensation scheme.

5.3 Short-term policy implications and recommendations

Marginal cost estimated in our way including scarcity may be viewed as a part of the "costs directly incurred as a result of operating the train service". In addition, operation gives rise to costs related to environment, safety etc.

We advocate recommending estimates of usage elasticities rather than specific marginal costs. These can then be multiplied by country specific average cost estimates to yield estimates of marginal cost. We do still find some variation in usage elasticities within countries, but there is a more systematic pattern which allows us to make recommendations for usage elasticities based on traffic density of the network.

Our research has clearly demonstrated that marginal costs differ considerably by traffic density and infrastructure quality. This supports charging different routes, each with different traffic density and infrastructure quality characteristics, within countries different marginal costs. This will be more cost reflective although there is the obvious trade-off between cost reflectiveness and complexity. Our proposed generalisation approach allows for this flexibility. This can be undertaken by the country simply providing average cost by route and choosing a suitable elasticity for each route from our research.

Our recommendations on the values of usage elasticities are presented below. Before these are presented it should be noted that it is important that the definition of average cost covers the cost elements to which the recommended usage elasticites apply to. In particular for maintenance only cost average cost should include the following elements: permanent way costs; signalling and telecoms costs and electrification and plant costs.

Network wide overheads should be excluded. For renewals, our recommended elasticities are less precise given the limited number of studies available for consideration. However we recommend that the average cost for maintenance and renewal includes all the elements of maintenance cost described above and also includes as many elements of renewal costs except for network wide overheads.

As such we recommend that if countries want to charge for maintenance costs and renewals, they compute separate marginal costs for maintenance and renewal component. We recommend generalisation as follows:

I. For the maintenance component, a country would use the usage elasticities in the table below multiplied by the appropriate average cost to come up with measures of marginal cost for the whole network or for specific routes within the network.

Table 5 Recommended usage elasticities by traffic density

Traffic density classification Traffic density range (tonne-km / track-km per annum)	Low < 3,000,000	Medium 3,000,000-10,000,000	High > 10,000,000
Recommended Usage Elasticty	0.2	0.3	0.45

There maybe instances where a country has available some specific analysis to inform the precise level of the elasticities in their country. In this case and providing that the analysis is robust, it may be better to use these country specific estimates. However, we consider that the estimates in Table 5 are generally robust and so there maybe cause for concern should any country specific estimates differ substantially from those presented in Table 5.

II. For the renewal component we recommend that the country compute a network wide renewal marginal cost calculated as renewal average cost multiplied by an elasticity of 0.35. Our estimate is based only on the results of two studies and so has a large amount of uncertainty surrounding it. The use of country specific evidence would be especially beneficial for informing this estimate as to be applied to a specific country.

III. We do not provide elasticities by passenger and freight traffic since we have no clear evidence that passenger traffic is more or less damaging per gross tonne-km than freight traffic. The engineering study found that passenger did slightly more damage than freight and this was supported by the econometric studies, however there was little consensus in relative magnitudes of the marginal cost for the two traffic types with some of the econometric results looking unrealistic. Further the engineering research indicated that freight could feasibly be more damaging than passenger traffic depending on the exact vehicle mix. We also note that any difference in the usage elasticity for each traffic type depends not just on differences in relative damage but also the share of total traffic of each traffic type. The engineering research clearly demonstrated that there are large differences between the damage on the infrastructure for some vehicle types even per gross tonne-km. Therefore costs would be better reflected by differentiating the charges by vehicle type. This could be undertaken in a number of ways. One way is to come up with a charge per vehicle-km for every vehicle using the network. The advantage is that there are clear incentives to operators to run less damaging vehicles and demand such vehicles from operators. However, this would require a lot of work since a bespoke engineering study would be needed to determine the relative damages of the specific vehicles on the track. A less resource intensive and complex method of differentiating charges is to adopt a bonus/minus system where the most damaging vehicles pay a higher charge per gross tonne-km and the least damaging vehicles pay a lower charge. All other vehicles pay a medium charge per gross tonne-km. This is likely to be less resource intensive as the engineering models only needs to identify the group of vehicles.

On most routes throughout Europe it is possible to identify a dominant operator and type of service, and to estimate the opportunity cost of slots as the cost of taking a slot from that operator, although the regulatory authority will not always have as good data as in Britain, where it has access to detailed traffic, revenue and cost data. In the absence of such data, continued consideration should be given to the role of auctioning slots as a way of revealing their value to train operators. Similarly many countries use long term framework agreements on infrastructure access, as provided for under Directive 200/14, and such an approach makes good sense where operators are investing in assets or the development of services and want reassurance that they will be able to reap the rewards of their investment. Such agreements are particularly relevant where services are franchised for a period of a number of years, as is the case not just in Britain but also for subsidised services in Sweden, and increasingly in Germany, Netherlands and Denmark.

For any part of the overall system where only franchised services are operated, we believe it important that franchising authorities should be faced not just with the short run marginal cost of the services they operate but also the additional cost of adding the capacity they require. Thus we recommend the use of two part tariffs, with the fixed charge based on avoidable costs, in such cases. On lines with more than one operator, two part tariffs could jeopardise the entry of new operators.

5.4 Research issues

We consider that the outstanding research issues for the econometric models are:

1. The need to incorporate panel data techniques into models which use the Box-Cox functional form. This is potentially very important as the Box-Cox model seems to explain the data better than the equivalent double-log model, however we are currently unable to use panel data techniques to control for unobserved heterogeneity in these models;

2. Both pooling and country specific modelling approaches should be taken forward within future research. There are both relative advantages and disadvantages of each approach and both yield interesting insights into the differences in marginal costs across countries;

3. The pooling approach can be best developed through:

- Incorporation of more infrastructure variables;

- Incorporation of more years of data;
- Further harmonisation of data definitions (particularly cost definitions)

4. To continue to develop further measures of usage elasticities and marginal cost which better harmonise for the actual quality of the infrastructure. This could involve specification of actual levels of each infrastructure quality variable for each study which is comparable with the levels used in all other studies, as opposed to defining them relative to sample reference points as adopted in this project. This is an onerous task but with suitable engineering advice may be achievable. Harmonising the infrastructure quality variables available for use in each study would obviously help this process.

5. Even when we control for infrastructure quality, we still find that track sections with low tonnage density have very high estimates of marginal cost. This could be because the models do not predict the marginal cost levels very precisely for these extreme observations, however this should be investigated further. In particular it would be useful to compute confidence intervals/prediction intervals for these observations/predictions.

6. Need to better model renewals costs. In particular longer panel datasets need to be collected to allow analysts to 'smooth out' lumpy renewals and possibly adopt dynamic modelling techniques. Andersson (2006) has attempted incorporation of dynamics into models with some success, however was limited by the length of his panel. Further the further use of survival analysis should be considered. However both techniques require a long time series of data.

7. The quality and comparability of data across countries is critical for making valid comparisons and recommendations. Great effort has been taken to control for as many factors as possible in this research however we suspect that datasets are still not totally consistent between countries. This is partly because datasets are generally collected for purposes other than for econometric analysis. It would be better if the EC could urge member states to be more forthcoming with respect to data collection for future research purposes. There is a need to understand the composition of costs better and in particular eliminate any arbiter allocation of costs to observations as this can distort estimated results.

We consider that the primary outstanding research issue for the engineering analysis is to find ways to be able to better generalise the results of specific case studies. In CATRIN we only undertook case studies for two track sections in Sweden and it is not clear how transferable the results are to other track sections both within and outside Sweden. Therefore there is clearly the need to undertake more case studies across various countries.

To undertake a case study requires detailed information on traffic composition and characteristics as well as infrastructure characteristic data. They also take a long time to numerically compute and the results can be sensitive to fairly subtle differences in traffic and infrastructure composition. As such once a reasonably large number of case studies have been undertaken we could undertake statistical analysis on the outputs, relating damage to a simple set of variables describing traffic and infrastructure characteristics. This may provide a suitably simply means of generalisation of the engineering results.

6 Road[12]

An important foundation to CATRIN was laid in the GRACE (Generalisation of Research on Accounts and Cost Estimation) project, which was financed by the European Commission. In GRACE, the short-run marginal road infrastructure cost related to an additional vehicle was divided into four distinct components.

- Wear and tear of the road leading to additional routine maintenance,
- Damage to the road leading to earlier future periodic maintenance,
- Costs inflicted on the operation of other vehicles,
- Congestion costs.

This section (and project) focuses on the first two components as they are directly related to the infrastructure cost.

The present three case studies show similarities as well as differences to previous work. In Sweden, the Swedish Road Administration (SRA) supplies the data. SRA manages the national roads in Sweden. Despite a long transport policy tradition of marginal cost pricing, collection of data is a huge task and available data is highly aggregated. In Germany, the situation is dependent on the good will of the federal states to collect and provide data. Polish data is gradually improving and growing, and is supplied by the Road and Bridge Research Institute (IBDiM) based on a common system used by Polish road administrations.

A common denominator for the three countries is that road infrastructure maintenance and renewals are contracted work, where contracts in general cover a large area. For this reason, Swedish data only comprises observations of maintenance units each including a number of road sections. None of the case studies include data complete for the entire country, but rather for some fraction of the network. There is also limited information available about the infrastructure in the three cases. When comparing the results, it should also be kept in mind that the German case study focus on motorways, while the Swedish and Polish case studies include both single and dual carriageways. This leads to a situation where complete cost data is unavailable at a disaggregated, road section level.

The remaining part of this chapter follows the outline of the previous chapter; Elasticity and marginal costs (6.1), current regulation (6.2), short term policy implication (6.3), long-term development issues (6.4) and finally a specific section on our proposed European road damage experiment (EURODEX) project (6.5).

6.1 Elasticity and marginal cost estimates

6.1.1 Usage Elasticity

Previous research in GRACE has found that road operation elasticities are found to be close to zero, maintenance between 0.12 and 0.69, and renewals from 0.57 to 0.87. Across studies, the variation of the cost elasticity is larger for studies which deal with maintenance costs than for those dealing with other types of infrastructure measures which might hint at problems with defining and quantifying maintenance expenditures.

[12] Based on D6 – Andersson et.al. (2009)

For each new CATRIN case study, a number of alternative model specifications with regard to cost base, output and infrastructure variables as well as level of aggregation are estimated. To facilitate comparisons of results, models from each case study that are similar in terms of specifications, cost base, outputs and level of aggregation are presented here. For Sweden and Germany (Model I), both models use maintenance costs, work unit data, total vehicle kilometres (Vkm) as output, and log-linear specifications. The Polish model is slightly different as it also includes renewals and uses a six-year accumulation of road section data. There is also a German model using motorway section data (Model II).

In the same way as was elaborated on in the chapter on rail, focus in the subsequent presentation is on elasticities. The reason is that average costs vary much more between countries due to variations in maintenance policies, than elasticities.

Table 6 . Country comparison of cost elasticities

Country	Cost	Output	Aggregation level	Elasticity
Sweden	Maintenance	Total Vkm	Work units	0.39
Poland	Maintenance and Renewal	Total Vkm	Accumulated road sections	0.30
Germany	Maintenance	Total Vkm	Work units	0.47
Germany	Maintenance	Total Vkm	Motorway sections	0.87

The general picture given by table 6 is that elasticities seem to be between 0.3 and 0.5 when using aggregated data. This is approximately the same range as what was previously found in GRACE. The German estimate is the highest, but the costs included are selected on a criterion to vary with traffic, which would drive the elasticity upwards. The Swedish elasticity is in the mid-range of current knowledge, while the Polish estimate deviates from what has been previously found. Since it includes renewals, the estimate is expected to be in the top range for maintenance and low range for renewals, but we find a low estimate at 0.3.

The fact that we also have German data at a more disaggregated level, which shows an elasticity of almost 0.9, gives us reasons to believe that good road section data would increase rather than reduce these estimates. The overall fit of the German disaggregated models using disaggregated data is also higher.

6.1.2 Marginal cost

The marginal cost is a function of the average cost and the elasticity. Average costs are usually falling, and evidence from previous studies shows that it is falling quite rapidly with output. The same pattern is found in these case studies. A model with a constant elasticity will then produce a falling marginal cost curve. Even though the German case study found increasing elasticities, the combined effect with rapidly falling average costs results in marginal costs falling with output.

Comparing marginal costs is in general more problematic as cost levels and service catalogues vary between countries. The table below gives marginal cost estimates for the models recommended in each case study. We can see that there is a difference between Sweden and Germany by a factor 10, but we draw no major conclusions from this observation.

Table 7 : Main results from recommended models in CATRIN road case studies

Country	Cost	Model	Output	Aggregation level	Elasticity	MC (€c/vkm)
Sweden	Maintenance	Log linear (panel)	Total vkm	Work units	0.39	0.15
Poland	Maintenance and Renewal	Log linear (panel)	Total vkm	Accumulated road sections	0.30	0.66
Germany	Maintenance	Box-Cox (pooled)	Total vkm	Motorway sections	0.87	1.61

6.1.3 Differentiation by road and vehicle type

The issue of differentiation has been a part of this project, but we have had limited success in that area. Two differentiation options have been investigated; by road and by vehicle type.

Regarding road types, we find no conclusive results. The attempt in the Swedish case study failed partly to identify any evidence for motorways versus dual carriageways due to a limited sample. Germany observed only motorways, and Poland was unable to differentiate the data in this way.

Regarding vehicle types, the Polish study found no statistical evidence to support differentiation between vehicle types. The Swedish case study managed to differentiate, but found higher elasticities for passenger cars than heavy goods vehicles. One possible reason for this is the use of studded tyres in Sweden generating ruts and driving resurfacing measures. The elasticity was also higher for passenger cars than for heavy vehicles in Germany. It is, however, not feasible to explain the reason in the same way as in Sweden, since studded tyres are banned in Germany. Another possible explanation could be that passenger cars dominate total traffic, and hence the variation in data. Although elasticities are higher for passenger cars, marginal costs are higher for HGV's.

These findings are not in line with what is commonly known as the 4^{th} power rule. This rule has been in use since the late 1950's and states that the damage done to a road is proportional to the 4^{th} power of a vehicle's axle load. Since the 4^{th} power rule relates to road damage and we observe maintenance costs, it might be passenger car friendly maintenance policies that cause these results. However, we discuss the engineering aspects of costs related to road maintenance in relation to a forthcoming large scale road damage experiment. This discussion shows that the general use of the 4^{th} power rule, based on the AASH(T)O road tests, can be challenged on grounds related to pavement types and materials, loads, climate and other local factors. On a more general basis, the aspects that challenge the 4^{th} power rule are not accounted for in the econometric models as infrastructure data is scarce. This makes it difficult to expect an outcome of directly comparable results from the case studies, and points at the importance of improved infrastructure information in future studies. We will discuss the outline of the road damage experiment in section 6.5.

6.1.4 Summary

The main findings in the three road case studies can be summarised in the following way.

- Firstly, we corroborate previous studies by showing cost elasticities being below unity. This means that infrastructure cost recovery is not possible when using short-run marginal cost pricing.
- Secondly, we find that marginal costs are falling with output. This is found in all three case studies.
- Thirdly, despite the findings on elasticities and marginal cost, there is still a strong need for data improvements. We see a large potential for econometric analysis in this field, but current studies are highly restricted by available data. The issue of differentiation lies in the hands of improved road sector cost data.
- Fourthly, renewals are problematic in an econometric framework. The lumpiness of renewals requires long time series to capture renewal cycles, which are seldom present. Analysing observed age data is a possible solution to this.

6.2 Current regulation

The Eurovignette Directive (1999/62/EC as amended by 2006/38/EC) sets out the rules for charging heavy goods vehicles in the European Union. The maximum level of tolls are defined as - “the weighted average tolls shall be related to the costs of constructing, operating and developing the infrastructure network concerned” (Article 7(9)). Member States has the freedom not to recover the costs in full through toll revenue, or the freedom to vary the amounts of specific tolls away from the average taking emissions or congestion into account. Member States still have to oblige to the average toll level over the network.

The core principles for defining the cost categories are presented in an annex to the directive. This annex offers principles on how to calculate investment costs, maintenance and repair cost as well as operation cost and how these costs should be allocated to vehicles. The costs shall be apportioned to HGV’s on an objective and transparent basis taking account of the proportion of HGV traffic to be carried on the network and the associated costs. The vehicle kilometres travelled by HGVs may for this purpose be adjusted by objectively justified “equivalence factors” to make due allowance for the increased costs of constructing and repairing infrastructure for use by HGV’s. The table below gives a set of indicative, but not mandatory, equivalence factors.

Table 7 Equivalence factors

Vehicle class[1]	Equivalence factors		
	Structural repair[2]	Investments	Annual maintenance
Between 3,5 t and 7,5 t, Class 0	1	1	1
> 7,5 t, Class I	1,96	1	1
> 7,5 t, Class II	3,47	1	1
> 7,5 t, Class III	5,72	1	1

[1] See Annex IV for the determination of the vehicle class
[2] The vehicle classes correspond to axle weights of 5,5, 6,5, 7,5, and 8,5 tonnes respectively

Source: Directive 2006/38/EC Annex III

6.3 Short-term policy implications and recommendations

Directive 2006/38/EC allows charges to equal the average infrastructure cost, i.e. average investment cost, average renewal cost, average maintenance cost and average operational cost. From economic theory, we know that investment costs are irrelevant if we look at cost categories to include under a short-run marginal cost pricing scheme. The research in CATRIN (and GRACE) also guides us towards how the average cost approach suggested in the Eurovignette directive conforms to a marginal cost approach. We have found that the relationship between marginal maintenance cost and average maintenance cost is between 0.3 and 0.5 which suggests that only 30 to 50 percent of maintenance costs should be included in marginal cost based charges. For renewals our findings are less conclusive, but previous work in GRACE indicates that 60 to 90 percent of renewal costs are relevant on the same basis. For operation costs, no research has been undertaken in CATRIN, but once again results from GRACE show that this relationship is close to zero.

Following a short-run marginal cost pricing principle would not lead to full infrastructure cost recovery, but one has to remember that a pricing at marginal cost also means that congestion charges are introduced where necessary. Therefore, it is difficult to say in advance whether cost recovery is feasible or not. In densely utilised areas, congestion charges will make up for some or all of the cost not recovered, but in sparsely utilised areas it is less likely. The main conclusion is that this has to be analysed at a lower level of detail, and a necessity for this is that data is collected.

In summary we follow the same approach as in the railway section bearing in mind that the uncertainty seems to be bigger in the road sector due to data-limitations. The CATRIN principle would be:

I. A country defines its average cost for
   a. structural repair/renewal,
   b. annual maintenance and
   c. operation

   and apply the usage elasticity in the table below from the CATRIN and/or GRACE project.

Table 8 Elasticities or proportion of average cost relevant for pricing

	Structural repair[1]	Investments	Annual maintenance	Operation
Directive 2006/38/EC	all	all	all	all
CATRIN	na.	irrelevant	0.3 – 0.5	na.
GRACE	0.58 – 0.87	irrelevant	0.48 – 0.58[2]	0.12 – 0[3]

[1] The CATRIN definition of Structural repair is Renewal
[2] Maintenace and renewal
[3] Maintenace and operation

II. The directive also supports differentiation between vehicle types, but our research has so far given no support of this. Once again, data is limiting us in our conclusion on this matter.

III. The directive uses the so called 4th power rule which we know is only relevant under some very specific circumstances and we propose:
   a. to use large European research resources on the EURODEX project, described in the following section, which will give new and relevant evidence on vehicle differentiation.
   b. in the absence of this project, care should be taken when relying on the vehicle differentiation suggested in the directive.

6.4 Research issues

There are two major issues that we would like to point out as long-term development issues. Firstly, data is currently very difficult to collect and collate and it is of most importance that it is brought to the attention of European road administrations that any steps towards marginal cost pricing must start with a strategy for data collection.

Secondly, econometric analyses have their limitations and as we approach differentiation issues, we must lean towards engineering knowledge to guide us more in detail. The merits of he 4th power rule, which has been used by road administrations for almost 50 years, have been questioned by researchers over the years, but no attempts to improve the situation have been undertaken. We therefore suggest that a large-scale European road damage experiment is launched to give Europe the leading role in pavement damage analysis. A summary of the proposal is given in the following section.

6.5 EURODEX proposal

This section summarises the proposal to run a European large scale pavement test programme to come up with new knowledge on pavement performance and the relationship between road infrastructure damage in different forms and vehicle characteristics as well as material properties and climatic conditions.

EURODEX will be a European project with various participating partners from pavement research and other professions. To make sure that the approach is co-ordinated and efficient, a strategic plan was developed within CATRIN. It consists of a foundation with basic and most important elements and four levels of planning, each relying on the level below, producing more pertinence and serving as input for the next level.

6.5.1 AASHO Road Test and the 4th power rule

The prominent 4th power rule stating that pavement damage caused by vehicles is related to the 4th power of their axle weight was derived from the US AASHO Road Test (1958-1960). Although it was clear from the beginning that the 4th power rule is only valid under specific conditions of the test with regard to time, place, environment and material properties, it is still the basis for many pavement design guides around the world. Ever since the AASHO Road Test had been completed, researchers proved that a constant pavement deterioration exponent of 4 which depends only on the axle weight does not meet the requirements of the process of road damage. Factors like temperature, moisture content, vehicle speed, etc. have an essential effect on pavement deterioration. Later full-scale pavement tests resulted in deterioration exponents between 1.7 and 10.

An efficient transport infrastructure is the lifeline for a sustainable and prospering European economy. Efficiency as well as sustainability regarding road infrastructure can only be achieved when construction and maintenance also work efficiently and sustainably. Therefore a deeper knowledge of the complex material-vehicle-environment interaction is needed to develop a new relationship between pavement deterioration and material, as well as environment and vehicle parameters. In order to create an improved rule for this interaction, it is necessary to combine comprehensive material testing with statistical, analytical and numerical methods which have been developed in the last 40 years (within EURODEX). This goal can only be achieved if the research is done on a European level.

6.5.2 European full-scale pavement testing: Status quo

Pavement testing in Europe has a long tradition. The first test track was built at the British National Physical Laboratory in 1911. At the moment there are 12 active full-scale accelerated load testing (ALT) facilities within Europe. An ALT facility is an installation where a full-scale pavement section consisting of several layers can be tested by means of rolling wheels or any other device that simulates traffic loading. The pavement response and performance under the controlled, accelerated accumulation of damage is monitored throughout the test. The acceleration of damage is achieved by means of increased repetitions, modified loading conditions, imposed climatic conditions (e.g. temperature and/or moisture), the use of thinner pavements with a decreased structural capacity and thus shorter design lives or a combination of these factors.

More than 70 ALT have been carried out in the last 20 years at different test sites. The results have been published in more than 100 papers in the last years. The number of ALT related publications as an indicator for the interest and importance of full-scale pavement testing has increased heavily in the last 30 years within Europe as well as around the world (Figure 9).

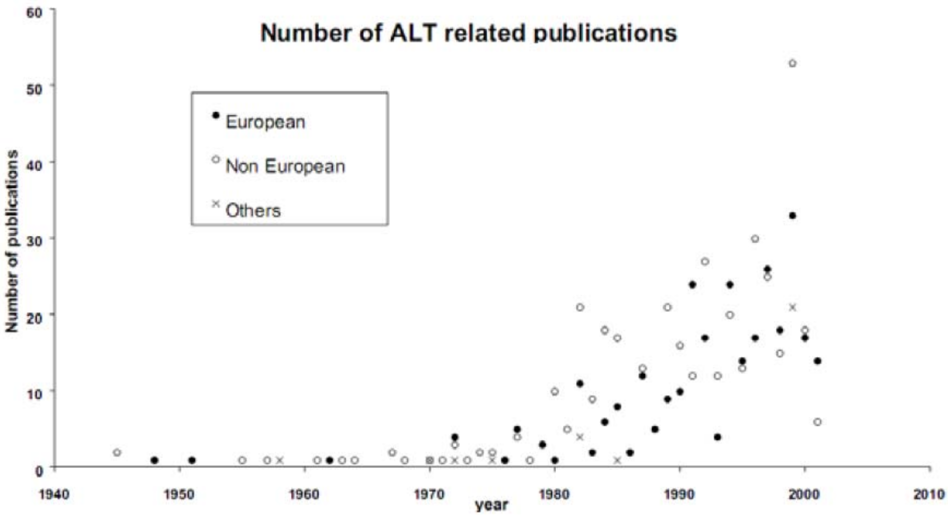


Figure: 10 : Number of ALT related publications versus time

Different research teams at the European ALT facilities provide high-quality results especially for the national authorities. But along with 12 different national ALT facilities come

- o 12 different techniques how to construct pavement test sections,
- o 12 different types of instrumentation and test evaluation for obtaining parameters of pavement performance and deterioration and
- o 12 different ways to process and save data and apply statistical methods.

So there is an extensive amount of data from all over Europe but the results are hardly comparable as the different ALT facilities use different methods from the very beginning of a test to its end. Also no one has an overall view as there is no common European database for ALT results, no European co-ordination and hardly any co-operation. Furthermore, 25,000,000 € have been spent in the last 20 to 30 years for ALT tests in Europe, not taking into account construction and maintenance of the facilities, but up to this day no consistent data for a European (economic) analysis exist. From the European perspective funds are not spent efficiently enough as the results are useful for national authorities only.

As the counter piece of ALT there is real-time load testing (RLT) on test sections on the public road network. Pavement performance as well as environmental and traffic conditions are monitored on a long-term basis. Unlike ALT with controlled test conditions, RLT provide results of pavement structures under real traffic and real environmental conditions. Test roads on the public road network are important to verify results from ALT. We assume that there are hundreds of RLT within the European Union, but as for ALT also in this area of research, there is no European co-ordination. This is why we neither know the number of test roads in Europe, nor any other parameters such as objectives or duration of the tests.

6.5.3 Lessons from US-LTPP

In 1984, the Long-Term Pavement Performance Programme (LTPP) started in the United States. After a 5-year planning phase, data acquisition started in 1989 on over 2,000 test sections on the public US road network. The plan is to monitor pavement performance, environmental and traffic conditions for 20 years across the US. One major objective is to strengthen the co-operation of different partners in road construction and research. So the consortium consists of many private and official road authorities as well as private and university institutes. The LTPP-website (http://www.fhwa.dot.gov/pavement/ltpp/index.cfm) provides comprehensive information about the organisation, partners, objectives and the progress of the project as well as papers with results and findings. EURODEX can benefit from LTPP if the lessons learned from this long-term programme are taken into account when building up EURODEX.

6.5.4 The Road to EURODEX

For EURODEX to be carried out in the forthcoming FP it is of crucial importance to set up an environment capable to meet the challenges mentioned above.

Shared European Database for ALT and RLT results: As a first step it will be necessary to build up a European database for test results to find out where we stand in research. Therefore data and results from as many previous tests as possible have to be collected, stored and analysed. From this evaluation we will find out what we already know and where gaps of knowledge are located. Also there should be a future obligation for ALT and RLT funded by the EU to provide data according to the standard of the database. The database should be accessible to as many research teams as possible to spread the idea and make it a lively knowledge pool rather than a fenced-in ivory tower.

Common European standards/guidelines for ALT and RLT including quality control and quality assurance (QC/QA): To make sure that data and results from future ALT and RLT carried out for EURODEX or other national and international projects can be used for a European analysis, common guidelines for ALT and RLT have to be created. The European COST action 347 (Improvements in Pavement Research with Accelerated Load Testing) was started to provide a “Common code of good practice for the application of ALT” but never made it to a complete final report. Still, findings from the different work packages can be used. We need guidelines or standards for each step of a test from testing the materials used for the test sections to construction of the test sections, instrumentation, data acquisition, evaluation and storage (in a European database) up to statistical methods.

Only if these preliminary steps are taken, we can make sure that EURODEX – with a co-operation of as many European ALT facilities as possible – will be successful and provide consistent data for further (economic) research.

These first actions will provide a clear vision of the existing knowledge as well as of knowledge gaps and we can make sure that future tests will provide data that can be used on a European level. Based on that the strategic planning of EURODEX can start:

- Isolate major factors on pavement performance and deterioration for different kinds of road structure designs (flexible, semi-rigid, rigid)
- European experts decide about the most important road structure and designs to concentrate on the essential matters and prevent EURODEX from becoming a giant-size, everlasting, non-financeable test programme.

Together with a detailed inventory of European ALT facilities, the need of any additional equipment or capacity to carry out EURODEX can be isolated.
To strengthen the co-operation, regular workshops of all research teams working at the different European ALT facilities will not only help communicating results and latest achievements but also bringing personal and informal contacts.

6.5.5 Benefits from EURODEX

If the planning of EURODEX is done step by step, the experiment will be the very first programme in pavement research worldwide to provide consistent data and performance indicators for further economic research. Other benefits from EURODEX include:

- A solid basis for a European transport policy and legal certainty of transport pricing on European roads
- Providing guidelines for optimal HGV weights and dimensions
- Providing a tool for evaluating research project proposals to get more efficient spending of research funds
- Evaluation of existing design methods and materials on a European basis
- Development of more sustainable and efficient strategies for the rehabilitation of existing pavements to reduce the need for public funding
- Establishing a strong European database for research and highway industry
- Development of improved analytical and numerical models to describe the performance and deterioration behaviour of pavements
- Determination of the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance in a consistent way

As this experiment can only be carried out successfully if the national authorities, facility operators and road concessioners play along, co-operate and support the project, it is important to promote the idea of EURODEX from the beginning in all member state and especially in the European ALT facilities.

7 Aviation[13]

This section extracts the main conclusions and recommendations that support policy makers and regulators in implementing efficient pricing strategies in transport infrastructures. In particular, this section deals with main results obtained in WP6 regarding the allocation of infrastructure cost in air transport sector. It is necessary to highlight here that these pricing strategies are based on the social marginal cost principle and that CATRIN focuses only on infrastructure costs, that is, on the costs of providing, maintaining, renewing and operating infrastructure, but some remarks were made on scarcity and congestion costs because it is well know that when airports are highly congested the opportunity costs associated to the scarce slots can be highly significant.

This project extended some results previously obtained in GRACE. Among the principal changes, we would like to highlight that the database was extended and models were also updated with a more sophisticated output specification. The approach to calculate input prices was also modified. In CATRIN, marginal cost estimates were made by different types of aircraft and a different output for freight or passenger was also considered. And finally, as economies of scale were anticipated, it is well known that pricing schemes based on these estimations will provoke commercial deficits in the aeronautical provision of airports. Thus, cross subsidization by commercial activities are necessary if airport managers and regulators want to apply pricing schemes based on marginal costs estimates.

7.1 Elasticities and Marginal cost estimates

The model is based on a database with 1069 observations of 161 international airports with the following variables[14]:

- Total costs: labor, materials and capital expenditures (amortization and interest);
- Output:
  - Passengers (PAX),
  - commercial Air traffic movements (ATMs),
  - metric tons of cargo (CGO) and
  - commercial (non-aviation) revenues (REV);
- Fixed factors:
  - gross floor area of terminal buildings (TER-m^2),
  - total runway length (RUN-m),
  - number of gates (GAT),
  - and check-in desks (CHK);
- Other:
  - time (t),
  - full-time equivalent employees (FTEE), and
  - total landed MTOW.

ATMs are generally defined as either a landing or take-off movement, mostly performed by a commercial carrier. From the airport's perspective, the output is defined as the provision of infrastructure to the carrier in order to perform such movements. However, the ATM variable, as defined above, implies the aggregation of landings and take-offs which may not be fully comparable in terms of infrastructure usage. Since landings and take-offs are usually

[13] Based on D9 – Martin et.al. (2009)

[14] All the variables related to costs and revenues were converted to 2006 Purchasing Power Parity (PPP) USD using OECD published indicators.

produced in sequence and jointly charged, this study consider the number of landings, redefining the ATM variable to represent a landing-take-off (LTO) cycle. The ATMs were standardised in "737-equivalent" [15] aircraft operations (ATM_{737}). The second output included in the cost function is the provision of infrastructure for passengers and baggage (PAX). The inclusion of these two variables creates an econometric challenge as we have strong linear correlation between the explanatory variables. Freight and mail operations are the third output considered in the provision of infrastructure (CGO). Cargo operations are performed exclusively in the airport's landside, and comprise the processing of both air and ground freight. The fourth output included is the provision of infrastructure for commercial activities such as retail, food and beverage, parking, real estate and many others. The unit of observation was defined as thousands of PPP USD (2006) of non-aviation revenues.

7.1.1 Elasticities and the economies of scale

The analysis of the economies of scale is based on the first- and second-order output parameters of the estimated cost frontier. The scale elasticity, i.e. the inverse of the usage elasticity, at the geometric mean airport[16] is 1.85, a very significant value which is significant differ from unity (i.e. constant returns to scale can be rejected).

The elasticity is not constant with output and the values are plotted against the number of ATM_{737} in the figure below. The minimum efficient scale is not reached until roughly 2,275,000 ATM_{737} per year. This result provides a strong economic justification for the actual expansion trend observed in the industry because there is still considerable scope for future expansions, as the biggest scales of production currently serve almost a million annual ATM_{737} (Atlanta, Chicago O'hare, and London Heathrow). Hence, within the current technological frontier, the world's leading airports will continue to benefit from scale economies in the provision of infrastructure for air transportation and commercial activities until they reach between two or three times their current scales.

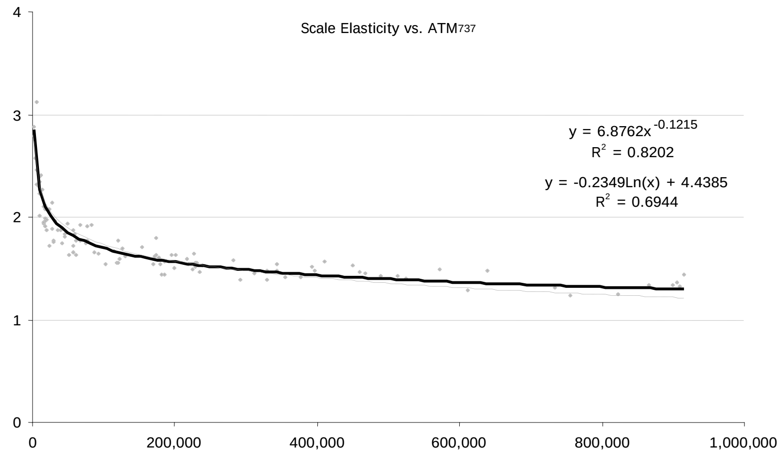


Figure: 11 Scale elasticities (inverse of long run elasticity) for both aeronautical and non-aeronautical production

Taking into account all external factors – environmental cost etc - the industry's real (social) minimum efficient scale might possibly be located in smaller levels of production. In the same

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[15] The total number of ATMs (landings) will be scaled by the proportion of each airport's average landed MTOW with respect to the base aircraft's MTOW. The Boeing 737-400, with an MTOW of 68 metric tons, was chosen as "base aircraft". The assumption of a linear relationship between the aircraft's MTOW and its marginal cost makes the election of the base aircraft a trivial issue. Of course, this approach is not perfect and is only intended to serve as a first approximation to the standardisation of aircraft operations for cost function research.

[16] 4.7 million passengers ; 48,000 ATM_{737}

line of reasoning, the effect of the airport size and the scale of production on the airport's organizational complexity may also play a very important role in the validation of these results. And, finally, other aspects such as the quality of the service should also be taken into account, as many of the world's leading airports are consistently ranked bottom in passenger surveys related to the overall service quality.

A cost complementarity between aviation and non-aviation activities at major commercial airports indicates that the range of operations where airports enjoy increasing returns to scale will be reduced if airport regulation does not allow joint production of aeronautical and commercial activities.

The calculation of an approximate value of the aeronautical minimum efficient scale will depend almost exclusively on the values obtained at the set of big hub airports. It was observed that, over 50,000 ATM_{737}, all airports were producing commercial revenues significantly over the sample's geometric mean. Hence, only these airports were used and the aeronautical minimum efficient scale was found to be located between 1.54 and 1.76 million $ATM_{737,}$ with a mean value of 1.65 million[17]. This is not very far from projected capacities at many of the world's leading airports. As offered capacities are approaching the minimum efficient scale, it is possible that some airports experience decreasing returns to scale created by temporary lack of capacity. In these cases, major airports may draw on their commercial activities in order to increase their own short-run efficient scale, though at some degree of inefficiency in transport provision.

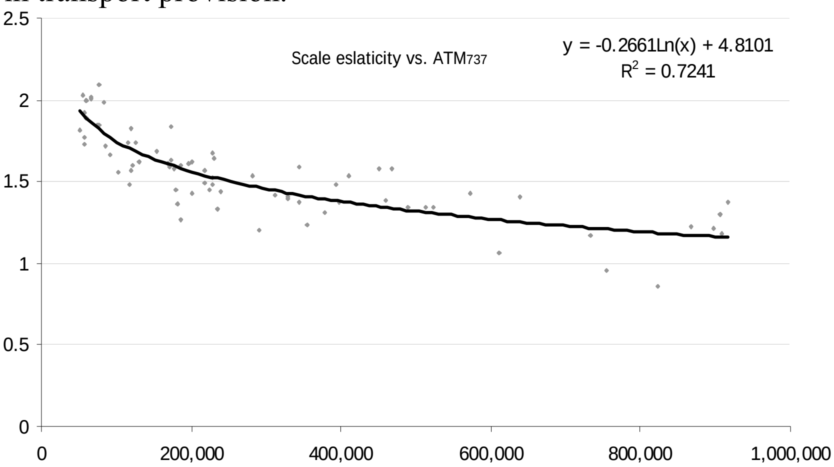

Figure: 12. Scale elasticities (inverse of long run elasticity) for aeronautical operations (ATM_{737})

7.1.2 Marginal cost

In this section, a comparison between the actual airport charges and the estimated infrastructure marginal costs (MC) as an indication of how far optimal pricing is from current practices is made. However, this analysis is limited because of two important issues: first, the lack of information on externalities does not allow us to interpret the obtained MC in terms of social benefit[18]; second, the presence of strong increasing returns to scale in the industry

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[17] The same regression was made using the *pax* variable as the output to explain the scale elasticity, obtaining a confidence interval for the minimum efficient scale from 117.8 to 134.6 million passengers, with a mean value of 126.4.

[18] It would be quite interesting to incorporate external costs in our database to see if our main results are still valid. In most of the airports worldwide, it is usual to analyze the effects of noise using aircraft noise contour maps which show lines joining points of equal noise around the vicinities of the world. There are different

clearly hinders the adoption by the airport authority of these *first-best* prices, except, in the event that airports were to be subsidized by public authorities, or aeronautical activities were to be cross-subsidized by commercial revenues; and finally because in some of the most congested airports the opportunity costs for the scarcity of costs could hinder some of our results.

The first part will develop the estimation of long run marginal costs (MC) for aircraft operations (ATM), passengers (PAX), cargo (CGO), and even commercial revenues (REV), using the parameters of the cost function. The marginal cost is estimated as a product of elasticity and average cost and presented in the table below.

Table 9. Average long-run marginal costs at different production levels (USD)

ATM737	**MC**		**PAX**	**MC**		**CGO**	**MC**	
(000)	**mean**	**range**	**(mppa)**	**mean**	**range**	**(mmtc)**	**mean**	**range**
0 to 5	425.0	415.9-439.2	0 to 1	4.11	4.03-4.21	0 to 0.1	221.3	81.6-360.9
5 to 15	392.3	373.9-411.4	1 to 5	3.75	3.52-4.03	0.1 to 0.5	62.4	48.6-81.6
15 to 75	285.8	247.9-370.0	5 to 25	3.47	3.17-3.68	0.5 to 1	43.1	38.8-48.6
75 to 300	278.3	249.3-288.9	25 to 50	4.04	3.68-4.33	1 to 1.5	36.3	34.1-38.8
300 to 500	301.3	289.0-314.9	50 to 60	4.42	4.33-4.51	1.5 to 2.5	31.2	28.9-34.1
500 to 900	350.3	315.0-390.9	60 to 85	4.74	4.51-4.98	2.5 to 4	26.6	24.8-28.9

The evolution of the moving average MC for the ATM_{737} is presented in the table above with an overall decreasing tendency until reaching the minimum at roughly 75,000 ATM_{737}. After this level, the average MC increases steadily and due lack of additional information we do not have very precise estimation of the slope over a million ATMs. Regarding passenger service, the average MC has its minimum at roughly 9 mppa with an estimated value of USD 3.23. The moving average keeps the same level until reaching 40 mppa, where a significant increase in MC estimates is appreciated when serving an additional passenger starts to require additional investments (people movers and ground access infrastructures). The average MC of the *cgo* variable is decreasing in the whole range of production, indicating that the provision of infrastructure for freight processing is a major contributor in the creation of scale economies. However, a more plausible explanation for this trend is that the increase of production also increases the presence of the freight companies which provide their own facilities, and thus have less impact on the airports total costs.

These results allow us to test the convenience of a separate specification of both the *pax* and the *cgo* variables instead of the usual WLUs. If only the information provided by the average values is considered, the wrong conclusions could be drawn. As the cargo variable was measured in metric tons, the average MC for an additional 100 kg of cargo is USD 4.0, which is actually very close to the average costs imposed by the additional passenger (4.52). However, the evolutions of these MC are very different as can be seen in the figure below.

software tools which draw the contours from data describing aircraft movements, routes, noise generation and sound propagation. Analysis of the noise impact of airport developments or changes to air traffic operations are needed by airport managers and regulators.

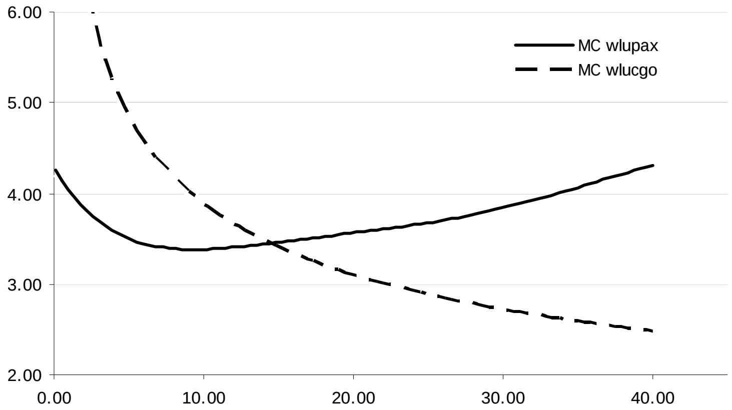


Figure: 13. Comparison between PAX and CGO (100Kg) long-run average marginal costs (in million wlus)

The average MC invested in the production of an additional USD 1,000 of commercial revenues is estimated at USD 160.57. The main conclusion to draw from this value is that, on average, airports are still very far from their optimal commercial development (i.e. MC*rev* = USD 1,000) indicating that they still have enough room to expand their scope of on-site services. The provision of infrastructure for air transportation might become completely subsidized by the revenues generated by both passengers and visitors. These results reinforce the Beesley (1999) argument which puts emphasis on the demand complementarities in order to show that airport price regulation was not needed, because airports would not extract the monopoly rents from aeronautical activities on account of the presence of important demand complementarities from commercial activities.

7.1.3 Case studies

This analysis focus exclusively on landing *(atm)* charges and taking into consideration the linear assumption on MTOW that has been made in the study. For this reason only those airports featuring constant or increasing unit rates per metric ton MTOW could be analyzed. Finally, it is worth noting that, in the presence of noise or other environmental surcharges to the landing price, the total amounts will be calculated using the most neutral conditions.

We focus on three airports; Brussels, Copenhagen and Stuttgart. Brussels and Copenhagen airport are recently privatized airports or public companies with a significant share of private owners. Airport charges are regulated with the declared objective to reach *dual-till* returns (see section 7.2). The first conclusion to draw is that, as expected, runway charges are calculated according to long-run considerations, i.e. including capital costs. The depreciation of the airside infrastructure is the most important source of costs at an average commercial airport. Therefore, it seems to be obvious that the use of the infrastructure will be the major component of the final price, as required by the *dual-till* approach. The short run marginal cost is estimated without capital cost. Stuttgart, on the other hand is a publicly owned and managed airport. Most German airports are regulated under a *single-till* approach. The table below summarise our results regarding long- and short-run marginal cost for aeronautical activities as well as actual charges levied.

- None of the airports apply a short-run infrastructure marginal cost pricing scheme.
- Narrow-body aircraft (that represent up to 90 percent of the annual movements) are priced about 14 percent below their estimated long-run MC in Brussels. Moreover, the wide-bodies segment (less than 10 percent of traffic) is also blatantly underpriced, putting in doubt the declared aeronautical cost recovery. The setting of an upper weight limit at 175 metric tons makes actual charges deviate up to 150 percent from their MC.

At first sight, these results deny the existence of true engagement with the *dual-till* principles which could be induced by the excess capacity.

- Copenhagen is often referred to as one of the cheapest airports in Europe. However, all aircraft segments seem to be significantly overpriced compared to the long run MC.
- The landing charge rule in Stuttgart is perfectly linear in MTOW. The optimal long-run turnaround price is only 3.5 percent lower than the actual charge, indicating a very high degree of long-run marginal cost pricing, and at the same time, a very low degree of aeronautical cost recovery.
- The aeronautic underpricing in Brussels will help to increase traffic and passenger flows through the uncongested terminal buildings and thus maintain a high level of commercial benefits in order to sustain a *single-till* pricing policy.
- Airport charges are very important strategic variables, and some other goals than cost recovery could be envisage. In this case, the cross-subsidized prices for heavier aircraft in Brussels clearly indicate the existence of an underlying "mix-reorientation" policy, with the objective of consolidating Brussels as a long-haul hub for transatlantic destinations, especially with the US.

Table 10. Marginal costs and actual landing charges (in EUR)

	Long-run	**Short-run**	**Actual**	**No Weight limit**
Brussels airport				
unit rate	3.63	0.97	3.12	3.12
ATR72	79.86	21.34	78.0	68.6
B737-300	206.91	55.29	177.8	177.8
A320-200	279.51	74.69	240.2	240.2
B767-300	620.73	165.87	533.5	533.5
B777-200	969.21	258.99	546.0	833.0
B747-400	1368.51	365.69	546.0	1,176.2
Copenhagen airport				
unit rate	5.73	2.86	8.75	-
ATR72	126.0	62.9	192.4	-
B737-300	326.5	163.0	498.6	-
A320-200	441.0	220.2	673.6	-
B767-300	979.4	489.1	1,495.8	-
B777-200	1,529.2	763.6	2,335.6	-
B747-400	2,159.3	1,078.2	3,297.8	-
Stuttgart airport				
unit rate	6.57	2.55	6.80	-
ATR72	144.54	56.1	149.6	-
B737-300	374.49	145.35	387.6	-
A320-200	505.89	196.35	523.6	-
B767-300	1123.47	436.05	1,162.8	-
B777-200	1754.19	680.85	1,815.6	-
B747-400	2476.89	961.35	2,563.6	-

In addition to the aeronautical charges airports levy passenger charges. We have made a similar comparison for passenger charges and long run marginal cost.

- Brussels is known to charge one of the highest passenger charges in Europe (only to outbound pax). The comparable MC estimation is EUR 6.60, which is certainly well below the current charges (as of 2006) of EUR 14.95 for originating and EUR 7.60 for transfers[19]. Hence, passengers are cross-subsidizing aircraft operations. As an example, the turnaround of a full A320-200 (all departing passengers) generates EUR 2482.7 of revenue, against a MC of only EUR 1269.5.

- An average passenger fees for Copenhagen was calculated at EUR 13.90, which is significantly higher than the comparable MC estimation at EUR 4.7 given the same structure as in Brussels.
- If the passenger security fee is added, the average charge is EUR 5.36 and the comparable MC in Stutgart[20] is EUR 5.94. As in the *atm* case, Stuttgart airport is very close to long run MC pricing, yet the presence of scale economies, technical and allocative inefficiencies will not allow financial breakeven of aeronautical assets. This result turns out to be very interesting when taking into account that Hence, it can be deduced that commercial revenues are expected to cover aeronautical losses, derived not from the subsidized infrastructure charges but from the airport's own operational inefficiency.

In summary, it can be concluded that airport charges are always closer to the estimates of the long-run approach rather than to those of the short-run approach. The explanation for this is that, historically, the airports have proved to be financially robust firms. In fact, in many countries, airports are still in public hands but they do not usually receive any kind of financial government assistance because they are expected to operate as commercial entities with a diverse degree of autonomy.

7.1.4 Eurocontrol and air traffic control

Charges are levied for the use of air corridors and for the provision of air traffic control services, referred to as air navigation services charges (ANS charges). Depending on the flight phases of an aircraft, ANS charges are further subdivided into: i) charges for en-route services (en route charges), and ii) charges for air navigation services provided during the approach and aerodrome phase. The ICAO recommends that approach and aerodrome control charges are to be distinguished from en-route air navigation services charges. In Europe, since 1981 this distinction has been realised by the responsibility of Eurocontrol to collect en-route charges based on a harmonised en-route charging scheme. With the adoption of the EC regulation 1794/2006 (EC 2006) also the calculation of terminal charges has been based on common principles.

Within the Eurocontrol area, the borderline between the en-route phase and the approach and aerodrome phase is defined as the 20 km radius of the flight closest to the airport. However, over the resent years it has been debated whether the 20 km rule provides a correct separation of costs associated with the approach phase and the en-route phase of an aircraft.

The basis for determining and raising ANS charges are two ICAO documents (ICAO1997 and ICAO 2001) which are for the Eurocontrol member states specified in more detail in CRCO 2003 and CRCO 2007. Air navigation Services refer to the following five broad categories of facilities and services: Air Traffic Management (ATM), Communications, Navigation and Surveillance (CNS), Meteorological services for air navigation (MET), Search and Rescue (SAR), Aeronautical information services (AIS).

[19] Note that these prices only account for the use of facilities because security is levied separately.
[20] The calculation of the passenger fee is a bit more complicated because prices are slightly different according to the passenger's origin/destination. The intermediate price category comprises the flights within the EU

The ICAO rules require that the costs to be recovered by ANS charges are determined in accordance with generally accepted accounting principles. National accounting practices (for the treatment of interests, the taking over of write-offs and the provision of doubtful accounts) can be applied as far as they do not deviate from generally accepted accounting principles. Depreciation rules relating to taxation purposes have to be disregarded wherever they differ from the common principles. The Eurocontrol charging schemes for en-route and terminal charges follow these rules. Both en-route charges as well as charges for approach and aerodrome control are based on a full-cost principle. Given the EU charging policy which postulates the social marginal cost principle as the leading charging principle, the potentials of introducing the SMCP principle in particular for terminal charges has been discussed (see for example PriceWaterhouse (2001)).

- The types of costs eligible for recovery via air navigation serves charges are
- staff costs,
- other operating costs (purchase of goods and services to provide navigation services, in particular outsourced services),
- depreciation costs relating to the total fixed assets in operation for the respective navigation service,
- cost of capital calculated as the average net book value of fixed assets and the weighted average of the interest rate on debts and of the return on equity, exceptional items such as non-recoverable taxes and custom duties paid.

The Eurocontrol member states report a forecast of these costs in their country for the subsequent year t+1 to the CRCO. The costs of EUROCONTROL are added and the costs for exempted flights are deducted. The obtained costs are divided by the service units forecasted for t+1 in order to yield the unit rate for the respective charging zone. En-route charges constitute remuneration for i) the costs incurred by States and Air Navigation Service Providers in respect of en-route services, ii) the costs incurred by Eurocontrol. The en-route charges are calculated by considering three basic elements:

- the aircraft weight factor,
- the distance factor,
- the unit rate of charge for each charging zone.

7.1.5 Congestion and scarcity

According to a new EUROCONTROL report, by 2030, climate change and a lack of airport capacity will mean that one flight in two will risk delays or cancellation at highly-congested airports. The study, Challenges of Growth, finds that even taking the economic downturn into account, demand for flights in Europe will rise from 10 million today to 20.4 million in 2030. Airports are working to make the most of their capacity and expand to meet demand, but on current plans, they will only be able to handle 18.1 million of those flights, leaving 2.3 million flights a year or 6,300 flights a day unaccommodated.

As a result, airport congestion is set to rise substantially - by 2030, around 20 of the largest airports will be saturated, that is operating at full capacity, for 8 hours or more a day. About half of every day's flights will pass through one of these saturated airports.

Despite the economic downturn and a prospect of slower growth in the future - because of maturing European markets, higher fuel-related costs and climate change- demand in the longer term is still set to rise substantially. As a result, airports are going to run out of space - and with half of each day's flights going through one of the saturated airports, a small delay at one airport could rapidly escalate to infect the whole European air network.

Our research showed some evidence on the issue of congestion and scarcity. The difficulties in disentangling scarcity and congestion lead in practice to cope with delays without differentiating between these two different concepts, and congestion at airports is generally addressed through the application of peak and off-peak charges that are generally only related to scarcity. Such practices also lead to ignore the evaluation of congestion in terms of opportunity costs (i.e. the value of time and resources lost due to delays).

Concerning scarcity, recent trial experiments in the United States Airports have developed market based slot allocation as a way to solve scarcity problems. If primary auctioning of slots happens, then secondary trades can take place and the system could go towards an increasing transparency. However, it is underlined that devoting efforts to solve scarcity not necessarily leads to solving congestion problems: in fact it might happen that, if capacity is increased, a newly generated demand appears and congestion is not eased.

We present some marginal congestion cost estimations for Madrid and Rome airports. The Madrid airport shows higher passenger and airlines congestion costs, €6.2 and €1970; in comparison to €5.5/passenger and €1740/aircraft in the Rome airport.

7.2 Current regulation

UN's International Civil Aviation Organization (ICAO) publishes periodically some guidelines which suggests that it is essential that "a transparent cost recovery system with a fair and equal treatment of all users" be up-to-date. So "that the users shall ultimately bear their full and fair share of the cost of providing the airport". In determining the cost basis for charging policies, the following should be applied:

1. The cost to be shared is the full cost of providing the airport, including cost of capital and depreciation of assets, maintenance, operation, management and administration.
2. Airport users should not be charged for facilities and services they do not use.
3. The cost of facilities exclusively leased or occupied and charged for separately should be excluded.
4. The proportion of costs allocable to various categories of users, should be determined on an equitable basis.

This should make possible, that airports' revenues cover all direct and indirect operating costs and provide for a reasonable return on assets to contribute towards necessary capital improvements. The similarity of fare structures found at the majority of airports rests on the fact that most countries follow ICAO and IATA guidelines. The increasing involvement of the private sector in airport activities has broken somehow the uniformity of pricing structures around the world, leading to a more efficient pricing system at privatized airports.

The choice between single-till and dual-till is one of the most debated issues amongst airports and airlines. It is now widely accepted that the single-till mechanism, whereby the entire airport's revenues are taken into account when setting charges, is a disincentive to maximising non-aeronautical revenues (or at least dilutes the airport's incentive to minimise non-aeronautical costs). As a consequence, some important allocative inefficiencies appear for very congested airports, because the low aeronautical charges artificially exacerbate the scarcity costs of slots, creating the appearance of a lack of capacity. Furthermore, it distorts investment decisions, because the existence of cross-subsidies makes it difficult to estimate the "true" returns on the aeronautical assets.

The alternative mechanism to regulate prices in airports is the dual-till approach in which commercial revenues are not factored into the charges equation, resulting in higher, un-subsidized, prices for airlines. This method may be more consistent with the user-pays principle, under which prices should exactly reflect the marginal cost of using the facilities. Thus, commercial activities cannot be used to cross-subsidise aeronautical activities and the allocation of costs is more concordant with the user-pays principle.

7.2.1 Recent developments in EU airport policy

European Commission presented an 'airport package' on 24th January, 2007. The package consists of the Communication on Airport Capacity, Efficiency and Safety in Europe, the Proposal for a Directive on Airport Charges, and a report on the implementation of the Directive on ground handling.

The action plan described in 'Airport Capacity, Efficiency and Safety in Europe' aims to identify areas where EU member states can work together to meet future challenges on airport capacity, and outlines five measures to improve the capacity of the European airport system. The measures are built upon existing EU initiatives such as the Single European Sky programme to reform the architecture of European air traffic control, and the European navigation satellite system, Galileo. The Proposal for a Directive on Airport Charges will structure the discussions on airport charges between airlines and airports. The Proposal is based on three ICAO-principles: non-discrimination, transparency and consultation. The report on ground handling confirms that the Directive on ground handling has improved the functioning of the market in ground handling services at European airports. Slot allocation will continue to play an important role in accommodating the forecast increase in traffic at European airports.

The objective of the Directive on Airport Charges is to establish a general framework for levying charges to ensure a structured dialogue between airlines and airports. It focuses on the process of how airport charges are levied, and therefore cannot be compared with any existing regulatory regime in the EU on price regulation of airports. The objective is to ensure good business practice between airlines and airports in a sector where some airports have a strong market power over airlines. In addition, at some airports, there are airlines which have a strong position in comparison to other airlines.

The proposal is based on three general principles stemming from International Civil Aviation Organization (ICAO) recommendations on airport charges.

1. Airport charges shall not discriminate between airport users or passengers. Each airport user shall be charged in a non-discriminatory way according to the quality and the quantity of the services provided to the airport user. This implies that each and every airport user is charged identically for the same service.
2. Airports shall consult with airlines on any changes to airport charges. The proposal lays down the frequency for the consultation, and when airports shall communicate to the airlines any changes in airport charges. This consultation shall take place at least once a year. Airlines will have the possibility to give their views on any proposed changes before they enter into force.
3. The directive also determines the scope and detail of the information that shall be exchanged between airlines and airports. Airports shall have the possibility to explain the components of airport charges and how they are calculated, and airlines shall have the possibility to verify that they are only being charged for services they actually use.

The allocation of landing and taking-off slots at Community airports is regulated by Council Regulation No. 95/93. The purpose is to ensure an efficient distribution of slots in a transparent and open manner. This regulation, which is still in force today, is broadly based on well-established slot scheduling procedures devised by the International Air Transport Association (IATA). However, the Commission has recently proposed a modification of the Regulation in order to:

- clarify the legal nature of slots.
- promote efficient allocation of slots through clear rules on methods and procedures, better definition of airport capacity and transparent, neutral procedures of consultation and mediation.
- encourage the efficient use of slots.
- enhance competition between incumbent carriers and new entrants.

The problem with most allocation systems is that they are arbitrary, and for this reason there is no guarantee that the scarce slots are allocated to those who have the highest willingness to pay for them, so it is possible that some allocation systems could create some allocative inefficiencies. However, it has been argued that auctioning and trading are preferable to "grandfathering" because competition could be more effective due to the fact that new airlines could enter into the market without having any existing slot; and it gives the airlines the option of trading into the market some slot rather than deliberately running an unprofitable route so as to avoid application of the "use it or lose it" clause.

Recently, this regulation has been partly amended because it has been decided to waive the 'use it or lose it' slot rule for the summer season in 2009. The Association of European Airlines, representing Europe's most important network carriers has applauded this decision because the economic downturn has created a temporary excess in capacity over demand which the airlines are constrained from addressing by rules designed for a growth market. However, ACI EUROPE, representing airports in Europe is not so enthusiast with this measure as the suspension will result in an inefficient use of scarce capacity at congested airports and expose the travelling public and communities to late cancellations of air services in particular on regional routes. It will also create an artificial barrier to market access for new entrants.

However, ACI EUROPE is appreciative of the European Parliament's efforts to subject any extension of the suspension to the winter 2009 season to a number of conditions, including a prior impact assessment of the suspension effects on all stakeholders, as well as a revision of the existing slot Regulation to ensure the optimal use of scarce capacity at congested airports. It is clear that the suspension of the use-it-or-lose-it rule is not beneficial to European airports at a particularly critical time in which negative impacts on both their commercial and aeronautical revenues are expected.

7.3 Short term policy implications and recommendation

It has been shown that there are important economies of scale in airport operations, and, thus, it can justify the current trend of capacity expansion programs observed in major hubs. For the year 2006, the range of estimated economies of scale varies between 4.36 and 1.23, with an average value of 1.75. A basic methodology was proposed in order to analyze the likely level of output at which the economies of scales would be exhausted. The industry's minimum efficient scale (MES) was calculated to be at 2.27 million ATM737. The most interesting conclusion to draw from this result is that, within the current technological frontier, the world's leading airports will continue to benefit from scale economies in the provision of infrastructure for air transportation and commercial activities until they reach between two or three times their current scales.

The below examples in Europe show that airports have an interest in increasing its capacity. The Madrid Barajas airport in Europe was aimed to become one of the world's 10 busiest airports after the recent addition of two new runaways and the new Terminal 4. Frankfurt Germany's busiest airport has entered a EUR6.4 billion investment program that is aimed to increase hourly-capacity from 83 to 120 movements by 2015. The UK government has introduced mixed-mode operations in peak hours, which is aimed to increase annual capacity by 10-15%. An airspace redesign by Dutch navigation service provider (LVNL) and an innovative partnership between Amsterdem Schiphol and national carrier KLM has delivered increased capacity in the airports. Munich has reported an increase in connecting airport traffic and has highlighted that Heathrow is aimed to offer increased runaway capacity by 2015.

Economies of scale were found to be highly dependent on the cost complementarities between aviation and commercial activities. Without commercial support, the provision of aeronautical infrastructure alone exhausts all its scale potential at approximately 1.65 ATM737 or 126 million passengers. Hence, if only operating costs are considered, the upcoming generation of major airports will be still enjoying scale economies in their aeronautical activities in the long run. Nevertheless, as offered capacities are approaching the MES, it is possible that some airports in the near future will encounter decreasing returns to scale when considering only the aviation sector. This result is of a vital importance regarding the type of regulation: single till vs. dual till.

From the comparison between optimal and current charges, it was found, as expected, that most landing and passenger charge schemes are higher than the first-best prices calculated as the long-run marginal costs, but, in general, fare schedules are consistent with airport characteristics, such as excess of capacity or the price regulation approach. In addition, it was shown that airport charges are always closer to the estimates of the long-run approach rather than to those of the short-run approach. The explanation for this is that, historically, the airports have proved to be financially robust firms. In fact, in many countries, airports are still in public hands but they do not usually receive any kind of financial government assistance because they are expected to operate as commercial entities with a diverse degree of autonomy.

The recommendations of international organizations (ICAO and IATA) regarding airport cost coverage include the application of average costs as the basic price. In addition, these organizations sought to establish a uniform fare structure for the whole industry. Dividing incurred costs by the number of processed traffic units provides a unitary tariff. Several fares for each service could be obtained with this procedure by distinguishing among the different components of total cost. Given that all users pay the same amount for the utilization of the same services, most airlines support this mechanism as objective and fair. However, the reality is that different operators impose different costs, and therefore should face different charges. For example, an airline that operates during peak periods imposes a cost (capacity cost) that is higher than others who operate during off-peak periods. There is a need to find a way to incorporate this and other industry particularities into the actual fare system within the context of regulation.

Short-run marginal costs are not applied in the airport industry. This result is usually advocated by the defenders of the abusive monopoly power that can be exerted by airports. However, airports usually defend their position saying that unlike airlines which have the flexibility to ground aircraft or cut routes and capacity at short notice to save costs in times of crisis, airports are bound by significant long term financial commitments linked to the development of their infrastructure. The economic cycles of airports and airlines are different and this needs to be recognised by air transport stakeholders, especially by regulators.

7.4 Research issues

The increasing involvement of the private sector in airport activities broke the uniformity of pricing structures around the world, leading to a more efficient pricing system at privatized airports. For a private firm, coverage of actual costs, as well as the coverage of those costs generated by future investments in additional capacity is of critical importance. The actual pricing structure upon which regulatory devices are applied must be consistent with additional capacity investment so that corresponding costs are also covered. Since the allotted period to recover the investment is quite long, the regulator should permit price variations during the investment period with the aim of adjusting costs and generating revenue. However, among the various problems that a regulator might encounter are the difficulty of establishing credible commitments and the need to develop a deep knowledge of the operations and opportunities of a privatized airport.

There still exists an important debate about the pros and cons of the different approaches that have been applied in the past to the economic regulation of airports. In fact, many of the most important private airports have been re-regulated in Australia, the UK and New Zealand in the last years. Policy makers and regional planners are usually confronted to whether it is preferable to adopt a single-till or dual-till approach.

However, the convenience of such regulatory schemes has been put under scrutiny. It has become evident that some price-caps at congested airports have resulted in a reduction of price-capped charges for aeronautical activities to levels below short-run marginal costs. Other problems are more implicitly linked to the retail activities which can be or not formally excluded from the scope of the price caps. The range of airport activities subject to regulation may be extended without an explicit mention if the price caps take into account the retail revenues when determining the admissible charges. And finally, at non-congested airports the price-caps may not be effective and charges could be optimal.

Airports essentially have three sources of revenue. Land rental for industrial use on or adjacent to the airport is relatively stable from year to year. Similarly, concession revenue, generally a percentage of sales, does not vary significantly from year to year in congested hub airports. Airport/terminal revenue does vary with the volume of traffic. At most major airports this does not vary much. Therefore, revenue in aggregate is relatively stable over time. Hence, since airports cannot affect revenue except over the longer term, they must focus on costs as a means to increase profits. For these reasons airport managers and regulators need to measure airport performance and efficiency from a financial and an operational perspective. It is a crucial tool in order to evaluate alternative investment strategies and to monitor airport activity. Managers require information to enable them to identify areas that are performing well and those where corrective action needs to take place. Regulators also need this type of information in order to make a good job regulating the airport activity. Other stakeholders such as, consumers and airlines have also other performance information requirements.

8 Maritime[21]

The maritime sector exhibits many interesting features of economies of infrastructure provision. Navigation aid in the form of lighthouses is one of the classical examples of a public good where the cost of an additional user is virtually zero. On the other hand we have the existence of heavily congested ports where severe congestion costs arises. An often forgotten part of the infrastructure is the ice-breaking service necessary for winter navigation.

This chapter summarise the current knowledge on the marginl cost of maritime infrastructure (8.1), and presents the results from the case study on cooperation of icebreaking in the Baltic Sea (8.2). The two final sections deals with short term policy implications (8.3) and long term development issues (8.4).

8.1 Marginal costs

Our review suggests that the use of fairways in general has a very low marginal cost although the literature to support such a claim is almost non existent.

Pilotage seems also to run under economies of scale. The cost is, to a large extent, independent of vessel type and size, as long as the vessel due to such characteristics does not require more than one pilot. The practice in charging for pilotage in some Member States is a two part tariff structure where one charge is related to the actual pilotage while the other is a form of tax levied on all ships to recover the cost of pilotage. In other Member States there is a hidden cross subsidy between fairway charges on all ships and the cost of pilotage. In practice pilotage charges actually applied increase strongly with vessel size. Comparing the expected marginal cost with the price structure suggests that the category of ships with lowest charges are charged something equal to marginal cost while the bigger ships pay a mark-up, basically to improve cost recovery.

Current pilot charging schemes divert from the theoretical optimum. In most cases, for most vessels, charges seem to be well above marginal cost. Given a cost recovery constraint, schemes where large vessels pay more might be a reasonable way to address the issue. However, this project has not looked into the issue in all detail. It may be an area of interest for further research.

Port charges are a complex issue as they have to consider both the port infrastructure for ships as well as the infrastructure for cargo and moreover also the ship costs. While the port in the real world is a multimodal switch between sea and land-transport it seems generally to be examined as a part of the maritime infrastructure system. Nevertheless, the question of port charges can be analysed with traditional economic approaches.

In general the conclusion seems to be that ports should be regarded as a multi-product industry where production is taking place under economies of scale and scope. Consequently, charges based only on the marginal infrastructure cost will not recover the full cost of production. This is true under the assumption that a long run marginal cost pricing is applied. The review has shown that the goal of cost recovery is an important aim for most of the port sector.

[21] Based on D10 – Eriksson et.al. (2009)

While the consumption of the ports' resources is of minor importance the vessel cost is dominant. In Bickel et.al. (2006) the vessel cost is approximately 10-20 times higher than the infrastructure cost of a port call which were analysed as the cost of locks, pilotage and tugboats. This takes us back to the principle of infrastructure pricing where the whole system has to be included into the problem. Thus one important element of infrastructure pricing is the (external) cost imposed on other users. This is true for congested road and rail networks as well as for ports. In ports the problem is analysed in two parts, the queuing cost during constant service time and the additional congestion cost due to increased service times caused by congestion. The optimal port charge would take the queuing cost into account which is the natural form of the short run marginal cost. This cost can be analysed both for the ship and for the cargo. The charge will thus comprise the two dominant element of charging port services today – charges related to vessels and charges related to cargo.

The queuing model based pricing approach will take into consideration costs incurred for other ships but the approach will nevertheless not ensure cost recovery. The literature has developed a number of models along the lines of "Ramsey" pricing where joint costs are allocated in a way that disturbs demand as little as possible. However, this solution calls for different mark-ups on different cargo and ship categories to reflect the differences in the elasticity of demand.

Icebreaking in open water is not charged for by any EU Member State. Still the case study reported in this paper shows that the operation is characterised by considerable marginal costs. Marginal cost for ice-breaking is represented by the variable costs in the cost model used in the case study and is estimated at some € 30 million per year in the Baltic, given cooperation. Scarcity costs should be added to that and perhaps also the emission costs. To specify the marginal costs for different users, often would be complicated, however: Should the bulk of the variable costs be allocated to the first vessel in a convoy? How should costs for moving an icebreaker from one mission to another be split? What vessel causes delay for the others?

Obviously, current charging regimes are theoretically inoptimal. The scheme is not sanctioned by efficiency, but by regional equity considerations. In line with the arguments of the CATRIN presented in the forthcoming part III it could be argued that a club approach could be worth considering for the case of ice-breaking.

When it comes to icebreaking important efficiency gains can (also) be found in developing the forms for international co-operation possibly in the form of clubs.

8.2 Cooperation on icebreaking

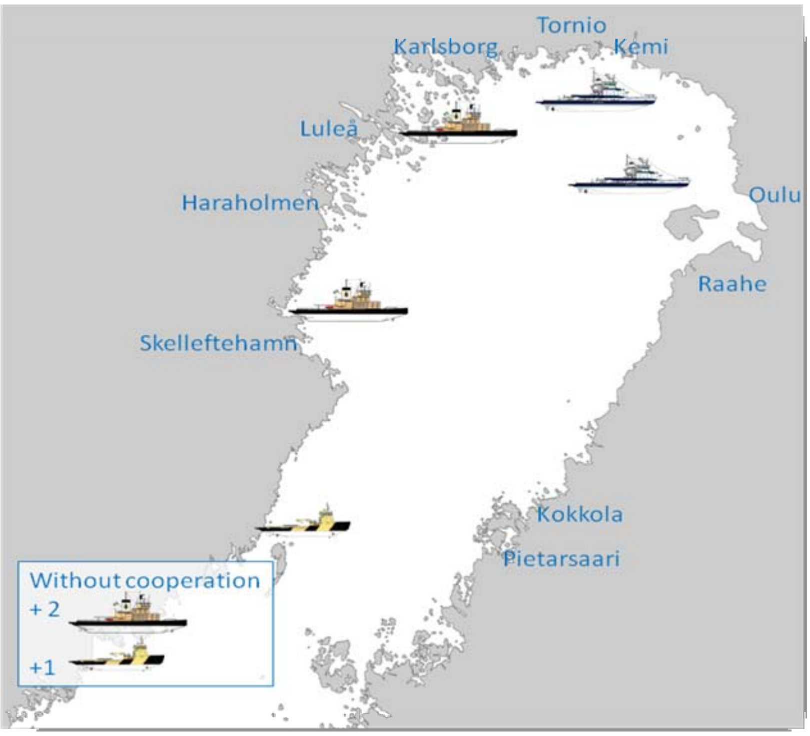
A crucial issue for the further development of icebreaking cooperation is that cost can be properly allocated between the contracting parties. This case study has examined the need for ice breakers in the Baltic Sea with a national policy and with cooperation. The study suggests that there are considerable economic gains to be collected. Thus, there is room for a solution that makes all participants winners. Conducted study suggests that it would be interesting to study this issue in more detail.

The Baltic's and even the world's icebreaker fleet consists of a limited number of vessels. Some of them are sister vessels e.g. the Atle-class (Atle, Frej, Sisu, Uhro and Ymer) and the Viking ice-breakers. The vessels' capacity as icebreakers depends on construction. Design of hull, engine size, existence of stern propellers, etc are factors of importance. An icebreaker's relative capacity also is influenced by ice characteristics. For the purpose of this study, there has been a need to classify icebreakers according to their potential as icebreakers. The analysis has led to a classification into four groups:

- Category A: Large icebreakers suited for off-coast operations. Their engine size and construction allow them to force the most demanding ice formations in the Baltic and their size (beam) offers ice channels wide enough for most vessels.
- Category B: Relatively powerful, somewhat smaller icebreakers. Well suited for operations near the cost, in relatively demanding ice conditions. Limited beam makes them less suitable for assisting large vessels.
- Category C: Less powerful icebreakers, with a medium icebreaker capacity, typically, well suited for operations in the Baltic Proper during severe winters, or similar.
- Category D: Smaller vessels with icebreaking capacities are typically, mainly engaged in other activities such as tug boat operations. The category is fairly diverse.

The allocation of icebreakers has then been done for different scenarios of the severity of the winter in different parts of the Baltic Sea. Below is the icebreaker allocation for the Gulf of Bothnia presented.

Figure: 14 Icebreaker allocation in the Gulf of Bothnia, during the scenario "Severe winter" the week of maximum ice extension.



Up in the Gulf of Bothnia ice conditions are relatively stable for a fairly long period. This means that maximum icebreaker allocation is identical for 13 consecutive weeks. All in all icebreaking services are conducted during 25 weeks. During a severe winter cooperation it is estimated to save 34 weeks of operation of A icebreakers, 15 weeks for B and three weeks for C icebreakers. During a normal winter seven weeks of operations of A icebreakers, two weeks for B icebreakers and three weeks for C icebreakers would be saved.

When the needs for icebreakers for the different parts of the Baltic Sea are summarized it is concluded that the existing fleet is more or less sufficient under cooperation to keep up with the traffic even during a severe winter. Russia is assumed to have moved another two category A icebreakers to the Baltic to keep up with the situation in the Gulf of Finland and in the port region. In the non-cooperation alternative, on the other hand, there is a considerable lack of capacity. All in all, twelve additional icebreakers are needed. The additional need is fairly evenly distributed among the different icebreaker categories.

Table 11 Summary of needs for icebreaker capacity a severe winter, given cooperation and non-cooperation.

	Cooperation					No cooperation				
Area	Cat A	Cat B	Cat C	Cat D	Cat A-D	Cat A	Cat B	Cat C	Cat D	Cat A-D
Bay of Bothnia	4	1			5	6	2			8
Sea of Bothnia	3	1	1		5	4	2	1		7
Gulf of Finland	6		4	7	17	7		4	7	18
Baltic Sea	1	1	1	1	4	2	1	2	1	6
Baltic entrance			4	5	9			6	7	13
Sum	14	3	10	13	40	19	5	13	15	52
Available	12 (14)	3	10	13	38 (40)					

Traditionally, countries with ports where ice problems occur have been seen as the rightful owner of the problem. Each country has got and taken the responsibility to cater for the access to and from ports in their own territory.

The benefits of icebreaking assistance are not only to be identified in the states around the Baltic, but also at the common market in general. The common European interest in winter navigation has been acknowledged by the fact that icebreaking has been included in the TEN-T guidelines and Member States have received EU TEN-T funds for icebreaking purposes. Along with the European discussion on TEN-T guidelines, and the policy implementation of the concept Motorways of the Sea and, specifically, Motorways of the Baltic Sea has been introduced. Maritime transport at the Baltic Sea has been specifically addressed. Seen from that perspective it is argued that the European infrastructure budget, TEN-T, could or should contribute to fund future icebreaking infrastructure. A common European icebreaker, and in the long run possibly even a common icebreaker fleet, could serve as a trigger for improved cooperation.

Discussions with infrastructure managers emphasises some practical an institutional perspectives on icebreaking. It is important that all nations follow the Helsinki Commission's recommendation 25/7 on "Safety of winter navigation in the Baltic Sea Area" when traffic restrictions are applied. Different levels would lead to imbalance in icebreaker assistance. Furthermore, nations should take benefit of the joint information system IBNet. Real time data on icebreakers, ships in need for assistance and icebreaking operation are then made available for all parties. It is also worth stressing that the efficiency of the icebreaking services is depending on the skill of commanding officers on the bridge of the icebreaker. With skilful staff assisting times of the icebreakers are reduced and fuel consumption is decreased at the same time waiting times for merchant vessels are cut.

8.3 Short-term policy implications and recommendations

A relevant question to address is to what extent there are justifications for European or international legislation on maritime charging in the light of economic theory. Obviously, it is useful to address different parts of the maritime infrastructure separately. Analytically, the passage of sea traffic in open waters is probably best seen as a common good. When used by someone, it does not prevent anybody else to use it and it does not add to costs for the "infrastructure manager". The financial cost to provide the infrastructure is close to zero. Charges on (foreign) traffic could be tempting, but would hamper the global economy and would not be in line with international law. Thus, current international legislation appears to be appropriate.

However, emission charges would be theoretically adequate to provide incentives for shipowners to reduce externalities in terms of air pollution. An international framework for emission charging would have potential. Emission trading could be an alternative.[22] Such a scheme could reduce administrative costs compared to pure charging; reduce risks for market distortions as well as for discriminating charging schemes.

Maritime accesses are used by the ports customers. Excessive charging would then first and foremost hamper the port business, but not the global economy. Local regional or national infrastructure managers may have incentives to recover their costs for providing the infrastructure, but to do it in a way that does not harm the port business. Apart from regular competition law that guarantees non-discrimination, there is no obvious need for international legislation to this end. Still arguments may be raised for environmental charges to make up for air pollution. On the other hand it can be argued that emissions are better handled within a general charging scheme (including open waters).

The main justifications for European policy related to Sea port infrastructure is to:

- Prevent distortive state (public sector) aid. As mentioned it has been argued that aid to one port can harm to competitiveness of a neighbouring port active in the same market segment.
- Trigger efficiency by eliminating monopoly and monopolistic charging for services like stevedoring.

8.4 Research issues

Also seen in a long term perspective it seems to be of strategic importance to reduce the environmental impacts from maritime shipping. IMO regulations will do a lot to reduce emissions of sulphur and nitrogen oxides during the years to come. Still, economic incentives may have a role to play.

When it comes to carbon dioxide no similar regulations has been passed. Learning from other sectors it appears likely that a policy solution on maritime emissions of carbon dioxide will involved economic instruments, probably in the form of emission trading. Perhaps carbon dioxide charges can be worth considering. The area deserves additional attention from researchers as well as from administrators and policy makers.

[22] Swedish Energy Agency et al analysed possible schemes, published 2007.

PART III
Implementation

9 Cost recovery[23]

Since long, it is accepted that marginal cost pricing is a way to guarantee that the infrastructure that has been built is efficiently used. If each vehicle pays for the costs it gives rise to, including the external costs, users of roads, railways, ports and airports would only do so if their benefit would be at least as large as this cost.

It is, however, also well known that marginal cost pricing in a natural monopoly would not generate enough revenue to cover the costs of providing these services. The reason can be found behind the natural monopoly concept: It costs a lot to have the infrastructure built, but once there, maintenance costs etc. – i.e. marginal costs – are low and would not suffice to recover also original investment costs.

Governments may, however, not accept that revenue from infrastructure use, is smaller than costs for infrastructure provision. It may not be seen to be equitable to have tax payers foot the bill for infrastructure provision, and there are indeed also other motives to recover more than marginal costs. Irrespective of motive, this chapter addresses this conflict of interest: on the one hand, it is efficient to charge only marginal costs; on the other hand governments may want road users, railway companies, airlines and shippers to contribute towards the full recovery of costs.

9.1 Not a problem for all modes

A first proposition of the work that has been done is that insufficient cost recovery is not of immediate relevance for roads, ports or airports. There are, indeed, difficult tradeoffs to be dealt with also in these modes. It is, however, no reason to believe that these modes are used below capacity due to overcharging.

But the cost recovery issue is a concern for the railway sector. It is demonstrated that some member countries indeed have accepted the Union's official policy that their railways should not be asked to pay the full costs for building and maintaining railway infrastructure. As a consequence, these governments provide upfront subsidies which have provided for growth in rail travel and transport. Other member countries formally require their national railway monopolies to pay for the industry's full costs. As a result, the annual reports are in the red, maintenance and upgrading of tracks and rolling stock lags behind and ridership and freight volumes shrink. The policy may also lead to the closure of branch-lines which still have a social value.

9.2 Congestion or scarcity charging is lacking

A second proposition is that current estimates of marginal costs, and indeed actual practice in many countries, fails to recognise that parts of the railway network, during parts of the day, week or year, are heavily used. One way to enhance cost recovery without jeopardising efficiency would therefore be to implement congestion and scarcity charges.

Charging for scarcity was not necessary as long as the rail industry was being operated as a vertically integrated monopoly. The reason is that one and the same company had to internalise the full consequences of all scheduling decisions and of priorities given at delays. The situation is drastically different in a deregulated railway industry with many different

[23] Based on D3 – Nilsson et.al. (2008)

operators. Different techniques are available for internalising congestion and scarcity using prices, but our focus has not been directed towards making recommendations for the choice of method. The essential argument is rather to establish that pricing the use of crowded railway lines would increase both efficiency – by providing priority to the most valuable services and by giving incentives to smarter ways to use existing capacity – and equity interpreted as cost efficiency.

9.3 Classical methods to recover cost are still useful

If the railway industry is required to increase its degree of cost recovery above marginal costs – including scarcity – the third proposition of this research is to use the acknowledged ways to do so. Over the years, economic theory has developed rules of thumb to raise revenue in a way which minimises any efficiency distortions. Ramsey pricing means that a mark-up could be made on marginal costs in order to generate revenue. The mark-up should then be higher on operators which have poor alternatives to rail, while operators which could readily switch to other modes should be charged a smaller mark-up. A complementary policy is to use a two-part tariff. Except for paying for the marginal cost, the operator would be required to pay a fee for having the right to run the services. This is particularly relevant in a system with competition *for* the market, while it is trickier to use in a system with competition *on* the market.

Several versions of these two techniques are available and a long range of experiences can be drawn on if an infrastructure operator would be required to charge more than marginal costs. It is, however, important to emphasise that while these mechanisms would contribute to the *minimisation of* disturbances, the disturbances would – except for in very special situations – not be eliminated. The manifested consequences would be seen in losses of ridership and freight volumes.

9.4 A club approach may be feasible

Except for this mainstream line of analysis, this part of the work has also considered an altogether different approach to organising infrastructure activities. The idea is thus to reflect on whether infrastructure users should be asked to establish a *club*. Club members would then decide on how much infrastructure to provide and how to charge for it. The research issue is if this decentralised approach to infrastructure provision would overcome the trade-off problem, i.e. if a club would both deliver an efficient total supply of roads, railways, ports and airports and to charge for its use in an efficient way.

A fourth proposition of this deliverable is that this would probably not be a good idea for the road sector as a whole. The reason is the messy decision structure of a “road club” with all road users as potential members. The prime benefit of the archetype club is to make it feasible for members to negotiate over the size and pricing of the network. The difference between meetings of the club’s elected representatives and the convention of a country’s parliament would be small. If a parliament has problems to establish an optimal trade-off, it is not reasonable to expect that it would be easier for a road club.

The corollary to this fourth proposition is that the club concept may have some relevance when it comes to the provision of ports, airports and railways. In particular, it is obvious that the number of potential members in these cases is more practical than in the road sector application. The club members as a collective could therefore take votes on the size of the club – the extent of the respective infrastructures – as well as the charges for using it. Non-members could readily be excluded and might even be offered to use the facilities on a limited scale at negotiated prices.

The prime challenge of the club solution lies in its incentives to protect the monopoly position it may have. Even though there might be capacity available to accept entrants, this could increase the competitive pressure, which would benefit society at large but would not sit well with the incumbent club members. Clubs may therefore stifle competition and also in other ways hamper efficiency in infrastructure supply.

There may be ways to reduce the risk that clubs have these negative consequences. The government could, for instance, establish framework rules for when and how a club should be obliged to accept new members. Since there are no free lunches, it should also be acknowledged that some degree of inefficiency may be acceptable if the club has balancing beneficial qualities.

9.5 Some insights possible from cooperative game theory

A fifth proposition of this work is that club theory in general, and cooperative game theory in particular, may offer some insights into the organisation of clubs for providing specific packages of infrastructure services. Two possible applications are the Eurovignette directive and Sweden's private Road Associations. Both applications describe situations which may be interpreted as clubs.

The basic idea is the following: There are situations where it is obvious that two or more countries would both/all benefit from cooperating, i.e. that it would be feasible to improve welfare by cooperating in a club. It is, however, less obvious how the benefits from cooperation should be split between the parties. The inability to agree on how to split the gains may altogether block the deal.

However, by using what is known as cooperative game theory applied to a club, it is feasible to suggest simple rules for sharing the gains. By agreeing on rules and principles that have a general appeal before calculating precise numbers, it may be easier to implement mutually beneficial deals.

Several specific examples of such rules have been analysed. It is at the same time only the first attempt to apply club theory on analysing these situations, and more research is required to provide more precise conclusions.

9.6 Summary

To summarise, the efficient provision and use of transport infrastructure provides huge policy challenges. The present part of the CATRIN project has dealt with several of these issues but has also had to leave out others. For instance, we have described the need to make the treatment of greenhouse gases in the transport sector part of an official policy, but have not considered the appropriate way to do so and what that might mean for governments' tax revenue.

The focus has rather been on the risk for insufficient cost recovery if marginal cost pricing is used. The analysis pushes important tasks back to the political level. In particular, it must be a policy decision to establish *which financial target* should be set for the rail industry in beforehand. Once this target has been established, the report has, however, identified the principles for implementing a policy which minimises the distortions from prices above marginal costs.

The report also opens the door for further analysis of another approach to these issues. Rather than expecting the public sector to be fully responsible for providing infrastructure services, the possibility to establish clubs to do so has been addressed, as well as the use of cooperative game theory to overcome some of the obstacles for club members to cooperate. To be sure, these principles are no panacea, but they may offer insights which were previously not considered.

10 New Member states[24]

Although most so called New Member States (NMS) emerge from a situation under state controlled economies and move towards the market economy, the transport policy have developed differently in different NMS. It would be a mistake to treat all NMS as one entity following one path of development. Usually in their pursuit of integration with Europe they use rather different and country specific methods. However, some similarities can still be found and those have been identified and described in detail. The role of the government in post-socialist countries is reoriented from its former task of directly managing transport enterprises; to assuring that competition among private transport operators is fair, protecting the public interest in safety, the environment and social working conditions.

Why should any special consideration be given to NMS? Firstly, there are significant differences between those countries, but still some common problems (resulting from economic transformation and ex ante conditions) and needs for infrastructure modernisation exist. Secondly, cost calculation principles arise from different practices and the introduction of real pricing is thus handicapped in some way among all new members. Thirdly, an additional obstacle could be attributed to the fact that best practice and good knowledge is not the case of NMS (especially insufficiency of data and research surfaces most often while dealing with costs in those countries). Fourthly, impact assessments are seldom done within the region as there is no funding for this and a lack of significant background of complex studies. On the other hand, a number of solutions in regard to pricing which are introduced in NMS are most advanced and the group as a whole could be perceived as more ready to accept innovative solutions than EU-15. A mode specific analysis is given in sections 10.1 – 10.4 followed by recommendations in 10.5.

10.1 Road

The legal and institutional framework for changing pricing policy in the NMS road sector differs significantly between countries. In most NMS the decentralisation of the road sector is ongoing, but it is still a more centralised network than in the rest of Europe. In some NMS the main road network is managed by state agency, while in some other countries it is a public company, but an independent legal entity. Furthermore, secondary roads are often managed by local authorities, but several countries have formed special organisations to manage secondary roads. It can be summarised that in smaller states, the role of state roads remains important while larger states have reduced its administration to manage roads below 5 percent of the total network.

While looking at pricing reforms, it can be stressed that a new system of electronic fee collection for HGV's in the Czech Republic has already been implemented. In some other NMS, the reforms are to be implemented soon. In Slovenia, microwave technology has a long tradition in toll motorway system for passenger cars. The experiences of the Czech Republic and Slovenia as well as Slovak and Hungarian plans prove that in all the cases Western European solutions are (or are going to be) implemented and that the special emphasis is put on ensuring technical interoperability between segments of the network and vehicles.

10.2 Rail

The rail sector in the NMS can be generally characterised as heavily subsidised, heavily indebted state monopolies which are self-regulated and devoid of any highly structured

[24] Based on D4 – Bak et.al. (2008b) and D5 - Bak et.al. (2008a)

outside control mechanisms. It has not been encouraged to reach beyond its own national borders to face customer demands. According to the notifications sent by the NMS to the EC concerning the measures adopted to implement the EU rail *acquis*, all of states are on schedule regarding the alignment towards the European railway packages. All states have communicated to the Commission about implementation measures from the first package, even the two new member states that joined EU in 2007. It seems that NMS have reorganised the sector more thoroughly than the EU-15. In the NMS, regulatory bodies are in charge of setting charges compared to Ministry of Transport as the case often is in EU15. Estonia has tried bold privatisation, but has cancelled the process due to some disadvantageous effects.

With regard to the separation of infrastructure and transport services, one of the determinants of the reforming of railways, there are still models in Europe that vary quite significantly. The degree of separation extends from a purely accounting separation, through functional separtion to a complete ownership unbundling of infrastructure and transport.

Looking at the organisational aspects, it should be noted that the majority of countries have set up regulatory bodies only on paper, but many of those bodies do not have any far-reaching legal powers and no staff that deals exclusively with regulatory matters. Considering the organisational structure of rail infrastructure managers in NMS, some countries have rail transport holding companies, independent enterprises and in some cases entities responsible both for infrastructure administration and operation.

10.3 Aviation

As for the air sector in Central and Eastern Europe, passenger traffic is more concentrated to one particular international airport than in most of the states of Western Europe. When analysing the situation of the ten recently admitted countries and the former EU-15 states in terms of airport capacity and efficiency, clear differences and clear similarities can be shown. Differences arise mainly from the different historical backgrounds and similarities stem from the harmonisation of the legal and financial system in these countries with EU standards. In general differences are decreasing year by year, as the integration into Europe is wider and wider. The ten NMS countries are harmonising their standards with those in the EU-10 and they are trying to use the same capacity enhancement techniques. However, due to the significant differences of the past, finding common solutions to present and future problems is not always possible.

Capacity bottlenecks at major EU airports are mainly due to a shortage of runways, ATC, or en-route capacity, whereas in the CEE countries runway capacity usually exceeds terminal and apron capacity. The level of service might be upgraded at many airports. This is however under the assumption that local airports could attract more traffic currently going through the central airport. In addition, the introduction of low-cost carriers has resulted in separate process of significant development in air traffic in regional airports across CEE countries. Extension of services has in many cases been blocked by inadequate airport infrastructure. Even if the main problem is not the number of runways it is certainly their technical condition and length. Still, the most serious bottleneck is in terminal handling capacity. There are simply not enough land based facilities to serve an ever increasing number of passengers. Here, the post-socialist past reveals itself. The whole structure of the air industry has been organized around the central airport serving as the only one external link model, while regional airports were only connected to this central hub. During the past couple of years, those regional airports given free hand have developed significant number of connections, but in the same time they usually lacked resources for serious terminal upgrades, which have led to the current problems.

Institutional separation of the Civil Aviation Authority has been established in all ten NMS. Main differences exist in the setup of charges, different bodies being responsible in different countries and often subject to government control. In rare cases, where the free-market approach is allowed, there is an official cap above which charges cannot be set. This is partially due to government tendency to maintain control and partially because of lack of competition and fear of super-high monopolistic charges. The airport operators are in general financed by charges collected. The degree of self-financing depends strongly on the ownership structure of the airport. In the instances when airports are part of a larger group, the financing might be accounted for by the group as a whole rather than at the individual airport. There are also cases of airports that are still fully state-owned where financing from the state budget might occur, like shared military/civil airports where financial sources are mixed. It should be stressed that in all NMS the goal is a self-sufficient financing of airports based on appropriate charges.

10.4 Maritime

In the case of waterborne transport, most seaports are operated by a port authority, which leases land within the port to private enterprises that operate in the port under different rules. Sometimes the rules are subject to free market negotiations while in other cases the free market price is capped by government regulation. The degree of ownership rights in managing authority varies. In some countries, the government maintains a strong ownership and controls authority activities. In others while maintaining ownership leaves all managerial decisions to the authority. Finally there is a third model of full privatisation and real separation from the state. In countries where more than one port play significant role, ports act as competitors on a free market. Technical equipment in most of them is modern or has been recently modernised, but with increased traffic, capacity problems might occur. The process of setting up charges is also country specific, usually with mixed responsibilities. Some charges (e.g. pilotage) are established by appropriate ministries (transport or maritime affairs) while others are free to negotiate. In some instances all charges for vessel operators are capped by the national law, which dictates maximal level that could be levied. A price could be set at any point by port authorities, as long as it falls below the government set level. On operational level, the maritime sector of NMS could be characterised as a highly decentralized and competitive market. On the other hand, strong competition exists between major ports in some given areas, while smaller ports lack both capacity and investment capital to threaten main ports.

10.5 Recommendations

To formulate specific recommendations, an overview of each of NMS is necessary and also a comparison of opinions from practitioners and researchers in the countries in question. In order to accomplish this aim, a questionnaire has been prepared and distributed to contacts within NMS countries. The results show that there are no simple and universal answers to the pricing policy question within NMS. On the contrary, there are different solutions among NMS and these countries cannot in general be treated as one homogenous group. The charging schemes used are often unique and incomparable. While NMS are coping with deteriorated infrastructure compared to EU-15, there is a lot of acceptance for change and also a political and social will to catch up with western counterparts. There is also a high level of acceptance for advanced and innovative solutions.

In terms of infrastructure quality and best management practices, NMS are behind EU-15, but in other areas like data availability, cost calculation problems etc., they do not differ significantly from EU-15. Therefore some recommendations that might be drawn are specifically NMS-oriented, but many could also be applied to EU-15. In annex 1 we summaries our recommendations.

11 Infrastructure managers[25]

This chapter summarises the Infrastructure managers (IM) feedback concerning the possibility to implement the CATRIN recommendations. The background activities carried out by the CATRIN IMs in preparation of this chapter have been the following:

1. A **survey** among IMs, in which the CATRIN IMs have reviewed the current pricing principles and have expressed their positions concerning the adoption of such principles in the formulation and implementation of pricing policies.
2. **Interviews** with the IMs in order to discuss cost allocation methods in use, for which the review of current practices has led to the identification and discussion of the most relevant issues at stake, problems, uncertainties and achievements.
3. **Meetings** with IMs in which the CATRIN IMs have provided input to the case studies and discussed the possibility to implement the CATRIN recommendations, as emerged from the CATRIN case studies. The following sections summarise the main recommendations for each transport mode, highlighting how short and long-term implications for their implementation can be derived.

11.1 Rail

The CATRIN rail IMs meetings have been mainly devoted a) to review the current state of the art and to contribute to understanding the issues to be addressed in the rail work package (first meeting) and b) to discuss about the conclusions of the CATRIN rail case studies and implementation issues (second meeting). In the second meeting the discussion focussed on the following five issues, which represent the basis upon which short and long term recommendations can be formulated:

1. the relevance of marginal cost measurement for the IM activity
2. the accuracy of the CATRIN results
3. the possible use of the CATRIN recommendations
4. the differentiation by type of rolling stock
5. the issue of capacity charges

Concerning the **relevance of marginal cost measurement**, it was agreed that the measurement of short run marginal cost provided important information for the infrastructure manager. Short run marginal cost can in fact be considered as the floor below which infrastructure charges should not be set, although they may have to be considerably higher on average unless the government provides sufficient funding to cover all fixed costs. It is therefore more important to obtain accurate measures of marginal cost in those locations and sectors where prices are close to marginal costs than where they were well above them. From the point of view of future planning, long run marginal cost are also very important, according to IM.

The following hypothesis appears to be the corollary of what the discussion in CATRIN has stressed, given that they do not neglect the issue of overall full cost coverage:

- Annual State Funding (maintenance) = [Full costs (maintenance)] – [Costs of maintenance * maintenance elasticity factor] - [aggregated additional mark up + scarcity + reservation charges]
- Annual State Funding (renewal) = Full annualised costs (of projected renewal programme to meet future traffic demand plus any backlog) * (1- renewals elasticity factors)

[25] Based on D11 – Enei et.al (2009)

- The balance of non state-funded costs is collected through track access charging, using marginal costing, with appropriate mark-ups, scarcity and reservation charges.

Concerning the **accuracy of the CATRIN results**, it was commented that, although the best information available, the CATRIN results remained affected by considerable uncertainty. This is particularly true of renewals costs, where little evidence is available. Whilst it is not possible to provide formal confidence intervals, the uncertainty surrounding the relevant elasticity should therefore always be emphasised.

Concerning the **CATRIN recommendations**, it was recognised that these provide a suitable methodology for estimating short run marginal costs where data are not available for an in depth study, and that, being based on good data and state of the art methodology, adopting the recommended methodology is to be preferred to relying on a superficial study. However, where a good ad hoc study is undertaken its results are likely to be more accurate than transferring those of CATRIN.

Concerning the **insights from the engineering models**, it was agreed that the engineering approach provides the possibility of differentiating charges in great detail by type of rolling stock. Only Britain however currently does this. It was seen as important to give train operators appropriate incentives regarding the type of rolling stock they used, although the franchising system in Britain actually offers passenger operators limited choice, so that the existing charges may be unnecessarily complex. Some countries do not even differentiate charges between trains according to gross tonne kilometres, which is the obvious first step.

Concerning **charging for scarcity**, the discussions stressed the fact that most countries do not currently charge for capacity; for instance in the Netherlands capacity is allocated according to the relative social benefits of alternative uses and pricing plays no part in this process. However, the high reservation charges on congested routes in France, both in the Ile de France and on high speed routes such as Paris – Lyon, may be seen as a sort of capacity charge somewhat in line with the CATRIN recommendations.

Furthermore, it has been noted that the opening up of the market does not only require non discriminatory access to tracks, but also to other facilities such as freight terminals, marshalling yards and maintenance depots. Charges for such services also need further examination.

In the light of the feedback received from IMs, the CATRIN outcomes can be usefully applied, both in a short and a longer term perspective. In the short term:

- To adopt shortcut instruments (transfer of values) for the assessment of marginal wear and tear infrastructure costs (if country-based studies are not available)
- To reconcile short-run marginal costs assessments with the issue of the overall full cost coverage, including State funding
- To provide information on the differentiation of charging by route and by type of vehicle, so as to offer train operators appropriate incentives in relation to the type of rolling stock used

In the longer term, it appears that:

- Further support and enhancement of the CATRIN recommendations about how to generalize the findings should be pursued, notably through the comparison with specific rail cost allocation studies for different countries.

- The EC should not force more differentiated charges, leaving it to the infrastructure managers. The industry in fact supports research, dissemination but not imposition of yet more rules on how to calculate infrastructure charges.

11.2 Road

The CATRIN road IMs have discussed the implications arising from the case studies recommendations, basically focussing on the following two issues:

1. The CATRIN research has proved the differentiation of wear and tear road infrastructure costs by vehicle type to be difficult, due to strong dependencies between passenger car and heavy goods vehicle volumes
2. Data collection is a general problem in the road sector, and considerable resources and efforts are required to fill the existing data gaps.

Concerning **cost allocation studies**, the CATRIN IMs, have shed light on methods and procedures for assessing the avoidable costs on pavement structure, where avoidable costs are intended to be the costs individually attributable to specific vehicles (HGV and light cars). The method takes account of engineering approaches to calculate the pavement fatigue allocated to different vehicle types.

It has been noted and discussed that the literature about pavement costs allocation as reviewed in the SETRA paper[26] has introduced the indicator of the impact of an HGV on pavement design. In the French case, the concept of HGV aggressiveness has been used, and its implications simulated with specific software accounting for each HGV technical characteristic, e.g. weight and axles. The concept of aggressiveness is in fact a relative measure of the fatigue caused on the pavement by an HGV passing on it and should be considered as more precise than the axle load alone due to the fact that it takes directly into account the axle configuration. This indicator has been used to define three different HGV classes characterized by an increasing aggressiveness.

The French IM contribution confirms that there is still no single solution to allocate road infrastructure costs and those different methods can in fact be developed along this perspective. Sensitivity to specific, national based costs structures is high and can influence the final results. On the other hand, the results of the French case are promising, to the extent that they are in line with the Eurovignette Directive 2006/38 overarching philosophy, i.e. to allocate costs to the vehicles responsible for their generation.

The sensitiveness of the infrastructure road charging to the proper evaluation of pavement damage, in the first place, confirms the **relevance of the EURODEX (EUuropean ROad Damage EXperiment) objectives** as stressed by the CATRIN research, to the extent that they aim at consolidating a reliable and improved basis for a sustainable and fair transport pricing on European roads.

In particular, the Swedish Road Infrastructure manager has stressed the importance for the road administrations in Europe to benefit form cooperation, which would provide cheaper and more efficient research insights if they could join research efforts through a dedicated call on this issue.

[26] P.Cousin " Applying the Eurovignette Directive for Infrastructure cost allocation in France" SETRA

Concerning **data availability**, the research carried out in CATRIN has emphasized the following issues:

- Marginal cost estimations may need complete, disaggregated, road section data in some case on several years basis. But data are often scarce, incomplete and even inaccessible.
- The trend towards privatization and outsourcing for large road sections to save maintenance costs may lead the IMs (regulators) to lose control over maintenance data on selected small road sections. In addition, data collected by private operators may be regarded as confidential, and become de facto unavailable for public research.
- As for traffic data counting, the need to have frequent traffic counting for refining the analysis may impose additional data collection costs upon the IM. What can be suggested to overcome this? Can new technologies help in collecting traffic count data at lower costs ?

The feedback received from the IM contributes to addressing the above challenges.

The issue of data collection in a form suitable to be usable within the marginal costs approach may be hampered by institutional settings. For example in Switzerland, it was noted that roads are built either by the confederation, the cantons or by the communities. This may be accompanied by different data collection formats, calling for time and resource consuming post processing.

Furthermore, and more importantly, data collection at all levels is not focussing on marginal costs, but on full costs. This implies that necessary information for marginal cost estimates may be missed and often lost in aggregation.

The issue of privatization and its impacts on data collection deserves attention. It has in fact been acknowledged that privatization, once implemented and permitted by national legislations, might make data collection more difficult.

Concerning the costs for data collection, e.g. traffic counting, it has been agreed that they are, at least in comparison to the other costs for building, maintaining and operating the roads, rather limited. However, the fact that ad hoc infrastructure is required is hindering the increase in the number of traffic counters that would be required/beneficial from the point of view of traffic and infrastructure managers. Things might be different when all vehicles are equipped with tags, but this will certainly not happen in the near future.

Ultimately, recommendations based on the short- and long term implications arising from the discussion with the road IMs can be summarised as follows.

In the short term:

- To further develop cost allocation studies, taking stock of the international approaches and methods, and assuming the EC Eurovignette Directive 2006/38 as reference, i.e. comparing the new estimations with the equivalence factors indicated by the Directive. The most important factors requiring further analysis are the impacts of vehicles on the pavement structures.

In the long term:

- To develop the potentialities of new technologies for improving data collection, e.g. on-board vehicle equipments

- To take account of the potential problems in data collection arising from the growing trend toward privatization and private public partnerships (PPP), e.g. through ad hoc contractual obligations in concessions agreements and incentives for data collection

11.3 Air

The CATRIN air IMs focussed the discussion raised by the cost allocation case study in the air sector basically on two issues:

1. scale economy in airports: under which conditions and can thresholds be identified?
2. relationships between aviation costs and commercial activities

The CATRIN research has shown that there are important **economies of scale** in airport operations, and, thus, that the current trend of capacity expansion programs observed in major hubs can be justified. Within the current technological frontier, it has been said, the world's leading airports will continue to benefit from scale economies in the provision of infrastructure for air transportation and commercial activities until they reach between two or three times their current scales.

The Irish CATRIN air IM in the Dublin Airport has pointed out that the existence of scale economies crucially depends on the elasticity assumptions. In fact, in order to assess the existence of scale economies in airport operations it is important to separate out scale effects from genuine efficiency effects.

The regulator, the Dublin Airport Authority, acknowledged that in broad terms there are some opportunities within the airport sector for reaping the benefits of economies of scale given that there is less than full correlation between operating expenditure and passenger volumes. Economies of scale in fact will be determined largely by the fact that a certain portion of the Airport's operating cost base is fixed in the short term and therefore other things being equal the average fixed cost element of operating expenditure falls over a higher passenger base. However in order for an airport to capture the benefits of scale economies it is essential that there is adequate spare capacity in the critical areas such as terminal, runway and airfield. When an airport experiences capacity shortages in its key infrastructural areas this will put upward pressure on operating costs as expenditure is incurred in dealing with congestion and its associated costs, reducing the opportunities for scale economies and in fact potentially leading to diseconomies of scale.

In the case of Dublin Airport over the period 2002-2007 annual passenger growth reached unprecedented levels and there were recognised severe shortages in terminal capacity. It has been demonstrated that Dublin Airport incurred additional expenditure in dealing with congestion and additional terminal costs but this was combined with certain cost benefits arising from the scale effects of spreading fixed costs over a larger passenger base plus the achievement of certain cost efficiencies. This combination of factors must be taken account in assessing the likely contributing factors to the opex/passenger gains over this period.

Concerning the **relationships between aviation costs and commercial activities**, the CATRIN research found that economies of scale are highly dependent on the cost complementarities between aviation and commercial activities. In particular, it was noted hat some airports may, in the near future, encounter decreasing returns to scale when considering only the aviation sector. In spite of that, these airports could still enjoy scale economies if they were in charge of the development of commercial activities.

The CATRIN IMs (the Irish and the Swedish members) warned that the consideration of the actual elasticity between passenger growth and commercial revenues must be carefully scrutinized. In forecasting commercial revenues the regulator of the Dublin Airport has made an assumption about the relationship between changes in passenger volumes growth and commercial revenue growth, i.e. the elasticity of commercial revenues. The weighted average elasticity across all commercial revenue categories used by the regulator in 2005 was approximately 1.0, implying a one for one relationship between passenger growth and commercial revenue growth.

If the elasticity assumed by the regulator was correct, then scale effects alone should have resulted in no change on a per passenger basis in commercial revenues. This implies that the 62% increase in passenger numbers should have been roughly matched by a 62% increase in commercial revenues. However, the Dublin Airport witnessed a 21% decrease in commercial revenues on a per passenger basis, as an effect of declining performance over time.

Hence, the CATRIN air IMs stressed the fact that the relationships between passenger growth and operating costs as well as commercial revenues must be carefully scrutinized and that the conclusions of the case study in terms of future scale economies from air transportation and commercial activities must be accompanied by explicit caveats.

Furthermore, the CATRIN research found that airport charges are always closer to the estimates of the long-run approach rather than to those of the short-run approach.

The short term recommendation arising from the IMs contribution to the debate is to develop the analysis of elasticity between aviations costs and cost drivers, e.g. passenger growth, in order to provide an assessment of any scale effects when analysing the airport operating expenditures performance.

11.4 Maritime

The CATRIN maritime case study has analysed the specific topic of icebreaking allocation costs. Icebreaking in open water is not charged for by any EU Member State. Still the case study has shown that the operation is characterised by considerable marginal costs. Marginal costs for ice-breaking as represented by the variable costs in the cost model used in the case study, are estimated at some € 30 million per year in the Baltic, in presence of cooperation model, in which costs can be properly allocated between the contracting parties. given cooperation. Scarcity costs should be added to that and, arguably, emission costs as well.

It has been noted that current charging regimes are theoretically non optimal. The charging scheme is in fact not guided by efficiency, but by regional equity considerations.

The CATRIN waterborne IMs (the Finnish member) found the report making a strong case for transnational co-operation in icebreaking in the Baltic Sea area. A good model and strong proof of the importance and value added of co-operation in icebreaking is the already existing co-operation between Sweden and Finland.

It was further concluded that important preconditions should be met in the pursuance of a joint icebreaker fleet:

- All member nations should follow the HELCOM recommendation 25/7 “Safety of winter navigation in the Baltic Sea Area” in their traffic restriction policy. Different levels would in fact lead to imbalance in icebreaker assistance.
- All member nations should have access to IB-net, the real time data system of icebreaker, on their vessels.
- The efficiency of the icebreaker is depending to a large extent on the skill of commanding officers in charge of the icebreaker. Under-skilled officers entail longer assisting times of the icebreakers themselves, thus increasing fuel consumption and waiting times for merchant vessels.

Another important aspect of the case study is the relationship between icebreaking services and the TEN-T network. The common European interest in winter navigation has been acknowledged by that the inclusion of icebreaking in the TEN-T future guidelines, while Member States have received EU TEN-T funds for icebreaking purposes. However, the Finnish IM remarked that icebreaking is already included in the current TEN-T guidelines. In fact, Finland has received EU TEN-T funds in the end of the 1990’s. It is important that icebreaking continues to be regarded as a part of the TEN-T (i.e. important infrastructure) also under the new forthcoming guidelines. Also the rules for applying EU funding for icebreaking should be clarified in the new guidelines.

In terms of recommendations, the short term perspective for the development of efficient cost allocation practices is to specify the marginal costs for different users: Should the bulk of the variable costs be allocated to the first vessel in a convoy? How should costs for moving an icebreaker from one mission to another be split? What vessel causes delay for the others?

In the long term view, it could be argued that a club approach is worth considering for the case of ice-breaking. In fact, when it comes to icebreaking the most prominent efficiency gains may be to develop the forms for international co-operation, rather than aiming at efficient charging schemes that are unlikely to meet political acceptance.

In general, it should be stressed that the current system of charging is not transparent, because there is no direct relation between the level of charges imposed on a certain inland waterways and maritime infrastructure and the level of investments in infrastructure for these market segments. Furthermore, given that the rates are determined by local port authorities, the level of these rates differs significantly across ports.

PART IV

Conclusions and Recommendations

12 Conclusions and Recommendations

12.1 Infrastructure services will have problems on the market

Provision of infrastructure services has a number of technological characteristics that results in market failures, i.e. it is not reasonable to believe that the market in free competition between firms will supply the service in an efficient way. These characteristics are well known but are worth to repeat.

Infrastructure services exhibits usually such large economies of scale meaning that one supplier will be able to supply the whole market. It is difficult to imagine two parallel roads supplied by different firms competing for their customers. This characteristic, *natural monopoly*, also means that the average cost (per user) will fall as more users enter - to a certain level. Under the first demand phase (when average cost is falling) the marginal cost imposed by an additional user is lower than the average cost. Consequently, under this demand phase of producing infrastructure services the revenue from efficient charges will not recover the cost. However, under peak demand, efficient pricing would be able to generate additional revenue as congestion charging or scarcity pricing is introduced. Under this second demand phase (when average cost is rising) marginal cost based charges will thus more than recover the infrastructure cost.

In the absence of this peak load pricing it is easy to imagine that the capacity of (unpriced) infrastructure service is higher than necessary giving rise to a bigger problem of cost recovery than necessary.

Uncongested infrastructure should have a low price. This is a part of the non-rivalry characteristics of infrastructure as a *public good*. However, the other characteristics of a public good – non-excludability – is rapidly disappearing also in the road sector with the technological development. Owners of airports, ports and railways have always had the opportunity to exclude users that do not pay from using their infrastructure. Road owners have had a much tougher situation where the excludability has only been able to handle with expensive toll booths. This is rapidly changing with new payment systems.

A third market failure is the existence of *externalities*. All traffic generates negative externalities in form of accident risk, air pollution and green house gases. Also the congestion is a form of negative externality. It is well known that an efficient way of dealing with these externalities is through (Pigouvian) taxation.

- So, when limit the view to only infrastructure cost it is clear that most infrastructure services should be charged very low and will face a problem of cost recovery.
- Adding congestion and scarcity pricing will enhance the efficient use of the infrastructure. In addition, it will reduce the need for expanding the capacity of infrastructure - in all modes of transport.
- Finally, adding taxation of negative externalities will generate additional revenues solving the cost recovery issue for most of the modes leaving railways as the mode that for efficiency reasons should be financed by society in other ways.

12.2 Organisation of infrastructure services

A market economy is believed to make use of a society's scarce resources in an efficient way. Important preconditions for the overall belief in the marvel of markets are, however, violated in the transport sector, requiring the government sector to intervene in one way or another. This is indeed obvious from the extensive involvement of governments in the provision of road, rail, port and airport infrastructure.

In road and rail transport the regulation of charges has a mixed aim limiting the possibility to abuse monopoly power and to restrict tax competition. The HGV charges are, for example, limited to only (maximum) average infrastructure cost. The acceptance of any externality charges also comes with an upper limit which varies in form while the fuel excise duty is limited from below.

Our research has shown that the average infrastructure cost is far above the short-run marginal infrastructure cost in these sectors. Below we propose a method to generalise the CATRIN results on short-run marginal infrastructure cost which can be applied Europe wide. We presuppose that other externalities are included in other part of the charge and discuss solely the infrastructure cost part.

In addition to this, we note that it is scope for more time-depended charges in both road and rail infrastructure charges in Europe. Such charges will both generate revenues and move towards cost recovery in both sectors and reduce the excess demand for infrastructure services. This is not least important in the railway sector.

Airports are usually seen as single entities with a cost recovery objective. The regulation can be encoded as a single-till where both aeronautic and commercial revenues are included when setting the level of charges, or in a dual-till approach where the streams of revenues are separated and the aeronautical charges are required to recover the aeronautical costs.

The Maritime sector outside ports exhibits all classical examples of natural monopolies. We show that Icebreaking services exhibits substantial economies of scale making it possible for cooperation between Member States around the Baltic Sea to reduce the need for icebreakers.

12.3 Rail and road marginal cost estimates

Our research has clearly demonstrated that marginal costs differ considerably by traffic density and infrastructure quality in both modes. We are more certain about our results in the rail sector than in the road sector. We believe that our results support charging different routes within a countries, each with different traffic density and infrastructure quality characteristics, different marginal costs. We propose below the "CATRIN generalisation rule" which will allow estimates to be transferred across Europe.

12.3.1 "CATRIN generalisation rule"[27]

The CATRIN method of rail and road infrastructure marginal cost generalisation is based on the observation that usage elasticity is reasonable stable while the average cost varies between infrastructure type and Member States. The CATRIN method is based on the definition:

Marginal cost = Average cost x Usage elasticity

[27] This was first developed in the Rail Work Package reported in D8 – Wheat et.al. (2008).

Based on this relationship the method proposes the following steps to be undertaken.

I. A member State should be able to estimate the average infrastructure cost for renewal, maintenance (and operation) on its infrastructure network or a relevant part thereof.
II. The definition of included cost elements has to be in line with the CATRIN definitions and consistent with our elasticity[28].
III. The average cost estimated for the whole network or a relevant part should be multiplied with the "CATRIN 2009 usage elasticities" (see below).
IV. While the general knowledge suggest that this average marginal cost should be differentiated according to vehicle type our result are less conclusive.
    a. For the road sector the common practice is to use the so called 4th power rule. Our research concludes that this is only applicable under some very specific circumstances. In all other cases it can be everything from the "power" 1.7 to the power 10. This should be bourn in mind when differentiate the estimates and taken into account when approximating differentiated charges for vehicles on different road types.
    b. We therefore propose a European research project – EURODEX – to bridge the gap of knowledge around this vehicle differentiation which is further discussed below.
    c. Our research has not been able to find a firm conclusion on the differentiation in the railway sector either. We have seen that our engineering approach is working but may be time consuming for a generalised approach. As in the road sector further research should be geared towards bridging this gap of knowledge for policy use.

12.3.2 "CATRIN 2009 usage elasticity"

From our case studies and the general literature we suggest the elasticities in the table below to be applied on the country specific average cost to estimate the marginal infrastructure cost. We have more confidence in our results for rail than for road and for maintenance than for the other cost components. We have labelled our result "CATRIN 2009 usage elasticities" to highlight the fact that these estimates can be further improved. It is also clear that these estimates should be overruled by results from better studies.

Table 12: CATRIN 2009 usage elasticities

Mode	Renewal	Maintenance	Operation
Rail	0.35	0.2;0.3;0.45	-
Road	0.58 – 0.87	0.3 – 0.5	-

Note: the maintenance usage elasticity for rail is given in interval for low, medium and high traffic density

12.3.3 New study proposed - EURODEX

The knowledge about differentiation on vehicle types on roads is limited although often implemented in practice. CATRIN recommend a research that join current European research project together in a single structure to get benefit from all research in Europe in the area.

- As a first step it will be necessary to build up a European database for test results to find out where we stand in research. Therefore data and results from as many previous tests

[28] In particular for railway maintenance only cost average cost should include: permanent way costs; signalling and telecoms costs and electrification and plant costs. Network wide overheads should be excluded. However we recommend that the average cost for maintenance and renewal includes all the elements of maintenance cost described above and also includes as many elements of renewal costs except for network wide overheads.

as possible have to be collected, stored and analysed. From this evaluation we will find out what we already know and where gaps of knowledge are located.

- Also there should be a future obligation for facilities funded by the EU to provide data according to the standard of the database. The database should be accessible to as many research teams as possible to spread the idea and make it a lively knowledge pool rather than a fenced-in ivory tower. Databases are a pure public good.
- To make sure that data and results from future test carried out for EURODEX or other national and international projects can be used for a European analysis, common guidelines for these tests have to be created. This can be done.

If these preliminary steps are taken, we can make sure that EURODEX – with a co-operation of as many European facilities as possible – will be successful and provide consistent data for further (economic) research. These first actions will provide a clear vision of the existing knowledge as well as of knowledge gaps and we can make sure that future tests will provide data that can be used on a European level. Based on that the strategic planning of EURODEX can start: we can isolate major factors on pavement performance and deterioration for different kinds of road structure designs (flexible, semi-rigid, rigid) and decide about the most important road structure and designs to concentrate on which will ensure a cost effective project.

12.3.4 Data collection needs to be improved

CATRIN has have been struggling with collection of data. It is extremely difficult, especially in the road sector, to find data of high quality on a level that makes it possible to make good analyses. We have not in the project examined why the incentives in this sector is such that dataset for long term monitoring and auditing is non-existing in most Member States. For more reliable results road authorities have to be instructed to collect data for research as well as for auditing and benchmarking.

12.4 Cost recovery

The efficient provision and use of transport infrastructure provides huge policy challenges. The CATRIN project has dealt with several of these issues but has also had to leave out others. For instance, we have described the need to make the treatment of greenhouse gases in the transport sector part of an official policy, but have not considered the appropriate way to do so and what that might mean for governments' tax revenue.

The focus has been on the risk for insufficient cost recovery if marginal cost pricing is used and has concluded that the problem is currently a rail infrastructure problem. The analysis pushes important tasks back to the political level. In particular, it must be a policy decision to establish *which financial target* should be set for the rail industry in beforehand. Once this target has been established, the project has, however, identified the principles for implementing a policy which minimises the distortions from prices above marginal costs.

CATRIN also opens the door for further analysis of another approach to these issues. Rather than expecting the public sector to be fully responsible for providing infrastructure services, the possibility to establish clubs to do so has been addressed, as well as the use of cooperative game theory to overcome some of the obstacles for club members to cooperate. To be sure, these principles are no panacea, but they may offer insights which were previously not considered.

12.5 Airports

Airports are seen as single entities owned by public or private organisations required to cover their own cost. The regulation is thus geared towards cost recovery of the whole airport. We have seen that airports exhibit large economies of scale. The most interesting conclusion to draw from this result is that, within the current technological frontier, the world's leading airports will continue to benefit from scale economies in the provision of infrastructure for air transportation and commercial activities until they reach between two or three times their current scales.

Economies of scale were found to be highly dependent on the cost complementarities between aviation and commercial activities. If only aeronautical infrastructure is considered the optimal size of an airport is smaller than if commercial activities are included. It is therefore possible that some airports in the near future will encounter decreasing returns to scale when considering only the aviation sector driven by the economies of scale in the commercial area. This result is of a vital importance regarding the type of regulation: single-till vs. dual-till.

The choice between single-till and dual-till is one of the most debated issues amongst airports and airlines. It is now widely accepted that the single-till mechanism, whereby the entire airport's revenues are taken into account when setting charges, is a disincentive to maximising non-aeronautical revenues (or at least dilutes the airport's incentive to minimise non-aeronautical costs).

- As a consequence, some important allocative inefficiencies appear for very congested airports, because the low aeronautical charges artificially exacerbate the scarcity costs of slots, creating the appearance of a lack of capacity. Furthermore, it distorts investment decisions, because the existence of cross-subsidies makes it difficult to estimate the "true" returns on the aeronautical assets.

The alternative mechanism to regulate prices in airports is the dual-till approach in which commercial revenues are not factored into the charges equation, resulting in higher, un-subsidized, prices for airlines.

- This method may be more consistent with the user-pays principle, under which prices should exactly reflect the marginal cost of using the facilities. Thus, commercial activities cannot be used to cross-subsidise aeronautical activities and the allocation of costs is more concordant with the user-pays principle.

The recommendations of international organizations regarding airport cost coverage include the application of average costs as the basic price. It has been attempted to establish a uniform fare structure for the whole industry - dividing incurred costs by the number of processed traffic units provides a unitary tariff. Given that all users pay the same amount for the utilization of the same services, most airlines support this mechanism as objective and fair.

- However, the reality is that different operators impose different costs, and therefore should face different charges. For example, an airline that operates during peak periods imposes a cost (capacity cost) that is higher than others who operate during off-peak periods. There is a need to find a way to incorporate this and other industry particularities into the actual fare system within the context of regulation.
- Recent trial experiments in the US Airports have developed market based slot allocation as a way to solve scarcity problems. If primary auctioning of slots happens, then secondary trades can take place and the system could go towards an increasing transparency.

12.6 Cooperation in Icebreaking

We have examined the need for icebreaking in the Baltic Sea and compared the need for ships under a cooperative regime and under a non-cooperative regime. When the needs for icebreakers for the different parts of the Baltic Sea are summarized it is concluded that the existing fleet is more or less sufficient under cooperation to keep up with the traffic even during a severe winter. In the non-cooperation alternative, on the other hand, there is a considerable lack of capacity. All in all, twelve additional icebreakers are needed. CATRIN thus concluded that cooperation in Icebreaking is of large economic benefit for the European Union and that we should go further to facilitating such a process of co-operation.

12.7 New Member States

Although most so called New Member States (NMS) emerge from a situation under state controlled economies towards, in some cases, regional independences and a move towards the market economy the transport policy have developed differently in the NMS. It would be a mistake to treat all NMS as one entity following one path of development. Usually in their pursuit of integration with Europe they use rather different and country specific methods. However, some similarities can still be found – those has been identified and described in detail. The role of the Government in post-socialist countries is reoriented from its former task of directly managing transport enterprises; to assuring that competition among private transport operators is fair, protecting the public interest in safety, the environment and social working conditions.

To formulate specific recommendations, an overview of each of NMS is necessary and also a comparison of opinions from practitioners and researchers in the countries in question. In order to accomplish this aim, a questionnaire has been prepared and distributed to contacts within NMS countries. The results show that there are no simple and universal answers to the pricing policy question within NMS. On the contrary, there are different solutions among NMS and these countries cannot in general be treated as one homogenous group. The charging schemes used are often unique and incomparable.

- While NMS are coping with deteriorated infrastructure compared to EU-15, there is a lot of acceptance for change and also a political and social will to catch up with western counterparts. There is also a high level of acceptance for advanced and innovative solutions

12.8 Infrastructure managers

We have interviewed and discussed the project and its result with infrastructure managers in all modes of transport. The managers support the use of the “CATRIN generalisation rule” in road and rail transport and the estimated usage elasticities although they highlight the uncertainty (especially regarding renewal) and that where and when better studies exist they should overrule the CATRIN result. The usefulness of more engineering studies for differentiation by vehicle type is also encouraged by infrastructure managers. Also in the aviation sector the uncertainty of the result was highlighted. Regarding icebreaking the infrastructure managers supported the cooperative approach taken in CATRIN.

In the rail sector the infrastructure managers highlights the need for transparency and knowledge on facilities also outside the track, such as freight terminals, marshalling yards etc when the market is opened. In the road sector, where data collection is an important issue, it was highlighted that institutional settings (national, regional, local) was a problem in collecting data. Data is not designed for marginal cost studies and is expensive to collect. In the long run new technology may improve the situation but on the other hand the privatization of infrastructure managers deserves attention.

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14 Annex 1 – NMS recommendation

14.1.1 Legal and institutional context

Road transport

- to continue the process of decentralisation of the road network from the fully centrally planned administration towards more independent institutions,
- to ensure capability for efficient and coordinated decision-making processes within road infrastructure management, and better division of tasks and responsibilities,
- to improve administrative capacity on the local road network management level,
- to take advantage of 'best practices' in neighbouring countries,
- to assess institutional reforms in road transport management systems in new member states in a special transformation context showing barriers, successes and defeats,
- to improve reporting systems and databases for road traffic, network characteristics and expenditures,
- to improve cost calculation methods,
- to conduct studies on cost calculations and allocation using both engineering and econometric methods,
- to explore all potential solutions for revenue use in specific conditions of post-socialist economies and financial shortages for transport infrastructure investments.

Rail transport

- to continue implementation of the rail packages directives,
- to go on with the process of full institutional separation of infrastructure and transport services,
- to improve and standardise methods of cost calculations,
- to include external cost in charges for infrastructure use,
- to continue debt restructuring of state owned railway enterprises in face of continuous concerns about the growing debt of state railways in NMS,
- to generate a transparent charging system for the use of and to improve access to service facilities and stations,
- to separate safety certification from accident investigation,
- to undertake work on national procedures for licensing and safety certification due to them sometimes being non-transparent, arbitrary, too complex, lengthy and expensive.
- to improve the basis of market access to the passenger market by reducing the time and costs for external railway undertakings to acquire licenses when applying for train paths as well as during operation,
- to make a clear division of responsibilities and regulatory powers between different actors in railway sector.

Air transport

- to fully accept and introduce Eurocontrol solutions,
- to improve cost data collection and set standards for cost categories used,
- to introduce competition for ground services providers in airports,
- to improve administrative capacity in regard to CAA tasks in safety and security,
- to establish clear rules of control over navigation service provider,
- to move responsibility for navigation services provision from military to civil service providers,
- to make clear division of responsibilities and regulatory powers between CAA and MoT,

- to create transparent rules on capping charges or in cases with good and efficient competition, contemplate withdrawal from regulating charges.

Waterborne transport

- to allow more than one service provider in port or if not possible due to port size, promote occasional tenders for the role of "sole provider",
- to work toward introduction of comparable charges in ports,
- to separate investments in ports from investments on en-route waterways,
- to separate infrastructure and superstructure investments,
- to continue with set-up of independent port authorities,
- to reform the role of port authorities as owners of ground leasing it to companies operating in ports instead of performing all port functions by themselves,
- to continue privatisation of smaller ports as important competitors in local traffic and small scale shipping,
- to work toward introduction of more differentiated tariffs.

14.1.2 Technology context

Road transport

- to support research on technical solutions for ensuring interoperability on the base of specific national determinants,
- to take advantage of 'best practices' of the neighbouring countries, especially experiences of the Czech Republic for the implementation of electronic fee collection system,
- to prepare feasibility studies for electronic fee collection,
- to discuss and disseminate results of the studies and policy programmes.

Rail transport

- to support research on technical solutions for ensuring interoperability on the base of specific national determinants,
- to take advantage of 'best practices' of the most advanced in rail market liberalisation countries,
- to support rolling stock renewal, track rehabilitation, and modernisation of signalling systems to improve safety, eliminate speed restrictions and thus increase competitiveness.

Air transport

- to increase capacity of terminal and apron operations,
- to reduce dependence on only one central airport in international connections,
- to develop the role of regional airports,
- to develop new airports in capital areas,
- to analyse possibilities for automation of terminal services.

Waterborne transport

- to increase terminal capacity, especially container terminal capacities, to increase competition within a port,
- to improve land links with ports,
- to continue integration of maritime and inland water services where possible.

14.1.3 Acceptability context

Road transport

- to disseminate results of external international studies and research projects analysing pricing reform and acceptability determinants,
- to support domestic studies and case studies on impact analysis of pricing reform in road transport,
- to favour public consultations,
- to ensure that tariffs and allocation of revenues are in line with policy goals and public expectations.

Rail transport

- to overcome information barriers regarding access regimes, train path allocation, licensing, safety certification and homologation),
- to overcome language barriers for railway staff who have to communicate for train movements and other safety purposes.

Air transport

- to conduct national level studies oriented at airport charging,
- to prepare educational and consultation activities with air operators and passengers,
- to facilitate discussions on a charging reform within the air sector as it is reportedly not a major interest of stakeholders currently.

Waterborne transport

- to support domestic studies on pricing options in ports,
- to prepare public consultations with all stakeholders as to the rules regarding charging for port access,
- to create better communication between ports, shippers and other users since the sector is particularly fragmented.