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Funding Infrastructure: Guidelines for Europe - FUNDING

Deliverable 1

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EXECUTIVE SUMMARY

Objectives of FUNDING
The main objective of the FUNDING project is to develop a scientifically sound approach to the funding of large transport infrastructure investments in the European Union (EU). Two different avenues are explored for the funding of these investments. The first is the creation of an EU transport infrastructure fund financed by mark-ups on transport activities. The second is the use of mark-ups on the prices charged by the infrastructure suppliers for the use of the infrastructure. The overall structure of the research project is outlined in Figure 1.

Figure 1 Overall structure of FUNDING project

Role of this deliverable
The main objective of this deliverable is to review the different elements that matter for the construction and assessment of alternative scenarios for the funding of TEN-T projects. We will draw upon existing economic theory (public goods and political economy, transport economics and financial economics) as well as upon experience in EU and abroad with similar financing structures.

The review leads to the following sets of research questions:
A. What price setting behaviour can we expect from member states that can build infrastructure that is used also by transit and set user prices– and does the structure of the international network in which they operate matter?
B. What is the cost recovery ratio of transportation projects in the presence of marginal social cost pricing and what is the efficiency loss of increasing this cost recovery ratio within the project versus the costs of public subsidies?

C. Is there a consistent way to address the large uncertainties in transportation projects?

D. How have federal countries solved these problems up to now?
   a. In the EU and some European countries with a federal structure
      i. In the EU: what is the origin and performance of the current structure of EU level funds?
      ii. In Germany where the federal level also intervenes heavily in the construction of transportation infrastructure
   b. In the USA where there is a long tradition with the Federal Highway Fund

Price setting and investment behaviour of member states (regions) in transport corridors

Even the analysis of a simple parallel or serial network as the one shown in Figure 2 is sufficient to show that large inefficiencies in pricing and investment can exist in federal countries where member states (or the firms to which they subcontract) decide independently on pricing and investment.

In Figure 2, we distinguish between parallel and serial network structures as very simple descriptions of real-world toll and capacity competition problems. The first case (top of Figure 2) arises when different parallel links can be used to make a particular trip; each link is used by both local traffic and transit traffic (through traffic) and is operated by a different authority (say, a member state). Moreover, transit traffic has a choice between the different parallel links, so that governments compete for transit tax revenues. The second prototype network arises when transit has to use a route that sequentially runs through the territory of different governments. The existence of this ‘transport corridor’ leads to a different type of user charge or tax competition: transit no longer has any route choice, but the same transit traffic may sequentially be taxed by each of the governments operating the serial links. Note that in the two network types, origins and destinations are assumed to lie outside the network. We assume that member state governments are interested in maximizing a (local) social welfare function that reflects three concerns, viz. (i) the travel conditions of its local users and the associated...
welfare,(ii) total tax revenues on the link it controls and (iii) investment costs associated with capacity provision

In serial networks (where transit traffic uses an infrastructure that passes through two different countries) the main problem is the potential for excessively high user prices because each country charges a monopoly margin without taking into account the revenue reduction for the other country (“double marginalisation”). This can be overcome by cooperative solutions between the two price setters or by giving the concession for the pricing of the network to a single infrastructure manager rather than to one infrastructure manager per country. Contrary to common belief, the requirement to charge transit the same tolls as local users is not at all sufficient to avoid user prices that are too high. The excessive pricing problem can be so severe that it may be better for the federation not to allow any user charging at all, even if that leaves congestion unpriced.

In parallel networks, the main problem is insufficient investment whenever there is no user pricing. The origin of the problem is the transit that shifts to the link where transport costs are lowest. This acts as an important disincentive for each member state to invest. Whenever user pricing is possible, even if it discriminates against transit traffic, user pricing will give incentives for more investments and the competition between the two parallel links will keep tolls from becoming much too high.

These lessons have been drawn from a simple network setting and using many simplifying assumptions. This implies that the network structure and the strategic behaviour of member states (or the operators they control) need to be integrated in the cost benefit assessment of the investment project.

Mark up rules to fund investments internally and to finance the operation of a fund
Marginal social cost (msc) pricing is not always sufficient to cover the cost of an infrastructure project. There are three ways to cope with this problem. Either the users of the infrastructure project pay more (internal mark-up), the infrastructure is financed by letting the whole transport sector (even those who do not use the specific infrastructure) contribute (external mark-up) or non transport money from the general budget is used. In this text we examine the economic efficiency cost of decreasing the financial deficit of a transport project by using internal mark-ups. These will later be compared with the two other ways to fund the deficit. The use of mark-ups in the rest of the transport sector will be analysed in D3 using TREMOVE II that covers the whole transport sector. For the cost of general budget money one can rely on estimates of the marginal cost of public funds.

Using a simple model of one transport market it can be shown that

- the cost recovery ratio\(^1\) is equal to the degree of scale economies in capacity extension – for rail this may be as low as 0.2 while for roads this may be closer to 1

- the cost recovery ratio can be increased by higher user prices but the maximum cost recovery may remain well below 1
  - the efficiency cost of increasing the cost recovery beyond the degree of scale economies becomes quickly very high

\(^1\) The ratio between user charges for infrastructure and the capacity costs of this infrastructure.
this implies that one has to be careful to advance minimum cost recovery rates that are not in line with the economies of scale of the project.

If there is an underpriced existing substitute for this project (typically road or air traffic are substitutes for a rail project), there will be an additional welfare loss when the cost recovery ratio is increased since part of the users that decided not to use the overpriced mode anymore will switch to the underpriced mode (road, air) and increase the existing inefficiency. In the case of rail TEN-Ts, the substitution mode is often interurban road or air and it is important to know whether prices for these modes are too low or not. Prices that are too low are a clear justification for lower cost recovery requirements in rail or IWW.

Car and truck use is mostly underpriced in urban areas and in the peak. This is less the case for interurban traffic because cars and trucks are becoming much cleaner than in the past, there is an important fuel tax, congestion is limited and congestion pricing is making its way on the most acute segments. As regards air travel, there is indeed an air pollution cost that is not internalised but some of the air traffic prices have also an important monopolistic margin so that again underpricing has to be shown on a case by case basis.

Risk in transport infrastructure projects
We have observed a large number of failures of large projects. The Suez Canal and Euro Tunnel provide only two among numerous well known examples. There are various sources of uncertainty which may affect the costs and the benefits of large scale projects. They correspond to, roughly speaking, demand uncertainty, supply uncertainty as well as to various macroeconomic shocks. Risk and uncertainty are not well taken into account in current cost-benefit analyses. However, risk and uncertainty affect the major ingredients of the cost-benefit analysis during the whole process of construction, operation and maintenance of a project.

The introduction of risk in the standard cost-benefit analysis used in transportation is analysed in this text. Typically, the value of a project is measured by the Net Present Value (NPV), which measures the discounted value of the investment. In practice, both supply and demand are random: this variability is due to microeconomic as well as to macroeconomic factors.

If one is only interested in the expected Net Present Value, one can look for rules of thumb to adapt the investment rules in function of the risks. As an uncertain future demand is one of the main issues for the timing and capacity choice of the TEN-T investment projects we analysed whether a systematic overinvestment could be justified. It is shown that this could be justified when demand is relatively inelastic but this cannot serve as general principle.

When the decision-maker is sensitive to the randomness of the Net Present Value (typically, decision-makers are risk averse), the decision rule has to integrate a priori the whole distribution of NPV. We argue that the standard average and Mean-Variance models, widely used in finance, are not adequate for the evaluation and comparison of projects. The reason is that these criteria do not take into account the default risk which is of primarily importance both for the private and public sectors.
To model the attitude towards risk when selecting a project among several candidates, we borrow two criteria developed in finance which are used to optimize portfolio. Indeed, the investor often wishes to maximize the expected return under the constraint that the probability of a negative (or lower than a given level) return is small enough. The two proposed criteria are the Value at Risk and the Conditional Value at Risk. We show that they can be used to compare projects. The idea is that a “good” project is such that poor returns occur with low enough probability. For a given probability, the Value at Risk is equal to the corresponding quantile, while the Conditional Value at Risk corresponds to the average Net Present Value of the worst outcomes (below the corresponding quantile). It is shown how these criteria can be computed in practice and how they are implemented in MOLINO II, the model used to assess the individual case studies.

European Experience with infrastructure funds
There are currently no transport infrastructure funds operating at the EU level and the main existing European Community sources of funding for the TEN-Ts are the TEN-T budget line itself, the Cohesion Fund and the European Regional Development Fund (ERDF). At the member state level, the German federal model of infrastructure procurement bears most resemblance to a potential European structure and has therefore been analysed in more detail. Several countries also have experience of national transport infrastructure funds from which useful lessons can be drawn for the formation of a European fund. The private sector is, in addition, a potentially important source of finance for the TEN-Ts.

The main federal planning instrument in Germany is the federal infrastructure master plan. This contains a list of priority projects for investments, ranked according to the results of a project appraisal. A quota system is then applied for the distribution of investments between the states. The federal government is responsible for providing federal motorways and trunk roads, while the states administer them. The division of powers between federal and state level in the road sector has raised several issues of criticism, including delayed planning processes, inefficiencies in the planning, and an excessive number of projects that have to be decided and financed at the federal level. This experience suggest clear rules are necessary to determine whether transport infrastructure is eligible for EU funding, and the involvement should be restricted to projects that clearly fulfil transport functions benefiting European objectives in order to avoid over-subsidisation and excessive involvement in regional transport infrastructure investments. There also needs to be a clear division of responsibilities between the European and the member state level with control mechanisms installed over the whole procurement process to protect the interests of the financing actors.

An infrastructure fund promises more flexibility and higher stability of the investment budget than funding from general budgets. Several EU member states have established transport infrastructure funds via financing agencies as a means of managing and providing infrastructure financing independent of public budgets. Prominent examples of such agencies have been established in Germany, Austria and France. Of these, only the Austrian ASFINAG has been in existence for more than a couple of years. Between them, the three agencies have a number of attributes, which could be considered for a European infrastructure fund. The German VFIG and French AFTIF have been set-up with a view to financing multi-modal projects and facilitating PPP involvement. The
VFIG is financed by HGV and IWW tolls, which has led to a debate on the public acceptability of user charging when cross-financing of modes is allowed. ASFINAG, which is only responsible for motorways, obtains capital from the capital market, with the loans being guaranteed by the Austrian state. The refunding of the investments is done via user charges which are set by the federal government. The agency is, however, involved in the selection of projects for investment, in contrast to VFIG and AFTIF. The organisation of a European infrastructure fund clearly needs to be considered carefully. The set-up is likely to contain elements of grant contributions from government as well as funding from user charges and private sector involvement in financing and project delivery. The clear assignment of the powers and responsibilities of the parties within the model is crucial to efficient delivery. There will also be a need not only for financial but also for organisational co-ordination of cross-border infrastructure procurement.

In the case of the private participation, rules are necessary to determine who bears the risk of cost overruns; experience shows that privately owned companies (and in particular railway network companies) need planning security and this issue must be considered in the financing rules of a fund. Empirical evidence from Great Britain suggests that private sector involvement is of greatest benefit for the management rather than the financing of road procurement. The experience from the fully privately financed M1/M15 project in Hungary indicates that private involvement in infrastructure provision requires support in the form of long-term commitment of the public partner. Despite being finished on-time and within budget, the concession company was renationalised after low demand led to high tolls, which were unpopular.

Survey of US experience
In the US, the Federal Highway Trust Fund (FHTF) was set-up to finance the National System of Interstate Highways using highway user tax revenues. The original system was completed by 1992. The Fund is mainly financed by dedicated taxes on motorfuel, collected by a federal agency. A great part of the FHTF funds has since been used to finance other transportation related projects than interstate highways. The federal matching grants for individual projects, on average 80% of the total costs, are based on technical criteria of the projects. The federal agency does not choose the funded projects: it only confirms that the project can receive federal funding if it complies with the criteria, which are increasingly widely defined. This leaves the actual project selection to the states.

About every five years the Congress approves a new set of legislation defining the appropriation formulas for the disbursement of the funds. The outcome of the formula has been very stable even though the formula and its computation rules have changed and become increasingly complex. The formula takes into account factors like the state’s length of road network, the number of motor vehicles in the state and the annual contributions of the state to the FHTF. The Congress does not decide on the project selection of the FHTF funds. However, the Congress representatives have developed a practise of requiring an increasing number of “earmarks” or “demonstration projects”, i.e. additional projects from other federal funds that they require as a condition for their approving vote for the legislation package. This increasing practise of pork barrel has increased the total transportation budget and made the transportation expenditures less efficient.

We can learn from the US experience that:
1) The very high share of federal aid (larger than the share of local benefits) together with the distribution of votes between representatives of individual states has given rise to common pool (or pork barrel) politics: politicians use their power to attract projects to their district but do not want the overall federal budget to become larger – empirical results suggest that the selection of projects is very inefficient.

2) The financing of the Fund was guaranteed by the use of dedicated gasoline taxes. The initial highway fund objectives have been altered to allow funding of a wide range of other transportation related projects to the extent that the Fund money is not expected to be able to cover its initial purpose: to maintain the interstate highways.

3) Although there is a federal agency to supervise the use of funds of the subsidy program, the agency supervises only the technical eligibility rules of the projects, and the collection and disbursement of funds. The selection and implementation of the programs’ projects is done by the states, while the selection of the demonstration projects is done by the Congress representatives. The states have been largely able to substitute the federal money for the state transportation money, in effect directing the federal money for other purposes than maintaining the interstate highways.

4) The current legislation aims to return to each state at least 90% of their gasoline tax contributions. This legislation developed after a long history of stable receiver-donor state status, which was an outcome of the Congress’ vote distribution giving relative advantage to rural, less populous states like Alaska. The return-to-origin features make the federal-aid highway program function as a cash transfer, a general purpose grant program. While this feature provides relief from the donor-receiver dilemma, it loses in efficiency to the federal administration totally withdrawing from the collection and distribution of the funds.

The differences between the US and EU systems that needs to be taken into account can be characterised as follows:
1) the US federal government redistributes directly between individual citizens, whereas the EU has mainly a system of intergovernmental transfers;
2) the US federal government is directly appointed by and accountable to individual voters, whereas political appointments and accountability are only indirect in the EU;
3) the US federal government controls a wider set of policy instruments than the EU.

When any recommendations from the US federal highway funding are applied to the EU infrastructure funding, they should be subject to these three differences.

In this light, the EU infrastructure funding program needs to pay particular attention to:

1. Limiting the share of the EU level in the financing of transport investments and tie this share to the non-local benefits – this is the major safeguard against pork barrel politics and could avoid that member states claim every year their share of the budget. To safeguard this principle, each member state should have an option to withdraw from the Fund with remuneration of its past contributions, if its contributions exceed the non-local benefits its inhabitants receive from those contributions.

2. Setting a consistent standard evaluation procedure for estimating the benefits of infrastructure investments for each transportation mode. This would make the benefits
of infrastructure investments in different transportation modes transparently comparable and safeguard against favouring any particular mode. Transparency is another major safeguard against pork barrel politics, which tends to favour investments that require high sunk costs.

3. Defining the technical infrastructure standards for each mode of transport funded by the EU Fund. This would safeguard against technical incompatibility between national standards and therefore promote realization of non-local benefits from the EU funded infrastructure.

4. Maintaining the member states’ right to choose the EU funded infrastructure projects that are realized on their soil. This would safeguard against locally harmful federal projects, which caused the largest obstacles in the US federal infrastructure program.

5. Looking for a stable, transparent funding formula for its Fund but avoid that the money could be spend on other projects than what the Fund was established for. The effective safeguards against both alteration of fund collecting principles and diversion of funds to other uses are the above mentioned cost-benefit transparency across different transportation mode investments combined with the member state’s option to withdraw from the Fund with remuneration.

6. There is an increasing interest in private partners as long as the private partner will carry their share of the risks of revenue. Both the presence of private partners and the political unattractiveness of gasoline tax hikes increase the attractiveness of tolls as a revenue source. The share of tolls versus taxes should therefore be one of the case study design dimensions. In the implementation of the options, attention should be paid in safeguarding against the private party evading risks through bankruptcy or other kind on non-existence, and the public party evading risks through non-accountability to its commitments.
1 OBJECTIVES OF FUNDING CONSORTIUM AND ORGANISATION OF THIS DOCUMENT

1.1 Objectives and structure of the FUNDING project

The main objective of the FUNDING project is to develop a scientifically sound approach to the funding of large transport infrastructure investments in the EU. Two different avenues are explored for the funding of these investments. The first is the creation of an EU transport infrastructure fund financed by mark-ups on transport activities. The second is the use of mark-ups on the costs charged by the infrastructure suppliers that make the investment. The overall structure of the research is outlined in Figure 1.

In this document (WP1), the economics of infrastructure funds and the mark up method are first explored conceptually. For the infrastructure fund we examine three questions: how to spend the resources of the infrastructure fund (what type of projects, subsidies or loans), how to finance the operation of the fund (contributions out of general budget or earmarked taxes on transport) and what decision rules to use for the fund (political body versus agency, accountability issues). These questions are explored using economic theory (political economy, risk pooling, network spillovers) but we also draw upon experience with infrastructure funds and mark-ups in EU, US and World Bank.

Figure 1 Overall structure of FUNDING project

The conceptual phase leads to the formulation of a limited number of alternative scenarios for a European infrastructure fund and for the use of mark-ups (WP2). These
scenarios are adjusted in function of the financing gaps that are calculated for the horizon 2020 by mode and country given the accepted TEN-T investments (WP3). The financing gap is computed using the SCENES – TREMOVE baseline 1995-2020. WP3 generates revenues from different mark-up rules and will therefore not only allow the order of magnitudes for an infrastructure fund scenario to be adjusted but will also provide information about the efficiency costs of different ways of generating revenues. As WP3 is based on one accepted baseline scenario for the EU it will also be used as much as possible as baseline for the other modeling workpackages. WP3 cannot evaluate the effect of scenarios on investments as the TREMOVE and SCENES model have exogenous investments.

The performance of the alternative infrastructure fund and mark-up scenarios in terms of investments and pricing is tested using two different but complementary modelling approaches. Each of the modelling approaches tests the same set of scenarios defined in WP2 but examines a different dimension.

The first model (WP4) is a multi-modal spatial general equilibrium model of the EU that checks the spatial equity effects of infrastructure aid and mark-ups for more than 1300 regions in the EU. It does this by translating the infrastructure and mark-up scenarios into lower transport costs between regions and simulating the trade and welfare effects of this cost reduction. The model is in line with the TREMOVE-SCENES baseline used in WP3 and tests scenarios developed in WP2. The main contribution of the model is the spatial equity dimension. The main missing dimensions are the endogenous investment behaviour and the non-competitive behaviour in the transport sector. These will be addressed specifically in WP5.

The second approach (WP5) is a case study approach. We take five important “TEN” infrastructure projects and use for each of them the same multi-modal pricing and investment assessment model. For every project, this model is calibrated on the basis of the cost benefit study that has led to the selection of the “TEN” project. The assessment model (MOLINO II) represents the transport flows, pricing, financing and investment decisions related to the project itself. It is complemented with corridor analysis information provided by corridor models for freight and passengers. The case study approach will enable the effect of infrastructure fund scenarios on each of the investment projects to be examined in terms of financial structure, advancing or delaying the investment decisions, the pricing decisions and on welfare. The corridor models are calibrated on the TREMOVE-SCENES baseline used in WP3.

The different tests lead in principle to consistent and tested guidelines for financing infrastructures via a European transport infrastructure fund and mark-up rules (WP6).

### 1.2 Organisation of this document

The main objective of this document is to put together the different elements that matter for the construction and assessment of alternative scenarios for the funding of TEN-T projects. We will draw upon existing economic theory (public goods and political economy, transport economics and financial economics) as well as upon experience in EU and abroad with similar financing structures.

In the first chapter we explore the economics of infrastructure funding: what are the economic justifications for a federation (the EU) to help the member states in infrastructure projects and if it does so what are the problems to be expected. We conclude with a list of research questions to be explored. These research questions are of two kinds: theoretical ones and empirical ones. We have chosen three theoretical questions to be studied in more detail. The first one is the pricing and capacity decisions behaviour to be expected from member states for corridor type of infrastructure that is
also intensively used by transit. The second one is the cost of increasing the cost recovery ratio in projects with important returns to scale as this is an alternative for large public subsidies. The third theoretical question is how to deal best with the large uncertainties (demand, costs) that are inherent in the large TEN-T infrastructure projects. These questions are dealt with in Chapters 3, 4 and 5.

The empirical questions deal with the actual experience with federal aid to member state projects in the EU and the USA and are dealt with in Chapters 6 and 7.
2 ECONOMICS OF FEDERAL INFRASTRUCTURE FUNDS

2.1 Introduction

Why and how a federal government should intervene in the local supply of public goods and infrastructure is a question that has received a lot of attention in the economic literature. To study the advantages and disadvantages of federal interventions (or absence of intervention) we proceed in three steps. We first analyse with the help of simple graphical examples what can be the motives for federal intervention and what are the likely effects of these interventions. Next we take a political economy stance and discuss briefly what could be the effects of political institutions on the outcome. We conclude with a list of research questions that are analysed in the next chapters of this document.

2.2 Subsidiarity and decentralisation

In a federal system one distinguishes three motives for federal aid in the provision of public goods for member states: spillover effects, fiscal and financial capacity and paternalism. Spillover effects exist whenever the infrastructure in a member state is also used by citizens or firms of another member state. Whenever these “foreign” users do not pay for the use of the infrastructure, member states will have lower incentives to supply the infrastructure. This will be one of the key motivations for a federal approach we will study in this chapter.

Whenever a member state has insufficient fiscal and financial capacity, the federal government could help the member states. This argument is probably more valid for the local public finance problems (at city or regional level) than at the level of the member states. At city or regional level, tax bases can be very mobile and this is the motivation for federal revenue sharing and different fiscal capacity grants that help the local governments to supply the appropriate level of public goods. This reasoning does not apply to the European Union Level as this level has only a very small share of the overall tax revenues so that the fiscal capacity is situated at the member state rather than at the Union level. Moreover even if there would be an insufficient fiscal capacity it is, according to the decentralisation principle, better to give an unconditional grant to the member states rather than a conditional subsidy scheme. For these reasons we will not study this argument in this chapter.

The third argument for federal aid is paternalism: the level of the Union knows better than the member states what the best investments are. This motive for intervention is sometimes used in federal contexts to protect minorities in some member states. Again this argument is difficult to defend in the context of the European Union where member states are all democratic regimes and where subsidiarity is one of the founding principles. In this chapter we will therefore not study paternalism as one of the acceptable reasons to set up federal aid systems for infrastructure.
2.3 Infrastructure provision by member states in the presence of spillovers

2.3.1 The case without congestion and without pricing

We will discuss the inefficiencies in the provision of infrastructure by a member state using a graphical example. We start with the simplest case where the use of the infrastructure cannot be priced and where the only decision is to build the infrastructure or not. Later we will introduce the option to price the use of the infrastructure and the choice of capacity.

Take a member country that can decide to build or not a given infrastructure (bridge, railway line etc.). Once constructed, the infrastructure is used by inhabitants and by non-inhabitants, there is no congestion and its use cannot be priced. To make things simple we assume the use of the infrastructure is constant over time and its construction and maintenance cost can be translated into a yearly equivalent cost $Z$. Whether it makes sense to construct or not the infrastructure can be analysed with the help of Figure 2.

![Figure 2 Benefits of building an uncongested and unpriced local infrastructure](image)

In Figure 2 we represent the total willingness to pay for trips of the local users ($MWP_{local}$) and the total willingness to pay of local and foreign users ($MWP_{local+foreign}$). The more beneficial (the higher the time and cost savings) is an infrastructure, the higher is the willingness to pay. As no price is charged for the use of the infrastructure, the use of the infrastructure is given by the points where the MWP curves cross the X axis. The total benefit per period of constructing the infrastructure is given by the area under the MWP curves: it can be seen as the sum of the total willingness to pay of all the trips. What is important for our case is the difference between the shaded (blue) area that represents the benefits for the inhabitants of the member state and the area under
the MWP_{local+foreign} curve that represents the total benefits for the federation: inhabitants of the member state plus other users that belong to the federation. The member state will be interested in the benefits for its own citizens, not in the benefits for the foreign users, so it will only build the infrastructure if the local benefit exceeds the cost of the infrastructure Z. A federal government will be interested in the benefits for all citizens. If Z is sufficiently large, there are cases where it is worthwhile for the federation to build the infrastructure but where the member state will do it.

### 2.3.2 Federal subsidies

These spillovers of benefits are one of the main motivations of federal aid for the infrastructure projects of member states. An obvious way for the federal level to overcome this inefficiency is to use a **federal subsidy**. What subsidy would be appropriate?

- It is clear that the subsidy has to be conditional on the construction of the infrastructure; otherwise member states will take the money and not build the infrastructure.
- The conditional subsidy should also be a function of the level of the spillovers: in our simple case a subsidy rate (%) equal to the share of the foreign use would make sure that the member states perceive an infrastructure cost that makes them take the federally optimal decision\(^{2}\).

Things are somewhat more complicated than the simple subsidy scheme proposed here. One of the issues is that the federal government does not have good information on the costs and the benefits of the proposed infrastructure. This asymmetry of information may lead to two types of problems:

- Some infrastructure would be build anyway because it is beneficial also from the viewpoint of a member state, so a subsidy is not really required
- The costs of infrastructure will be higher than necessary whenever the locals benefit from oversupply of some characteristics (say noise insulation etc.) as they do not have to pay the full cost

The design of an optimal subsidy scheme is therefore not a simple matter: one can include incentives for cost minimisation and for a truthful revelation of transport needs. This is one of the main motivations to leave the subsidy task to an agency with sufficient technical expertise (see Meunier and Quinet, 2006, Revenue book).

### 2.3.3 Introducing congestion and pricing

Whenever we introduce congestion on the infrastructure, the net benefit computation changes. Now the presence of transit traffic actually decreases the local benefits because the extra congestion created by transit increases the average travel time. Ceteris paribus, higher subsidies are needed to motivate the member states to build the new infrastructure.

Introducing the possibility to price the use of infrastructure changes the cost benefit computation drastically. In Error! Reference source not found. we represent the case of

\[^{2}\text{This can be easily seen. Assume the total benefits equal }\left(1+v\right)\text{Benefit}\text{ where }v\text{ is the relative benefit of the foreign users, then the federal cost benefit criterion is: }\left(1+v\right)\text{Benefit} > \text{Total Cost}\text{ and this can be written as }\text{Benefit} > \left(1/(1+v)\right)\text{Total Cost}\text{ and this means }\text{Benefit} > \left((1-s)\right)\text{Total Cost}\text{ where }s = v/(1+v).\]
an infrastructure that is subject to congestion but where the use of the infrastructure is priced by the member state.

\[
\text{Member state compares:}\quad \text{Total benefit local + tax revenue} > \text{total cost } X
\]

Compared to SMC pricing, larger chance that project is realised BUT smaller total surplus (mainly for the foreign users)

\[
\text{Federal intervention:}\quad \text{investment subsidy + Pricing contract}
\]

**Figure 3 Benefits of building a congested and priced infrastructure**

When the use of the infrastructure is not priced, one obtains an equilibrium use \( Q_{\text{no toll}} \): traffic increases up to the point where the willingness to pay of local and transit traffic equals the average user cost in terms of time and other costs. In Figure 3 we see that the absence of pricing leads to an excessive use of the infrastructure because the willingness to pay of the last user is lower than the marginal social cost (MSC). The MSC is larger than the average cost because of congestion. In the presence of congestion, the MSC consists of the average user cost plus the product of the delay caused by an additional user and the existing number of users. In Table 1 we report the benefit that is taken into account by a member state and by a federal government under different user price arrangements. The benefit areas reported need to be compared with the lump sum investment and maintenance cost of the project: if the benefit is larger then there is a larger probability that the project will actually be accepted by the decision maker.

In the first line we see that the benefits for a federal government are always larger than the benefits for a local government because it cares for the user benefits that accrue to the non-inhabitants. This property will hold for all the pricing regimes we consider.

In the second line we compare the benefits when the infrastructure would be priced optimally from a federal point of view "optimal federal toll". We assume that the transaction costs of pricing are zero. In the third line we assume that the member state maximizes the welfare of its own citizens plus the total revenues from user pricing. It can be shown (cf. Chapter 6) that a member state government would actually opt for a toll in excess of the marginal congestion cost.
Table 1 Benefits at federal and member state level for different user pricing regimes

This leads us to the following insights:

1. When user pricing is not very costly for a member state, user pricing increases the likelihood that an infrastructure project is actually realized without federal help. (the benefits at state level are always higher with pricing or AML+LNST > AHG)

2. The user prices charged by member states are in general too high, the federal level will prefer lower tolls (ACD+DCEF > ANL+LNST) but this decreases the probability that the project is realised by the member state without federal help (AML+LNST > ABD+DCEF).

3. As a consequence, whenever federal aid is needed to make a project happen, there is an interest to try to link the subsidy to the pricing policies pursued by the member states.

In fact most TEN-Ts are not isolated projects but are part of a network where competing or preceding links are controlled by other member states. This means that pricing policies and investment projects of one member state become complements or substitutes and there will be strategic behaviour by each of the member state governments. When successive links of the same corridor are controlled by different member states they become complements, when two links compete for the same transit traffic they become substitutes. In Chapter 3 we explore the likely properties of the investment and pricing games played in these trans-European networks.

2.4 The political economy of competing for federal transport funds

The pricing and investment results that have been discussed up to now assumed that the member state or federal level governments maximise the simple sum of the surplus of the users and the net revenue from user charges. This can serve as focal point or guiding principle for investment agencies at member state or EU level but it is naïve to assume that this represents real world decision making. One needs to take into account a richer model that accounts for the formation of public decisions. In this richer political economy model we need voters, agencies, administrations and lobby groups. We will briefly illustrate the potential implications of two simple models for the TEN-T investment decision making.

We start with the traditional static common-agency lobbying model. In the common agency model (see Dixit et al (1997)) there is a policy maker that is influenced by the voting process and by a lobbying process. The voting process is kept unspecified and results in policies that maximise a weighted sum of individual utility functions. Lobby groups propose to the government a menu of (truthful) lobbying contributions. The lobbying contributions proposed to the policy maker are a function of the policy proposed by the policy maker: the better the proposed policy matches the preferences of

---

3 The weights can differ from the weights described in the normative section 3.1.
the lobby group, the higher the lobbying contributions. Different groups compete to influence the policy maker.

This can be applied right away to the decision of building or not building a specific road or public transport investment that cannot be tolled. This can be a bridge or railway line to a remote location. This type of investment is called a specific public good\(^4\). As Persson (1998) and others pointed out, the supply of specific public goods paid by a general tax is a very common way to favour a lobby group (known as “pork barrel politics”). The problem is that the benefits are for a very small group while the costs are for a large group of taxpayers. This implies that lobbying may have a particularly high pay-off when the use of the infrastructure is not priced and the benefits are only shared by a small group (region or one specific mode).

The second model is the representative democracy model of Baron and Ferejohn (1987) where lobby groups are not present but where the elected representatives favour their constituency. When a representative becomes agenda setter, he will form a winning majority of states by selecting those states that are not costly to please in terms of public works and will use the opportunity to favour his district by selecting an oversupply of federally paid public works in his state. Empirical tests for the USA of this theory by Knight (2004) for the Interstate Highway Fund in the USA have shown that this is an important source of inefficiencies. This is discussed in more detail in Chapter 7.

Concluding, when transportation investments favour only a small group, be it in a particular region and/or a specific mode, there is definitely a risk of oversupply when they are paid for by the federal level.

### 2.5 Some research questions

This introduction to the economics of infrastructure funding in a federal context leads to the following sets of research questions:

A. What price setting behaviour can we expect from member states that can build and set user prices for transport infrastructure that is also used by transit? Does the structure of the international network in which they operate matter? (see Chapter 3)

B. What is the cost recovery ratio of transportation projects and what is the cost of increasing this cost recovery ratio within the project versus the costs of public subsidies (addressed in Chapter 4)

C. Is there a consistent way to address the large uncertainties in transportation projects (see Chapter 5)

D. How did federal countries solve the problems up to now? (see Chapters 6 and 7)
   a. In the EU and some European countries with a federal structure
      i. In the EU: what is the origin and performance of the current structure of EU level funds
      ii. In Germany where the federal level also intervenes heavily in the construction of transportation infrastructure
   b. In the USA where there is a long tradition with the Federal Highway Fund

---

\(^4\) In the case of transport infrastructure that is built with a large capacity but has almost no users, the marginal cost per user is very low as there is no congestion and this can therefore be considered as a public good that is non-rival in nature.
3 WHAT TYPE OF USER PRICING AND INVESTMENT DECISIONS CAN WE EXPECT FROM MEMBER STATES IN TRANSPORT NETWORKS? 5

3.1 Introduction

The purpose of this chapter is to understand the user pricing and investment decisions taken by member states in networks that are controlled by different member states. We do this for two very simple networks: one with a parallel structure and one with a serial structure. On both of the networks we introduce local traffic and interstate transit traffic and we compare the results of four user pricing regimes on prices, investment and welfare.

In section 2 we explain the network structure and the type of pricing behaviour that can be expected from each member state. In section 3 we explain the results with the help of a small numerical example and in section 4 we conclude.

3.2 Structure of the model

The models we use for the study of tax competition on simple transport networks can be summarized as follows. First, two very stylized types of network structure have been considered; they are illustrated on Figure 4.

![Figure 4 Parallel (upper part) versus serial (lower part) competition](image)

This section is largely based on the following three papers:


We distinguish parallel and serial network structures as very simple descriptions of real-world toll and capacity competition problems. The first case arises when different parallel links can be used to make a particular trip; each link is used by both local traffic and transit traffic (through traffic) and is operated by a different authority (say, a member state). Moreover, transit traffic has a choice between the different parallel links, so that governments compete for transit tax revenues. The second prototype network arises when transit has to use a route that sequentially runs through the territory of different governments. The existence of these ‘transport corridors’ leads to a different type of user charge or tax competition: transit has no more route choice, but the same transit traffic may sequentially be taxed by each of the governments operating the serial links. Note that in the two network types origins and destinations are assumed to lie outside the network.

To model both parallel and serial settings, we proceed as follows. We assume each link carries local traffic and transit traffic. Local traffic uses only the local link. Transit traffic chooses one of the links (parallel case) or passes through the two links (serial case). The capacity of each link can be augmented through investments that are decided upon by the member state government; however, once capacity is chosen for a given link it is potentially congestible.

We assume that member state governments are interested in maximizing a (local) social welfare function that reflects three concerns: (i) the travel conditions of its local users and the associated welfare; (ii) total tax revenues on the link it controls; and (iii) investment costs associated with capacity provision. The assumption that transit traffic has its origin and destination outside the two-link network implies that the two governments are not interested in the transport costs and the welfare of transit. Finally, we assume that all traffic flows are uniformly distributed over time and are equal in both directions, allowing us to focus on one representative unit period and one direction.

For every type of network, we will study four different user price regimes: toll differentiation, uniform toll, tolls on local users only and no tolling at all (see Table 2)

<table>
<thead>
<tr>
<th>TYPE OF TOLLING</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toll differentiation</td>
<td>Local users are tolled differently than transit users (locals are favoured via block pricing or two part tariffs)</td>
</tr>
<tr>
<td>Uniform toll</td>
<td>Local users and transit users pay the same toll</td>
</tr>
<tr>
<td>Local traffic only</td>
<td>Only local users are tolled (transit escapes by fuelling in other countries etc.)</td>
</tr>
<tr>
<td>No user charging</td>
<td>No charges for use of infrastructure</td>
</tr>
</tbody>
</table>

Table 2  Different types of tolling

In order to study the behaviour of the member states in the network we will make the following behavioural assumptions:

- for given capacity, each member state chooses the user prices that maximize its
own objective function, taking the user prices chosen by the other member state as given (the so called Nash pricing game in the second stage);
• each member state chooses the capacity of its own network, taking the capacity of the other member state as given and knowing how the Nash equilibrium prices will change in function of its capacity decisions (so called first stage of the game).

This setting allows us to study the infrastructure capacity decisions of the member states for different types of user pricing. This is a more complex question than the behaviour of only one member state in isolation that was discussed in Chapter 2. In this chapter, we have two member states setting user prices and capacities and they influence each other in different ways.

To give an idea of the type of interactions, take first the simplest case without user pricing. In a serial network (corridor), the increase of the capacity by one member country will attract more transit, this transit will via the serial network end up in the other member country. This country will then have an interest to also expand its network capacity in order to safeguard the quality of the network for its local users. So in a serial network, the investment of one member state tends to force the other member state to also invest.

Still in the absence of user pricing, take now the case of a parallel network where transit can choose between routes that are situated in different member states. If one member state expands its capacity it will attract a large share of the transit traffic so that its local traffic will benefit less from the expansion. It will actually do a favour to the parallel member state because it will experience a lower level of transit traffic. This type of interaction acts as a strong disincentive to invest in capacity.

Take now the other simple case where capacity is fixed but where user pricing of transit traffic is possible. In a serial network, each of the member country will try to charge monopoly prices to the transit traffic and this will lead to inefficiently high user prices. In a parallel network, this risk will be mitigated because when one member country charges transit too much, the transit traffic will switch to the parallel link. In a parallel network, the risk of overcharging is clearly much lower.

### 3.3 A numerical illustration

In Table 3 we give the main characteristics of a numerical example in which we compare the pricing and capacity decisions of two identical member countries for different user pricing regimes.

<table>
<thead>
<tr>
<th></th>
<th>Serial network</th>
<th>Parallel network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand function local traffic</td>
<td>Identical (price elasticity -0.3)</td>
<td></td>
</tr>
<tr>
<td>Demand function transit traffic</td>
<td>Calibrated such that the transit flows per member country are identical</td>
<td></td>
</tr>
<tr>
<td>Congestion function</td>
<td>Linear in flow/capacity and identical for each link</td>
<td></td>
</tr>
<tr>
<td>Cost of capacity extension</td>
<td>Identical</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3 Characteristics of the numerical example**
<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>No tolls</th>
<th>Nash Equilibrium differentiation</th>
<th>Nash Equilibrium uniform</th>
<th>Nash Equilibrium local tolls only</th>
<th>Centralised-differentiation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>serial</td>
<td>parallel</td>
<td>Serial</td>
<td>parallel</td>
<td>serial</td>
<td>parallel</td>
</tr>
<tr>
<td>Local demand</td>
<td>Trips</td>
<td>1300</td>
<td>1206</td>
<td>1219</td>
<td>1184</td>
<td>732</td>
</tr>
<tr>
<td>Transit demand</td>
<td>Trips</td>
<td>1300</td>
<td>1206</td>
<td>396</td>
<td>1122</td>
<td>732</td>
</tr>
<tr>
<td>Trip volume (country)</td>
<td>Trips</td>
<td>2600</td>
<td>2411</td>
<td>1616</td>
<td>2306</td>
<td>1465</td>
</tr>
<tr>
<td>Local MEC</td>
<td>Euro/Trip</td>
<td>15.6</td>
<td>23.5</td>
<td>16.8</td>
<td>13.0</td>
<td>10.8</td>
</tr>
<tr>
<td>Global MEC</td>
<td>Euro/Trip</td>
<td>31.1</td>
<td>46.9</td>
<td>22.3</td>
<td>25.3</td>
<td>21.7</td>
</tr>
<tr>
<td>Local Toll</td>
<td>Euro/Trip</td>
<td>0</td>
<td>0</td>
<td>22.3</td>
<td>25.3</td>
<td>104.7</td>
</tr>
<tr>
<td>Transit Toll</td>
<td>Euro/Trip</td>
<td>0</td>
<td>0</td>
<td>160.4</td>
<td>35.6</td>
<td>104.7</td>
</tr>
<tr>
<td>Capacity</td>
<td>Trips</td>
<td>2000</td>
<td>1229</td>
<td>1732</td>
<td>2179</td>
<td>1618</td>
</tr>
<tr>
<td>Local CS</td>
<td>Euro</td>
<td>141779</td>
<td>121929</td>
<td>124726</td>
<td>117517</td>
<td>45011</td>
</tr>
<tr>
<td>Tax revenue (country)</td>
<td>Euro</td>
<td>0</td>
<td>0</td>
<td>90793</td>
<td>69938</td>
<td>153333</td>
</tr>
<tr>
<td>Overall welfare</td>
<td>Euro</td>
<td>492348</td>
<td>441783</td>
<td>392658</td>
<td>504750</td>
<td>426209</td>
</tr>
<tr>
<td>Welfare change compared to the case of no tolls</td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>-20.25</td>
<td>14.25</td>
<td>-13.43</td>
</tr>
</tbody>
</table>

Table 4  Pricing and capacity choices by member states in serial and parallel networks for different pricing regimes
(transit share in no toll equilibrium is 50% - the distinction between countries is eliminated because results are symmetric)
3.3.1 What capacity decisions are taken in the absence of users charging?

In this case the two left columns of Table 4 have been used for the calibration of the numerical example and serve as the reference here. The first column represents the local and transit traffic flows when the transit has to pass through two member countries and when both member countries select the capacities that maximize the welfare of their own citizens. The second column does the same but now transit has a choice between passing through one of the two member countries. We see that there remain, both in the serial and parallel networks, important marginal external congestion costs that are not internalized. For example, in the serial case the local and global marginal external congestion costs equal 15.6 and 31.1, respectively. Note that the term ‘local’ refers to the marginal external congestion cost imposed on local users; ‘global’ refers to the overall cost imposed on local users and on transit. An important difference between the serial and the parallel case is that the capacities are much larger in the serial than in the parallel case. The main problem in the parallel case is that, because there is no user pricing, any unilateral capacity extension attracts the transit traffic to this country so that each country is reluctant to extend its capacity. We see that the overall welfare level (user benefits in the two member countries + user benefits of transit – costs of capacity) is much higher in the serial case than in the parallel case.

3.3.2 Is allowing differentiated tolling welfare improving?

Economists have often advocated the use of tolling instruments to cope with non-internalized congestion. In principle, one can allow differentiated (between local and transit transport) or uniform tolling. Both cases are considered in Table 4, for the serial and parallel network structure. In the serial case, the Nash equilibrium results show that allowing regions to toll all transport on their network (whether by differentiated or uniform tolls) implies a decline in total welfare, i.e., it makes things worse compared to the no tolling case. Overall welfare decreases by 13% to 20% in the uniform and differentiated cases, respectively. The reason for the welfare decline is related to the double marginalisation behaviour. It shows up because the two ‘monopolists’ do not coordinate their price setting of transit transport. As a consequence, we find very high margins on transit in the differentiated toll case; they are well above the marginal external congestion cost. In the uniform case it results in high tolls on all transport on the network. These high prices allow savings on capacity costs: optimal capacity is substantially lower than in the no toll reference situation. However, these savings do not compensate the losses in consumer surplus, especially for transit users.

In the parallel case, we find the opposite results. Introducing tolling allows the low investment incentives of the no tolls case to be overcome and this gives much higher capacity levels (about 2180 compared to 1229 in the zero toll reference). Optimal tolls are positive but transit tolls are much lower than in the serial case; this holds both for differentiated and uniform tolls. The consequence of much lower Nash equilibrium tolls on transit implies that in the parallel case overall welfare substantially rises.

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6 Even if the capacity levels would be kept at the zero toll case (not shown in Table 4), we found that allowing tolling would be beneficial. The gains of a better use of a given capacity are important, and abuse of a monopoly position by one region is limited by the Bertrand competition with the other region.
Note that, except for the toll levels themselves, differentiated tolling and uniform tolling generate very similar results in the parallel case. In the serial case, however, toll discrimination against transit is a more important problem because transit has no route choice; it can be mitigated somewhat by imposing uniform tolling. It is important to remember that the requirement to charge the same toll to local traffic and to transit traffic will not prevent member state from putting tolls well in excess of the marginal external costs.

### 3.3.3 Welfare effects of tolling local traffic only

Consider the results for the case where for whatever reason transit remains un-tolled. In Table 4, the share of local traffic is calibrated such that it represents 50% of overall traffic volume. When only local traffic can be tolled, one obviously rules out tax exporting. Contrary to the cases where transit was tolled, this implies that on a serial network small welfare improvements are now attained compared to no tolling at all. The toll is slightly below local marginal external cost, and the toll somewhat reduces demand so that a lower capacity is optimal compared to the zero toll case (1945 compared to 2000). In the parallel case the welfare benefits are positive as well, because one can achieve a better use of the network by the local traffic and save some capacity costs. However, as only part of the traffic is actually controlled, the welfare gains that can be achieved remain very small. Also observe that the optimal local toll is smaller than in the serial case. The reason is that the purpose of the local toll is to indirectly control transit as well as local traffic. Reducing transit by local tolls requires higher tolls in the serial case because transit demand through any given region is only affected via congestion increases. The reaction of transit is stronger in the parallel case because an alternative route is available, unlike in a serial corridor.

### 3.3.4 The ideal solution from an EU federal government perspective: the first-best

Finally, we move away from tax and capacity competition between the two member states. Instead, we assume that the whole network is under the control of one ‘federal’ government; it decides on tolls and capacity investments for the network by maximizing overall welfare for all users of the whole network.

The results are reported in the final two columns of Table 4. First, at this federal optimum tolls are set equal to the global marginal external congestion cost that takes account of the time losses imposed on both transit and on local traffic. Note that, although tolls can in principle be differentiated, there is no need to do so; the tolls on local and transit transport are equal at the optimum. Second, capacity levels are chosen simultaneously in each state such that the marginal cost of capacity extension equals the marginal benefit for all transport, transit and local. Third, note that except for rounding errors in the calculations, the optimum solutions for the parallel and serial networks are identical. This is due to the fact that the zero toll cases for both network types were calibrated using the same local demand functions, the same values of time, the same congestion functions and the same costs of extra capacity. Finally, given that the federal optimum yields identical tolls, capacities, demands and overall welfare levels for the two network types, the welfare improvement in the parallel case is much more important than on the serial network. This follows from the lower welfare level in the zero toll case for the parallel network.

Summarizing, the first-best outcome, marginal external cost pricing and optimal
capacity choice for the network as a whole yields much higher benefits in a parallel structure than in a serial setting. Note that the welfare improvements, even for the parallel case, seem rather modest: some 15% compared to the reference situation. This is however due to the fact that the reference itself was calibrated such that it corresponds to the Nash equilibrium with zero tolls but optimal capacity choice.

3.3.5 Summary of the numerical comparison

In Tables Table 5 and Table 6 we summarize the main implications of the numerical findings. We observe clear differences in the extent and the nature of tax competition (very severe in the serial case) and capacity competition (very severe in the parallel case). Moreover, welfare benefits differ according to network structure.

<table>
<thead>
<tr>
<th></th>
<th>% Welfare change</th>
<th>% Capacity change</th>
<th>Transit toll</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-best federal optimum</td>
<td>+3.67</td>
<td>+40</td>
<td>Toll=MECC</td>
<td>Higher capacity and positive tolls</td>
</tr>
<tr>
<td>Nash toll discrimination</td>
<td>-20.25</td>
<td>-13</td>
<td>Toll much larger than MECC</td>
<td>Lower capacity and very high transit tolls; severe toll exporting (double marginalisation); tolling reduces welfare</td>
</tr>
<tr>
<td>Nash uniform toll</td>
<td>-13.43</td>
<td>-19</td>
<td>Toll much larger than MECC</td>
<td>Lower capacity and high uniform tolls; severe toll exporting (double marginalisation); tolling reduces welfare</td>
</tr>
<tr>
<td>Toll on local demand only</td>
<td>0.33</td>
<td>-3</td>
<td>Toll zero</td>
<td>Lower capacity because it mainly benefits transit</td>
</tr>
</tbody>
</table>

**Table 5 Summary of findings serial case**

(% changes are relative to the reference case without tolling)
Table 6  Summary of findings for parallel network

(\% changes are relative to the reference case without any tolling)

3.4 Conclusions on network pricing and capacity choices by member states

The purpose of this chapter was to provide guidance on the toll and capacity choices to be expected from member states on serial and parallel networks.

In serial networks (where transit traffic uses an infrastructure that passes through two different countries) the main problem is the potential for excessively high user prices (“double marginalisation”). This can be overcome by cooperative solutions between the two price setters or by giving the concession for the pricing of the network to one operator rather than to one operator per country. Contrary to common belief, the requirement to charge the same tolls to transit as to local users is not at all sufficient to avoid too high user prices. The excessive pricing problem can be so severe that it may be better not to allow any user charging at all.

In parallel networks, the main problem is insufficient investment whenever user pricing is not present. Whenever user pricing is possible, even if it discriminates against transit traffic, user pricing will give incentives for more investments and the competition between the two parallel links will keep tolls from becoming much too high.

These lessons have been drawn from a simple network setting and using many simplifying assumptions. This points to the necessity to be very careful in including the network structure and the strategic behaviour of member states (or the operators they control) in the cost benefit assessment of project. We return to this issue in our conclusions.
4 MARK-UP RULES TO FUND INVESTMENT AND TO FINANCE THE OPERATION OF A FUND

Marginal social cost (msc) pricing is not always sufficient to cover the cost of an infrastructure project. There are three ways to cope with this problem. Either the user of the infrastructure project pay more (internal mark-up), the infrastructure is financed by letting the whole transport sector (even those who do not use the specific infrastructure) contribute (external mark-up) or non transport money from the general budget is used. The aim of this chapter is to examine the economic efficiency cost of decreasing the financial deficit of a transport project by using internal mark-ups. These will later be compared with the two other ways to fund the deficit. The use of mark-ups in the rest of the transport sector will be analysed in D3 using TREMOVE II that covers the whole transport sector. For the cost of general budget money one can rely on estimates of the marginal cost of public funds.

When internal mark-ups are used, only the users of the infrastructure will contribute to the cost of the project. Charging higher tolls will result in a lower usage; some of the users will choose not to travel anymore, but others will be diverted to other modes or alternatives. If we assume that all other alternative modes are correctly priced we can consider the project in isolation; this is called the one-mode approach. If, however, there exists another mode that is incorrectly priced we will have to consider the possible spillovers (two-mode approach). We will first study the effect of mark-ups in the one-mode approach and next add a second mode. In the third section we conclude and discuss a few caveats.

In this chapter we will use a very stylised model of the transport market. It is the well known “cost recovery model” that can deal with different elasticities in demand, different degrees of returns to scale in capacity extension and different congestion functions but can still deliver analytical results. We need the analytical results to have a rough idea about the cost recovery possibilities for very different circumstances. We will also assume throughout this chapter that the demand for transport is known and that capacity can be added continuously\(^7\). Risk and uncertainty aspects are dealt with in the next chapter.

4.1 One-mode approach

Extra mark-ups will be needed if revenues from marginal social cost pricing are smaller than the cost of capacity\(^8\). The aim of this section is to compute the efficiency loss of such internal solution.

To start we will first investigate how much of the investment cost is financed with optimal user pricing. We know from the literature (cost-recovery theorem of Mohring et al. (1962)) that if the user cost function is homogeneous of degree zero in volume and capacity, and capacity is perfectly divisible, then with marginal-cost pricing the cost-recovery ratio is:

\[^7\] Most of the results carry over in a setting where the timing of investments is not optimal (see Arnott et al. (1998) and discussion in de Palma et al. (2005))

\[^8\] We are using a one period model in which the cost of capacity is understood as the rental cost of capital (this is the annuity if constant demand and variable costs).
\[ \rho = \frac{\text{Toll revenues}}{\text{Capacity cost}} = \varepsilon \quad (1) \]

where \( \varepsilon \) is the elasticity of the capacity cost function and we call the revenues in excess of the variable costs “tolls”; this is the net contribution to fund the capacity costs. For instance, if doubling the capacity, costs only 50% more, the elasticity is equal to \( \varepsilon = 0.585 \) (and optimal tolls can cover the variable operating cost plus 58.5% of the rental cost of capacity. We are interested to go one step further and ask ourselves what will be the welfare cost of increasing the cost recovery ratio. We use the same formal framework as de Palma and Lindsey (2005), who assume constant-elasticity functions for costs and demand. The average user cost function (mainly the time and comfort cost) is

\[ C(N, K) = d \left( \frac{N}{K} \right)^s, \quad (2) \]

where \( N \) denotes the number of users of the facility, \( K \) the capacity of the facility and \( s \) the elasticity of user costs with respect to the volume/capacity ratio. The cost of capacity and the demand function are respectively;

\[ F(K) = kK^\varepsilon \quad (3) \]

and

\[ p(N) = p_0 N^{-1/\eta} \quad , \quad (4) \]

where \( \eta \) is the absolute price elasticity of demand. To study the effect of mark-ups it is assumed that the toll (\( \tau \)) is set at a fraction \( f \) of its first-best optimal level (here the marginal external congestion cost equals the derivative of the average user function times the number of users: \( c_N N^* \))

\[ \tau = f \cdot \tau^* = f \cdot c_N N \quad (5) \]

(Nota note that if the toll exceeds its optimal level, \( f \) can be higher than one.) Using these functional forms, it is straightforward to compute the equilibrium usage and second-best capacity. They turn out to be

\[ \bar{K} = \left( \frac{ds}{k\varepsilon} + \frac{f s\eta}{1 + s\eta} \right)^{1+\varepsilon} \left( \frac{p_0}{(1 + f s)d} \right)^{\eta(s-1) + s + \varepsilon} \quad (6) \]

and

\[ \bar{N} = \left( \frac{p_0}{(1 + f s)d} \right)^{\eta(s-1) + s + \varepsilon} \left( \frac{ds}{k\varepsilon} + \frac{f s\eta}{1 + s\eta} \right)^{\frac{s\eta}{(s-1) + s + \varepsilon}} \quad (7) \]

The cost-recovery ratio is then in this case given by

\[ \rho = \frac{\tau \bar{N}}{F(K)} = \frac{1 + s\eta}{1 + f s\eta} f \varepsilon \quad . \quad (8) \]

\[ \frac{F(2K)}{F(K)} = \frac{k(2K)^\varepsilon}{k(K)^\varepsilon} = 1.5 \Rightarrow 2^\varepsilon = 1.5 \Rightarrow \varepsilon = 0.585 \]
For a given \( f \) the distortion is a decreasing function of \( s \eta \), and in the limit where \( s \eta \to \infty \), the distortion vanishes and \( \rho \to \infty \). Since \( \rho \) is strictly increasing in \( f (\partial \rho / \partial f > 0) \), the maximum cost-recovery is attained when \( f \) goes to infinity

\[
\rho \to f\infty \left( \frac{1 + s \eta}{s \eta} \right) \varepsilon .
\]

(9)

If, for example, \( \eta = 0.5 \) and \( s = 4 \), then \( \rho \to 1.5 \varepsilon \). For rail, \( \varepsilon \) could be around 0.3 (Nilsson (2002) gives 0.2, other sources give higher values). So, in this case the maximum cost-recovery we can obtain is slightly less than half of the investment costs. We thus see that for small \( \varepsilon \) high mark-ups will be needed to finance infrastructure. The precise value will depend on the parametric values of the project in question.

So far we examined the potential of increasing the recovery ratio of a project. In the end we are interested in the efficiency cost of reducing the internal deficit of a project. A reduction in deficit (or an increase of the cost-recovery ratio) could be achieved by deviating from msc pricing and charging a toll larger than optimal (\( f > 1 \)). In this case the deficit will decrease but so will social welfare since charging is no longer optimal. To compute the loss in welfare recall that the social surplus is given by the formula

\[
\Omega = \int_{n=0}^{N} P(n) d\!n - c(N, K) N - F(K) .
\]

(10)

Making use of equations (2), (3) and (4), the loss (or gain) in welfare when raising the toll from \( \tau = \tau' = f^1 \tau^* \) to \( \tau = \tau^2 = f^2 \tau^* \) can be computed and is given by:

\[
\Delta \Omega = \eta \frac{P_{\tau\tau}}{\eta - 1} \left[ \left( N^1 \right)^{\frac{1}{\eta}} - \left( N^2 \right)^{\frac{1}{\eta}} \right] - d \left[ N^1 \left( \frac{N^1}{K^1} \right)^\varepsilon - N^2 \left( \frac{N^2}{K^2} \right)^\varepsilon \right] - k \left[ \left( K^1 \right)^\varepsilon - \left( K^2 \right)^\varepsilon \right],
\]

(11)

where \( N^i \) is the number of users when \( \tau = \tau' \) and \( K^i \) is the second best capacity.

Let \( D(\tau) = \tau N - F(K) \) denote the deficit of the project and \( z = D(\tau^1) - D(\tau^2) \) the extra revenue extracted out of the project when the toll is raised from \( \tau^1 \) to \( \tau^2 \). We are interested in the trade-off between welfare loss and deficit decrease and more precisely in the welfare loss per extra euro extracted out of the project. This will be given by the ratio of the loss of welfare and the extra revenue collected (\( \Delta \Omega / z \)).

As noted before, the cost-recovery and the efficiency loss from internal mark-ups will strongly depend on the parametric values of the problem. Suppose \( s = 4 \), corresponding to a steeply increasing user cost when one reaches capacity. If we moreover assume the absolute price elasticity of demand to be \( \eta = 1.11 \) and \( \varepsilon = 0.3 \) then we have the following results\(^{10}\), shown in Table 7 below:

The first column corresponds to the first best situation, where we normalized usage and capacity to 100. We see that when we increase the toll above its first best level, usage decreases. The decrease in usage implies that less capacity is needed and thus the second-best capacity will decrease. The decrease in usage is compensated by the decrease in capacity together with the increase in toll which results in an increase of the

\(^{10}\) The other parameters \( d, p_0 \) and \( k \) are all normalized to one.
cost recovery ratio (decrease in deficit). But this decrease in deficit is at the cost of efficiency (last row). We see that increasing the cost recovery beyond 0.356 becomes very costly; to reduce the deficit by one euro you will incur an average efficiency cost of approximately 2.5 euros.

| toll | 0.044 | 0.05 | 0.055 | 0.061 | 0.066 | 0.072 | 0.078 | 0.089 |
| quantity | 100 | 93.2 | 87.7 | 82.1 | 76.3 | 70.8 | 65.8 | 57.8 |
| capacity | 100 | 99.5 | 98.7 | 97.4 | 95.7 | 93.9 | 91.9 | 88.4 |
| cost-recovery average efficiency cost per euro of deficit reduction | 0.3 | 0.319 | 0.33 | 0.339 | 0.346 | 0.352 | 0.356 | 0.36 |
| N/A | 0.182 | 0.553 | 0.915 | 1.312 | 1.723 | 2.111 | 2.582 |

Table 7 Efficiency costs of internal mark-ups in the one mode model

Starting from an elasticity of the capacity cost function of 0.3, higher cost recovery is possible when the congestion function is less steep and when demand is more elastic but it remains very costly if not impossible to reach full cost recovery.

4.1.1 Two-mode approach

In the previous section we showed that a mark-up (price above msc-pricing) to finance the investment project will lead to a welfare loss due to overpricing of the infrastructure use. If there is an underpriced existing substitute for this project (typically road or air traffic for a rail project), there will be an additional welfare loss since part of the users that decided not to use the overpriced mode anymore will switch to the underpriced mode and increase the existing inefficiency (in Figure 5 we see that the increased toll on mode 1 shifts the demand on mode 2 to the right, resulting in an unwanted increase of the number of users).

Figure 5 Extra efficiency loss on underpriced mode due to mark-ups

The extra welfare loss will be given by $\Delta \Omega_2 \approx \Delta N_2 \left( p_2 - msc_2 \right)$ where the increase in demand will depend on the cross elasticity between the two modes ($\varepsilon_{12}$) and the new...
toll level of the first mode: \( \Delta N_2 = Q(\varepsilon_{i2}, \Delta p_1) \). Since \( \varepsilon_{i2} = \frac{\partial N_2}{\partial p_1} \frac{p_1}{N_2} \), if we assume that \( N_2 = \alpha N_1 \) when mode 1 is optimally priced, we have \( \varepsilon_{i2} = \left( \frac{\partial p_1}{\partial p_i} \right) \frac{\alpha N_1}{p_i} \) \( \Rightarrow \Delta N_2 = \frac{(\Delta p_1)(\alpha N_1)\varepsilon_{i2}}{p_i} \).

Returning to the numerical example of the previous section where \( s = 4 \), \( \eta = 1.11 \), and \( \varepsilon = 0.3 \), we now add an underpriced alternative. Suppose that the user cost on this mode is 0.015 euro less than the marginal social cost: \( p_2 - msc_2 = -0.015 \) and that the number of users of mode 2, when mode 1 is optimally priced, is five times higher \((\alpha = 5)\). The cross elasticity between the two modes is assumed to be equal to 0.07\(^\text{11}\). For these parameter values we get following results:

| toll mode 1 | 0.044 | 0.05 | 0.055 | 0.061 | 0.066 | 0.072 | 0.078 | 0.089 |
| quantity mode 1 | 100 | 93.2 | 87.7 | 82.1 | 76.3 | 70.8 | 65.8 | 57.8 |
| capacity mode 1 | 100 | 99.5 | 98.7 | 97.4 | 95.7 | 93.9 | 91.9 | 88.4 |
| cost-recovery | 0.3 | 0.319 | 0.33 | 0.329 | 0.346 | 0.352 | 0.356 | 0.36 |
| average efficiency cost per euro of deficit reduction for mode 1 | N/A | 0.182 | 0.553 | 0.915 | 1.312 | 1.723 | 2.111 | 2.582 |
| average efficiency cost per euro of deficit reduction for mode 2 | N/A | 0.116 | 0.143 | 0.167 | 0.191 | 0.210 | 0.225 | 0.249 |
| total efficiency loss per euro of deficit reduction | N/A | 0.289 | 0.695 | 1.082 | 1.503 | 1.933 | 2.336 | 2.830 |

Table 8 Efficiency cost of internal mark-ups with spillovers

In this particular example, a third of the users that do not use mode 1 anymore due to the increase of the toll will shift to mode two. An increase of the toll above its first best level will reduce the number of travellers on mode 1 and will thus also reduce the number of users that shift to the underpriced mode. Take as an example an increase of the toll from 0.044 to 0.05. This will increase the cost recovery to 0.319. This generates an efficiency loss of 0.182 euro per euro of deficit reduction on the market of mode 1. One third of the reduction in trips for mode 1 (here 1/3 of 6.8) will switch to the underpriced mode 2. This in itself will generate an efficiency loss on the market of mode 2 of 0.116 euro per euro deficit reduction on market of mode 1. The total efficiency cost on both markets of increasing the toll on mode 1 will now be equal to 0.289 euro per euro deficit reduction on mode 1. This means that 40% of the total efficiency cost is due to substitution effects, When one continues to increase the toll on mode 1, the extra efficiency cost due to the substitution to the underpriced mode will become relatively less important: if you increase the toll from 0.078 euro to 0.089 euro less than 10% of the total efficiency cost will result from deviated users. The main

\(^{11}\) This means that of the users of mode 1 only one third would switch to the other mode. This is obviously an assumption that does not necessarily correspond to reality.
reason is that we assumed that the market distortion on the market of mode 2 was constant: this makes more sense for say air pollution or accident externalities than say for congestion externalities.

In the case of rail TEN-Ts, the substitution mode is often interurban road or air and it is important to know whether prices for these modes are too low or not. Prices that are too low are a clear justification for lower cost recovery in rail of IWW.

Car and truck use is mostly underpriced in urban areas and in the peak travel periods. This is less the case for interurban traffic because cars and trucks are becoming much cleaner than in the past: there is an important fuel tax, congestion is limited and congestion pricing is making its way on the most acute segments.

As regards air travel, there is indeed an air pollution cost that is not internalised but some of the air traffic prices also have an important monopolistic margin, so that again underpricing has to be shown on a case by case basis.

4.2 Caveats and conclusions

In this chapter we used a very simple model to study the cost recovery ratio of marginal social cost pricing and the efficiency cost of increasing the cost recovery ratio. We found that:

- the cost recovery ratio is equal to the degree of scale economies in capacity extension – for rail this may be as low as 0.2 while for roads this may be closer to 1.
- the cost recovery ratio can be increased by higher user prices but the maximum cost recovery may remain well below 1:
  - the efficiency cost of increasing the cost recovery beyond the degree of scale economies becomes quickly very high
  - this implies that one has to be careful to advance minimum cost recovery rates that are not in line with the economies of scale of the project.

The analysis in this chapter is based on a very simple model using strong assumptions. Some of the assumptions introduce a clear bias:

- the model only used a single price (or toll) and did not consider price discrimination, block pricing, multi part pricing etc.. It is well known that the use of more sophisticated pricing techniques allows the cost recovery ratio to be increased and can do this at a lower welfare cost. Unfortunately there is no simple general model that allows general results to be obtained.
- We assumed that the user cost is a function of the volume over capacity ratio and this rules out Mohring effects. The Mohring effect means that the absolute volume of traffic allows the frequency of service to be increased and the waiting time to be reduced. This implies that first best user prices should actually be lower than in the model we used, in order to allow for the positive externalities, and that our simple model would overestimate the cost recovery ratio in first best. The Mohring effect is considered less important for interurban traffic so that the bias may not be important.
5 DEALING WITH RISK IN TRANSPORT INVESTMENTS

5.1 Introduction

Risk is an important element in all investment decisions. This is particularly true for long lead transport investments. The first section of this chapter discusses the origin of risks, the role of risk sharing in the funding of infrastructure and the monetarisation of risks. The second section deals in more detail with the introduction of risk in cost benefit assessments of transport projects. The final section deals with the question whether overinvestment in capacity is justified in the presence of demand uncertainty.

5.2 Risk taking

5.2.1 Risk factors in Cost-Benefit Analysis

In recent years a large number of failures of large projects have been observed. The Suez Canal and Euro Tunnel provide only two among numerous well known examples. One way to avoid such failure is to implement a good and realistic cost-benefit analysis (CBA). There are various sources of uncertainty which may affect the costs and the benefits of large scale projects. They correspond to, roughly speaking, demand uncertainty, supply uncertainty as well as to various macroeconomic shocks. It is our belief that risk and uncertainty are not well taken into account in current cost-benefit analysis. However, risk and uncertainty affect the major ingredients of the cost-benefit analysis during the whole process of construction, operation and maintenance of a project. Among other things, risk and uncertainty may affect:

- demand (passengers and freight)
- production cost (which are often underestimated)
- maintenance costs (which are typically underestimated, especially in developing countries)
- industry structure and regulation (see, e.g., the unexpected crucial impact of the low cost companies in the airline industry)
- market regulation (potential market and contestability)
- execution time (which is typically underestimated to a large extent)
- macroeconomic and regional context (which, of course, have an influence on demand and interest rates)
- interest rate (which depends on the level of risk anticipated by the lender and is therefore endogenous)
- other financial variables (which are difficult to predict especially in the case of PPP)
- human resources context (which crucially depends on the quality of the management)
- political environment (which is especially crucial for public infrastructures, both between political parties and between cities or regions)
- evaluation of secondary infrastructures (the main problem is the definition of the area of interest and of the alternative modes taken into account)
- accompanying measures (for example, CBA gives very different results in the railway case for passengers in Europe and in Japan because in Japan the railways draw a large proportion of benefits from accompanying infrastructures such as shopping centres)
- value of time, value of reliability and schedule delay costs
• value of external costs (accidents, noise, human life, local and global environmental cost)
• scrap value (which is often forgotten or biased).

Various tools are proposed by different CBA studies to take risk into account. They include:
• sensitivity analysis (these approaches often ignore correlation between the different variables)
• analysis of different coherent scenarios
• Monte-Carlo simulations (which take into account some correlations, based on some joint distribution).

We argue that the last analysis should be used on a more regular basis, and should be based on a careful choice of realistic joint distributions, when the tails matter (which is the case in CBA studies). Indeed, the true distributions generally cannot be approximated in a satisfactory way via parameterized distributions such as Normal or even Extreme value. In addition, a limited number of correlation parameters is usually not enough to model the joint distributions. All this means that an analysis of extreme values for the final output of a project is necessary in order to parameterize the relevant figures in CBA analysis.

5.2.2 Risk sharing and funding of infrastructure

The different dimensions of risk are more or less intensively correlated both from an inter-temporal point of view and from a geographical point of view. For example, the demand for freight transportation depends on several factors including macro-economic conjuncture. As a result, demand for transport, which may depend (positively or negatively) on business cycles will obey a complex inter-temporal pattern. Our simulation tool (MOLINO II\textsuperscript{12}) allows this pattern to be translated into a set of random variables with a realistic joint distribution. Such data are typically analyzed using time series techniques with autoregressive terms. The MOLINO II tool will allow simulating series for each relevant variable based on realistic distributions estimated in the literature. The approach proposed here then allows us to evaluate how this complex inter-temporal pattern determines the distribution of risky costs and benefits.

Similarly, the demand for use on highway A and highway B, for example, are spatially correlated at a given point in time for two opposing reasons. First, the aggregate conjuncture may affect both highways in a similar way, inducing a positive correlation between the demands on both highways. Second, since some drivers have to choose between the two highways, positive deviations of the demand on highway A (for example as a result of some unobserved marketing campaign) will be associated with negative deviations of the demand on highway B, inducing a negative correlation between the demands on both highways. As a result of these two opposing forces, the correlation between demand on highway A and highway B may be positive or negative.

The management of the funding of infrastructure (and in particular of infrastructure funds) depends crucially on the way the different facets of risk imbedded in the joint distribution of all relevant variables aggregate in the distribution of the discounted net benefit. We argue that the analysis limited to the first two moments (mean and variance)

\textsuperscript{12} The MOLINO model is described briefly in the appendix.
of this distribution is insufficient to provide useful advice on the best ways to manage infrastructure funds.

The optimal (first-best) share of risk requires knowledge of the joint distribution of the discounted net benefits. Two standard arguments have been advocated by several authors and in particular by Jean-Jacques Laffont and Jean Tirole (1993), to justify the fact that a system with a principal (the fund manager) and one or several agents (operators) may not behave optimally because of asymmetric information, inducing moral hazard (the agents do not perform their task with the optimal effort since its level cannot be observed directly by the principal) and adverse selection (only the “bad guys” are willing to participate). For example, in France, RFF (the principal) who owns the rail tracks has much less information about costs and demand, than SNCF (the agent), who operates the train and manages the tracks. This private information can be used by SNCF in the bargaining process.

Moreover, the right incentive (second best) should induce the most efficient operators to be selected (thus solving adverse selection problems) and should have them operate with the optimal level of effort (thus solving moral hazard problems). Therefore, the level of risk that will be borne by each actor will be such that, one the one hand, the “right” operator should be willing to participate (participation constraint condition) and on the other hand that, once he is selected, he will perform his task with the optimal level of effort (incentive constraint condition). The second-best situations are analysed in detail by Laffont and Tirole who use rather simplified assumptions on risk (e.g. the variability is summarized by two states of nature, good and bad). We argue that such simplified assumptions should not be used in the context of infrastructure funding because the distribution tails really matter. In the case of CBA under risk, we therefore wish to use more realistic descriptions of the impacts of risk, taking into account the whole distribution of the net benefits.

We are still some way from the situation where the correct tools will be used to take risk into account in the cost-benefit analysis. The next generation of researchers, in our opinion, will discover some rather sophisticated tools used in finance: “the theory of real option”, will play an essential role in the strategic management of investment in an uncertain situation, for example. There remains, however, a long way to go, and we propose here a first step in that direction.

### 5.2.3 Risk and uncertainty

The distinction between risk and uncertainty is important, although the treatment of this distinction remains very far from the current practice in CBA. A risky environment corresponds to situations in which probability distributions are known, whereas uncertainty corresponds to situations in which probabilities, and possibly the list of potential outcomes, are unknown. In this case, the decision maker should rely on some believes, which he can revise once he accumulates new relevant information. The distinction between risk and uncertainty has been extremely well summarized in the famous book by Keynes:

“By ‘uncertain’ knowledge [...] I do not merely distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty; nor the prospect of a Victory bond being drawn... Even the weather is only moderately uncertain. The sense in which I am using the term is that in which the
prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence... About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know”.

Even though it has been shown that individuals behave differently when they face risk than when they face uncertainty, here we will mainly focus here on risk. In the presence of uncertainty, the principle of minimum regret introduced by Savage (1954) can be used, but it is beyond the scope of this research.

5.2.4 Monetarization of risk

We will consider here a simple example due to Sudhir and Nalebuf (1987), which show that small fluctuations may have potentially a very large impact in the CBA analysis when these shocks are correlated with the macroeconomic context.

We use the following notation: \(z\) represents the certainty equivalent of a project with a random yield of \(Z\) (per capita). \(Y\) represents the (random) GNP (per capita). \(U(.)\) denotes the (increasing) utility function of a representative consumer and \(\mathbb{E}[]\) denotes the expectation operator. The certainty equivalent, \(z\), is the unique solution of the following equation:

\[
\mathbb{E}
\left[
U(Y+Z)
\right] = \mathbb{E}
\left[
U(Y+z)
\right].
\]

(12)

Clearly, when the utility function is linear (risk neutrality), we have: \(z=\mathbb{E}[Z]\). When the utility function is concave (risk aversion) and risks are not correlated, we have \(z<\mathbb{E}[Z]\).

We now argue that the variances and the covariance (for yield and GNP) play important roles in the measurement of the certainty equivalent. Let \(\text{Var}[Z]\) denote the variance of the yield and let \(\text{Cov}(Y,Z)\) denote the covariance between yield and GNP. We also introduce the relative risk aversion \(RR(x)\), which is defined as \(RR(x)=-xU''(x)/U'(x)\). In this case, it can be shown that the certainty equivalent is given by the following relation:

\[
z = \mathbb{E}(Z) - \frac{1}{2} \frac{RR\left(\mathbb{E}[Y] + \mathbb{E}[Z]\right)}{\mathbb{E}[Y] + \mathbb{E}[Z]} \left\{ \mathbb{V}[Z] + 2\text{Cov}[Y,Z] \right\}. \]

(13)

Note that, in the standard case, relative risk aversion is positive since agents are risk averse. When \(Y\) and \(Z\) are positively correlated (the most likely case), the covariance magnifies the impact of the variability of the yield (negative effect on the certainty equivalent \(z\)). However, the situation can be qualitatively different (the positive covariance effect can offset the negative effect of the variability of yield) when \(Y\) and \(Z\) are negatively correlated. In that case, if the absolute value of the correlation between \(Y\) and \(Z\) is large enough and if the variance of \(Y\) is large compared to the variance of \(Z\), (namely, if \(\text{Corr}[Y,Z] < -\sqrt{\mathbb{V}[Z]/4\mathbb{V}[Y]}\)), we have \(z>\mathbb{E}[Z]\).

We provide below a simple numerical example. We assume that the value of the relative risk aversion is \(RR(.)=2\) and that the per capita income is either 100 with certainty, or 110 or 90 with equal probabilities. We further assume that yield and GNP are negatively correlated (the reader can easily treat the more intuitive case in which yield and GNP are positively correlated). For a negative correlation, we have the following result:
Variable | Scenario 1 | Scenario 2
--- | --- | ---
Per capita income Y | 100 | 110 (Prob=½): state H
| | | 90 (Prob=½): state L
Yield project Z | 0.5 (Prob=½): state H | 0.5 (Prob=½): state H
| | 1.5 (Prob=½): state L | 1.5 (Prob=½): state L
\(\{z - \mathbb{E}[Z]\} / \mathbb{E}[Z]\) | -0.25% | +10%

Table 9 Impact of variance and correlation (RR=2)
Source: Adapted from Sudhir and Nalebuff (1987)

This example shows that fluctuations in yield are not negligible if they are correlated with the economic performance. When the yield is negatively correlated with the GNP, the value of the project (here measured by \(z\)) would be underestimated if the correlation term were omitted. In our numerical example, \(z\) is 10% more than \(\mathbb{E}[Z]\), whereas it would be 0.25% less than \(\mathbb{E}[Z]\) with deterministic per capita income. With negative correlation, the project has a significant additional social value because it damps the macroeconomic fluctuations.

5.3 Risk and investment

5.3.1 Net Present Value

Before the 1950s, two parameters were reported in the analysis of a project: the time horizon for full refund and the average rate of return of this investment. In the 50’s, several authors (see, e.g. Dean, 1951 and, later on, Lesourne, 1972) have introduced the concept of Net Present Value (NPV), which measures the discounted value of an investment. It is defined by:

\[
NPV_S(r) = \sum_{t=0}^{n} \frac{S_t}{(1 + r)^t},
\]

where \(n\) denotes the time horizon considered, \(S_t\) denotes the net cash flow for year \(t\) and \(r_t\) is the interest rate for period \(t\) (and \(r\) denotes the vector of interest rates over the time horizon considered). One project will be preferred to another one if its NPV is larger. In practice, the cash flow depends on demand and cost, which are uncertain, and there may be some disagreement concerning the value of the interest rate to be chosen. Indeed (at least if money is borrowed in the market), more risky projects should use higher interest rates. A simple way to address those criticisms is to consider the net cash flow as a random variable and define a criterion to compare projects, which explicitly takes into account the randomness of \(S_t\).

The (endogenous) interest rate is given by the following formula (see, e.g., Gollier, 2005):

\[
r_t = \delta + \gamma m(t) - 0.5\gamma^2 \sigma^2,
\]

where \(\delta\) denotes the impatience rate, \(\gamma\) denotes the constant level of the relative risk aversion parameter, \(m(t)\) denotes the average growth rate of the GNP per capita over the period considered and \(\sigma\) represents the standard deviation of the growth rate of the GNP per capita. In the following example, we assume that \(\delta=2\%,\ \gamma=4,\ m(t)=2\%.\ We\ also\ assume\ that\ \sigma\ is\ small\ enough\ that\ the\ last\ term\ in\ (4)\ can\ be\ omitted.\ Therefore,\ we\ get\ an\ interest\ rate\ of\ 10\%\ . (Note, however, that the interest rate used in France, for
example, in the cost-benefit analysis is slightly lower, typically 8%, as recommended by the “rapport Boiteux 2”, see Commissariat Général du Plan, 2001.) These figures have been updated recently by Gollier (2005) who suggests 4% for the short term interest rate and 2% for the long term (larger than 30 years) interest rate.

The simplest criterion is the Mean-Variance model. It can be seen as the expected utility of the NPV when NPV has a Gaussian distribution and utility is of the CARA (negative exponential) form. The expected value of NPV is:

$$\mathbb{E}[NPV_s(r)] = \sum_{i=0}^{n} \mathbb{E}[S_i] \left(1 + r_i\right)^{-n}$$

while its variance is:

$$\mathbb{V}[NPV_s(r)] = \sum_{i=0}^{n} \mathbb{V}[S_i] \left(1 + r_i\right)^{-2} + 2 \sum_{i \neq j} \mathbb{Cov}[S_i, S_j] \left(1 + r_i\right)^{-1} \left(1 + r_j\right)^{-1}$$

In the Mean-Variance model, the value of a project for a decision-maker is measured by $\mathbb{E}[NPV_s(r)] - \gamma \mathbb{V}[NPV_s(r)]$. Recall that $\gamma$ denotes the relative risk aversion of the decision-maker. A higher value of $\gamma$ means that the decision-maker is less willing to take risk.

5.3.2 Stochastic order and utility functions

When the NPV is stochastic, we have seen that the expected value and variance provide valuable information to rank projects. Although this model has been widely used in finance, it has been criticized in the transport literature (see, e.g., de Palma and Picard, 2006). Indeed, it can be shown that with this utility function an individual (enough risk averse) may prefer to received X for sure, than receiving $X - \varepsilon$ $(\varepsilon > 0)$ with probability 0.5 and X with probability 0.5. This violates first principles (the monotonic property of the utility functions). More general criteria based on second order stochastic dominance can be used to rank projects. 13 Let $F_i$ denote the cumulative distribution function (CDF) of the NPV corresponding to project $i$ and $G_i$ the integral of $F_i$.

Project $X$ is said to First-Order dominate project $Y$ if its CDF is always lower. Mathematically, this means that:

$$X \succeq_{FD} Y \Leftrightarrow F_X(\eta) \leq F_Y(\eta), \forall \eta \in \mathbb{R}.$$  

It can be shown that there is a close relationship between First-Order stochastic dominance and the expected utility criteria. Let $U(NPV)$ denote the utility of the decision-maker and $\mathcal{C}$ the set of continuous and increasing functions on $\mathbb{R}$. We have:

$$X \succeq_{FD} Y \Leftrightarrow \mathbb{E}[U(NPV_X)] \geq \mathbb{E}[U(NPV_Y)], \forall U \in \mathcal{C}.  \quad (19)$$

A stronger result can be obtained for risk averse decision-makers. Let denote by $\mathcal{CIC}$ the set of continuous, increasing and concave functions on $\mathbb{R}$.

Project $X$ is said to Second-Order dominate project $Y$ if its integrated CDF is always lower. Mathematically, this means that:

$$13 \text{ Second order stochastic dominance is also well known in the finance and economics literature. See, for example, Gollier 2001.}$$
It can be shown that there is a close relationship between Second-Order stochastic dominance and the expected utility criteria. We have an equivalence between Second-Order stochastic dominance and expected utility for risk averse decision makers:

\[ X \geq_{DS2} Y \iff E[U(\text{NPV}_X)] \geq E[U(\text{NPV}_Y)], \forall U \in \mathcal{C} \]  

When the NPV of two projects have the same expectation and the same variance, it is still possible to rank the two projects. It has been observed empirically that, in this case, decision-makers have a greater dislike of distributions, which are thicker on the left than on the right. More precisely, Menezes, Geiss and Tressler (1980) have shown that a project \( X \) is preferred to a project \( Y \) for all preferences \( U(.) \) such that \( U'''(\eta) > 0 \) for all \( \eta \) if and only if \( Y \) has more downside risk than \( X \). Recall (see Menezes et al., 1980) that \( Y \) has more downside risk than \( X \) if \( Y \) can be obtained from \( X \) by a sequence of probability transfers \( t_i \) which unambiguously shift dispersion from the right to the left without changing the mean and the variance (MVPT, or Mean-Variance Preserving Transformations). Note that individuals such that \( U'''(\eta) > 0 \) dislike downside risk, but may be risk averse or risk lovers.

The above discussion suggests that the expected value and variability are not enough to evaluate the distribution of returns, but that the tails of the distribution also matter\(^{14}\). When the decision-maker is interested in the NPV, he will focus on the left tail, whereas when he is interested in the cost, he will focus on the right tail. We now turn to quantitative indicators explicitly focusing on the relevant tail (the one corresponding to the worst events).

### 5.3.3 The Value at Risk

The Value at Risk of a project for a probability \( p \) (for example 5\%) corresponds to the value (quantile) \( q \) such that no more than \( p\% \) of the time \( \text{NPV}_X \) is less than \( q \). The Value at Risk \( \text{VaR}_X(p) = q \) satisfies the following equation:

\[ \text{Prob}(\text{NPV}_X \leq \text{VaR}_X(p)) = p \]  

Recall that the CDF of \( \text{NPV}_X \) is \( G_X(.) \), so that \( \text{VaR}_X(p) = (G_X)^{-1}(p) \). The VaR of a project \( X \) expresses the level of risk acceptable for this project. It depends on two ingredients: the probability distribution of \( \text{NPV}_X \) and the level of confidence of the decision-maker, which is measured by the probability \( p \). Of course, the VaR depends on the time horizon of the project as well as on the interest rate which has been chosen. Note also that it is reasonable to neglect events which are associated with a very low probability although they have a very dramatic impact on the project. They correspond to events which cannot be insured and which can therefore be omitted from the current analysis (earthquake, terrorist attack, coup d’état).

The computation of the VaR requires knowledge of the whole distribution of \( \text{NPV}_X \), and therefore of the joint distribution of the yearly returns of the project. Three methods can be envisaged for computing the VaR:

- The historical analysis assumes that the distribution of the returns can be inferred from the distribution of the yearly returns observed in the past for

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\(^{14}\) The distribution is a density function: \( x \) corresponds either to NPV or to cost, and \( y \) represents the corresponding density at point \( x \).
similar projects. This does not rely on a parametric distribution of returns. The drawback is that it requires a very large amount of data on similar past projects, so that the tails are significantly represented.

- The variance-covariance method assumes that the yearly returns are jointly normal, so that the joint distribution of returns can be easily computed. The drawback is that the tails can be very poorly represented under the normality assumption.
- The Monte-Carlo method involves the computation of a non-parametric joint distribution of the returns. It is less restrictive and more realistic than the previous ones. Its drawback is that it requires a very large amount of computations.

Although the VaR provides a convenient way of evaluating the risk attached to a project, it has been criticized over several aspects briefly discussed below. First, its value is sensitive to the method used to compute it (see above), and is therefore to some extent subjective. The VaR is more popular in finance, since the time scale (daily or hourly returns over many years) allows very large data sets to be used. It is then possible to perform backtesting, that is to compare the predicted VaR to the actual fraction of very low returns. Second, the information imbedded in the VaR is limited since it only tells the probability of the NPV being lower than some threshold, but does not specify how low the NPV is when it is below the threshold. We introduce another measure of risk below which does not suffer from this second drawback.

5.3.4 The Conditional Value at Risk

The Conditional Value at Risk of a project for a probability $p$ (for example 5%) corresponds to the expected value of $NPV_X$ conditional on $NPV_X \leq VaR_X(p)$. The Conditional Value at Risk is formally defined by the following equation:

$$CVaR_X(p) = \mathbb{E}[NPV_X | NPV_X \leq VaR_X(p)]$$  \hspace{1cm} (23)

It is worth noting that the CVaR can be obtained as the maximization of a concave one-dimension function. We transpose the result obtained by Rockafellar and Uryasev (2002) from the case of losses to the case of Net Present Value:

**Theorem:** The VaR and CVaR of a project $X$ for probability $p$ can be obtained as:

$$VaR_X(p) = \arg \max_{\nu \in \mathbb{R}} \left[ \frac{1}{1-p} \mathbb{E} \left\{ \max \left( NPV_X + \nu, 0 \right) \right\} - \nu \right]$$ \hspace{1cm} (24)

and

$$CVaR_X(p) = \max_{\nu \in \mathbb{R}} \left[ \frac{1}{1-p} \mathbb{E} \left\{ \max \left( NPV_X + \nu, 0 \right) \right\} - \nu \right].$$ \hspace{1cm} (25)

Note that the VaR and CVaR are linked by the following relationship:

$$CVaR_X(p) = VaR_X(p) - \frac{1}{1-p} \mathbb{E} \left\{ \max \left( NPV_X - VaR_X(p), 0 \right) \right\}. \hspace{1cm} (26)$$

In Figure 6, we represent the CDF of the $NPV$ of a project $X$ with an expected $NPV$ of 600 million euros and a standard deviation of 400 million euros. We can observe that the $NPV$ of this project is smaller than 185 million euros 15% of the time, which means
that $VaR_X(0.15) = 1.85$. The $CVaR$ corresponds to the expected $NPV$ in the 15% worst cases, that is when $NPV$ is less than 1.85. Assuming a Gaussian distribution, we obtain $CVaR_X(0.15) = -0.22$, corresponding to an average conditional loss of 22 million euros.

Figure 6  VaR and CVaR of a project X for $p=15$

Source: Authors’ computations

5.4 Implementation in decision rules

The simplest way to compare projects is to compare their expected $NPVs$, which implicitly assumes risk neutrality. Risk-averse decision-makers would prefer the Mean-Variance criterion, and select the project X with the largest $E(NPV_X) - \theta \sigma(NPV_X)$.

However, the above criteria neglect the asymmetry of the distribution of $NPV_X$ and neglect the very poor outcomes of the project, which are the most important ones because of default risk. To remedy this last drawback, we have introduced the $VaR$. For a given level of probability $p$ (chosen by the decision-maker), project $X$ is preferred to project $Y$ if $VaR_X(p) > VaR_Y(p)$. Recall that the asymmetry of the distribution is not taken into account by the $VaR$, and that the $CVaR$ meets this criticism. In this case, for a given level of probability $p$ (chosen by the decision-maker), project $X$ is preferred to project $Y$ if $CVaR_X(p) > CVaR_Y(p)$.

Importantly, the four criteria listed above may lead to different conclusion, especially when some projects have a high expected $NPV$ but a thick left tail. For example, the tail of the double exponential distribution is thicker than the tail of the Gaussian distribution. Since the double exponential distribution is an extreme value distribution, it is likely to be relevant for some parameters of the model.
5.5 Is overinvestment justified in the case of demand uncertainty?

In transportation planning there can be long lead times to adapt capacity. This section addresses two questions. Firstly, in a one mode world (say rail or road), what is the optimal capacity choice when faced with uncertain demand, long lead times and congestion. Using a simple analytical model it is shown that when demand is relatively inelastic, it is socially optimal to invest more than if only the expected level of demand is taken into account. In this case it may be beneficial to overinvest in capacity because congestion costs are a convex function of relative use. This result holds with or without optimal tolling. The second question deals with two competing modes and where only one mode has long lead times for capacity while the other has flexible capacity. This is typical for the competition between high speed rail and air for the medium distance trips (500 to 1000 km) or for the competition between inland waterways and trucks for freight. We find that overinvestment is less justified because the substitute mode can more easily absorb the high demand outcomes.

5.5.1 One mode model

The model

We have opted for a simple model that can be solved analytically. The (generalised) average user cost, capacity cost and inverse demand functions are assumed to be

\[ C(N, K) = \theta \left( \frac{N}{K} \right) \]

\[ F(K) = kK^\varepsilon \]

\[ P(N) = p_0N^{-\eta} \]

where \( N \) is the usage level, \( K \) the capacity of the mode, \( \theta \) value of time of the (homogenous) users. The model defined in (27), (28) and (29) has been used previously by de Palma et al. (2006) mainly to study cost recovery properties of tolls. The average user cost function, (27), becomes independent of usage and capacity when \( s = \theta \); for high values of \( s \) we have a user cost function that increases strongly once the capacity limit is reached. The average cost of capacity, (28), can be decreasing in \( K \) (\( \varepsilon < 1 \)), constant (\( \varepsilon = 1 \)) or increasing in \( K \) (\( \varepsilon >1 \)). In order to make capacity costs comparable to the user benefits in our model with a representative users' period, we need two assumptions. Firstly, the cost of capacity has been corrected with a discount factor to correct for the lag between investment and the realization of demand. Secondly, we measure capacity costs as a rental cost per unit period using an annuity of the capital cost.

The demand function given in (29) is a constant elasticity function where \( \eta \) can vary between 0 and \( \infty \).

Uncertainty on demand

The simplest way to model demand uncertainty is to assume that demand can take only two values (low and high).

With probability \( P \) the demand function is given by
FUNDING Economics of European Infrastructure Funds

\[ P(N) = p_0^- N^{-\eta}, \]  

(30)

with probability \( 1-P \) it is given by

\[ P(N) = p_0^+ N^{-\eta}. \]  

(31)

where \( p_0^+ > p_0^- \), so that, for equal user cost, demand will be higher.

The "expected" demand function is

\[ P(N) = \bar{p}_0 N^{-\eta} \]  

(32)

with \( \bar{p}_0 = P p_0^- + (1-P) p_0^+ \).

We are interested in comparing two solutions. Firstly, we consider one where no account is taken of the uncertainty range and where an average ("expected") demand function is used. In the second approach we take the range of demand functions that can materialize explicitly into account. We call this the expected welfare approach. In the next sections we compare the capacity levels that are optimal when only the expected demand functions are taken into account with the capacity levels that are optimal when explicit account is taken of the range of potential demand realizations.

The major result is that, if \( \eta \leq 1 \), then the optimal capacity chosen with the expected demand approach \( \bar{K}^* \) is smaller then the optimal capacity with the expected welfare approach: \( \bar{K}^* < K^* \).

It is useful to analyze a few special cases in order to understand the intuition behind this result.

If \( s = 1 \) (linear congestion function), and \( \eta \rightarrow 0 \) (inelastic demand) then we see in Figure 7 that the marginal benefits of an increase in capacity will increase more than proportionally with the realized demand level. (in Figure 7 \( ABC/N^- < ADE/N^+ \)). In this case it is clear that it will be optimal to invest more than the optimal capacity for the expected demand level \( N \). In other words, the average congestion costs are an increasing function of the demand level \( N \).
Figure 7 Marginal benefit from an increase in capacity when demand is inelastic

When the congestion function has a threshold usage level above which congestion rises rapidly with usage ($s \to \infty$), then $\alpha \to 1$ and the optimal investment level based on the expected demand function, is the best you can do. As can be seen from Figure 8, the capacity level $K$ minimizes the sum of the welfare losses occurring when demand realisation is low and when it is high. This graphical illustration brings out the importance of the congestion technology for this result. As long as an extra capacity investment benefits all the consumers it is interesting to "overinvest".

Figure 8 Welfare losses associated with a given capacity level when demand levels vary when $s$ goes to infinity

When demand elasticity is high ($|\eta| > 1$), there is rather a need to invest less than the expected demand function would tell us to do. The reason is simple: a high (generalised) price elasticity means that it is easy to reduce the number of trips...
(substituting to other modes etc.) and this implies that a capacity shortage when
demands happens to be high has only a small welfare cost.

It is interesting to note that this result holds whatever the pricing regime, since \( f \) can
take any value. Of course the value of \( f \) will affect usage and optimal capacity but it will
do this in a consistent way. One can, however conjecture that with optimal pricing \( (f=1) \)
the welfare loss of suboptimal capacity levels will be lower because tolls are a more
efficient rationing device than congestion costs.

5.5.2 Analysing a two-mode problem with demand uncertainty

One often faces investment problems where two modes compete. A typical example is
the rail-air competition where both rail and air are competing for the same travellers \( (N) \)
going from one city to the other. While air travel is supplied by airlines that can easily
adapt capacity by hiring extra planes, the supply of rail enjoys large scale economies
and the government has to decide on the capacity of the infrastructure long in advance.
The fact that for rail there is a large fixed cost and a long investment lag while air can
adjust its capacity fairly easily adds an additional feature; it implies that rail has to
decide first whether it wants to invest or not and if it does, how much. A similar
problem exists in freight transport where the construction or improvement of inland
waterways has a long lead time while the capacity of road freight can be more easily
adjusted at least when the road network is dense. Throughout the rest of this text we will
use the rail-air interpretation.

We assume that the cost function for rail is given by

\[
CC_r = K_F + l_r n_r + kK,
\]  

(33)

where \( K_F \) are the fixed costs, \( l_r \) the constant variable cost per passenger, \( n_r \) the
number of passengers and \( k \) is the constant average cost of capacity. The combination of
a high fixed cost and a constant average capacity cost allows cost functions with
increasing returns to scale to be approximated.

For air, we assume that the fixed costs can be neglected and that the variable costs per
passenger \( (l_a) \) are constant. The cost function is given by:

\[
CC_a = l_a n_a.
\]  

(34)

We use the simplest demand specification. Demand is fixed (unlike the one mode case)
at level \( N \) and users select the mode with the lowest generalised price (Wardrop
principle). We suppose that there are two possible realizations of \( N \): with probability \( P \)
we have \( N=N^- \), and with probability \( (1-P) \) we have \( N=N^+ \), where \( N^+ > N^- \). The expected
number of users is equal to:

\[
\bar{N} = PN^- + (1-P) N^+.
\]
Results of the two-mode problem

The results of the two-mode model are summarized in Figure 9 (where $L = l_u - l_r - \alpha$, $\bar{K}$ denotes the optimal capacity choice for the expected demand approach and $\hat{K}$ is the threshold value above which rail will serve the whole market even if demand is high). The two critical parameters are the variable investment cost $k$ (vertical axis) of the rail mode and the fixed investment cost of the rail mode $K_F$ (horizontal axis). We have four types of solutions. Firstly, if the variable and the fixed costs are too high it is better not to invest in rail at all: these are the North, East and North-East regions in Figure 9. In this case all traffic is served by the other mode (say air). When it makes sense to invest in rail, one will always invest such as to take the full market in the low demand case. In the second type of solution, one invests less in the expected welfare approach than in the expected demand approach ($K^* < \bar{K}$). This will be the case when the variable cost of capacity is relatively high or when the probability of the low demand outcome is high. In the third regime (when the variable cost of capacity is lower) it is of interest to provide a capacity $K^*$ in excess of what would be optimal for expected demand ($\bar{K}^* < K^* < \hat{K}$). In the fourth case it is optimal to provide a level of capacity that always takes the whole market even if the demand level turns out to be high ($\bar{K}^* < \hat{K}^* < K^*$).

Viewed from a distance, "overinvesting" in capacity ($K^* > \bar{K}$) is not in general better in this model. When the cost of capacity is relatively high, it is better to serve the "unexpected" part of the market with the other mode that is flexible. As in the one mode model, "overinvestment" can be optimal when the cost of capacity is relatively high because congestion costs remain a convex function of the demand over capacity ratio.
5.5.3 Conclusions

In this section we have analysed whether overinvestment in capacity, in the sense of investing more than for the expected demand level, can be beneficial. In both the one mode and the two mode case we found that this can be the case. The main reason is the presence of congestion costs that tend to be convex in the demand over capacity ratio. Overinvestment is not optimal when demand is relatively elastic or when a more flexible substitute mode is available. Even if the full range of possible demand realizations are taken into account, demand uncertainty remains costly when capacity decisions have long lead times. The "overinvestment strategy", studied in this section, should be compared with other strategies as there are, investment in improved information on future demand and more flexible capacity extension options.

5.6 Concluding comments

In this chapter we have analysed the introduction of risk in the standard cost-benefit analysis used in transportation. Typically, the value of a project is measured by the Net Present Value ($\text{NPV}$), which measures the discounted value of the investment. In practice, both supply and demand are random: this variability is due to microeconomic as well as to macroeconomic factors.

If one is only interested in the expected net present value, one can look for rules of thumb to adapt the investment rules as a function of the risks. As an uncertain future demand is one of the main issues for the timing and capacity choice of the TEN-T investment projects, we analysed whether a systematic overinvestment could be justified. It is shown that this could be justified when demand is relatively inelastic but this cannot serve as general principle.

When the decision-maker is sensitive to the randomness of the $\text{NPV}$ (typically, decision-makers are risk averse), the decision rule has to integrate a priori the whole distribution of the $\text{NPV}$. We argue that the standard average and Mean-Variance models, widely used in finance, are not adequate for the evaluation and comparison of projects. The reason is that these criteria do not take into account the default risk which is of primary importance both for the private and public sectors.

To model the attitude towards risk when selecting a project among several candidates, we borrow two criteria developed in finance which are used to optimize portfolio investments. Indeed, the investor often wishes to maximize the expected return under the constraint that the probability of a negative (or lower than a given level) return is small enough. The two proposed criteria are the Value at Risk and the Conditional Value at Risk. We show that they can be used to compare projects. The idea is that a "good" project is such that poor returns occur with low enough probability. For a given probability, the Value at Risk is equal to the corresponding quantile, while the Conditional Value at Risk corresponds to the average Net Present Value of the worst outcomes (below the corresponding quantile). We show how these criteria can be computed in practice and their implementation in MOLINO II is discussed in the appendix.
6 EUROPEAN EXPERIENCE WITH INFRASTRUCTURE FUNDS

6.1 Introduction

An important objective of the FUNDING project is to examine a number of different existing funding systems used for transport infrastructure investment in Europe, in terms of the institutional frameworks in which they operate, the fund raising methods employed, project selection methodologies and issues relating to their performance. By studying these aspects alongside the theoretical analysis of the economics of infrastructure funds described in the previous chapter, it will be possible to gain a much fuller understanding of the experience of transport infrastructure funding in the European Union, as an input into the development and formulation of appropriate scenarios for funding European transport infrastructure in the future. Transport infrastructure financing in Europe takes place against the backcloth of a multitude of different institutional setups and at different levels of decision making. In the first part of our review we examine the experiences of funding institutions at the European Union level and the current procedures in funding the Trans-European Transport Networks (TENs). Experiences from the national level are analysed in the second part.

6.2 European Infrastructure Funding

6.2.1 Principal Considerations

We begin by setting out some key characteristics of the regime under which transport infrastructure in Europe might be funded.

Levels of Government

Transport infrastructure ranges from the provision of international ports, airports and border crossing land transport to local roads and public transport. It is very unlikely that a single level of government should take primary responsibility for such a wide range. Considerations of efficiency and democratic accountability suggest that a range of levels of government from local to European is likely to be involved.

Given that a crucial question is how the different levels of government interact with each other and how the funding arrangements support this interaction. In other parts of this report, the arrangements within the USA and Germany are reviewed. At the broadest level, we can imagine two broad models:

Legal separation of powers model – here the federal government or national government has legal responsibility for federal/national infrastructure while local government has responsibility for local infrastructure. In addition, central government may make grants towards local infrastructure provision which may provide incentives to local government in particular ways. Advantages – clarity, accountability. Disadvantages – disputes between levels of government, difficulties of transferring responsibilities between levels, difficulty of treating the network as a single entity (road user charging, quality of provision etc.). Proposition – there are probably just a few transport infrastructure projects, such as GALILEO, motorways of the sea, where it is sensible for the EU to be the lead owner of the project.
**Competition between levels model** – This recognises that transport infrastructure has a range of externalities and network effects (see IASON project) which means that the value of the project to any one level in the hierarchy is not equal to the total system value of the project. Therefore some form of co-operative model is needed with suitable grant arrangements which give incentives for the delivery of such projects. This has the advantage of realism, but requires the designation of a lead level in the hierarchy. The biggest problem is the power of veto of one institution over the whole project. It is difficult to give incentives to agencies who don’t wish to do anything.

Of course, much depends upon history and upon the legal and constitutional arrangements involved. The US federal government had the legal power and authority to deliver the Federal Highway Program; it is difficult to imagine the EU being in the same position in the foreseeable future. A form of the cooperative model is therefore more likely.

**Forms of funding**

Broadly speaking, infrastructure projects can be funded by users or taxpayers. They can be financed by some mixture of grants and loans, the latter to be repaid by some mixture of user revenues and government debt. The intended funding mix is very likely to affect the way in which the governance of projects is organised.

*Strong grant schemes* give a high weight to Government (EU or national) in the organisation and delivery of projects. This is the case with investment in UK national highways; the Highways Agency is used as the planning and delivery agency, but the UK Department for Transport has strong control of the programme and prioritisation.

*Loan schemes* are likely to be organised through intermediary organisations such as the European Investment Bank (EIB). Such organisations can also be useful as co-ordinators of national and supranational sources of funding, i.e. putting a package together. The World Bank, Asian Development Bank etc. perform this role elsewhere in the world.

*User-pays schemes* are more likely to be organised through semi-autonomous bodies such as COFIROUTE in France or through project-specific franchises such as the M6 Toll in the UK.

However, in practice, any organisation is likely to contain elements of all three, such as grant contributions from government, a funding package organised by a bank, and a franchise or concession to a company with responsibility for delivering the project. The clear assignment of the powers and responsibilities of the parties within the model is crucial to efficient delivery.

### 6.2.2 Current situation of infrastructure funding at the European level

The prime movers for nearly all strategic transport infrastructure investment are the member states and their agents. If member states do not wish something to happen within their territory, it will not happen. If member states do wish something to happen,
it may happen. The EU is in the position of being a partner with influence, both political and via the funding mechanisms at its disposal.

There is currently no such thing as a European transport infrastructure fund in any autonomous sense, as distinct from monies available to support EU transport infrastructure in various EU budget lines.

This is seen as an important distinction for a number of reasons. First, EU budget lines are self-balancing; monies budgeted but not spent are not collected from member states. A fund on the other hand would have earmarked sources of funding such as elements of fuel taxes, or payments for the Eurovignette or road user charges/tolls. The fund could build reserves and would have a greater degree of autonomy, and arguably stability than a budget line. The advantages of semi-autonomous transport funds in the different context of developing countries are discussed in Heggie (1999). The fund might be managed by the Commission on behalf of the Community, or possibly by an agency such as the EIB. There are interesting institutional options here.

**TEN-T Funding – Present situation**

The main existing European Community sources of funding for the TEN-Ts are the TEN-T budget line itself, the Cohesion Fund and the European Regional Development Fund (ERDF), which is part of the Structural Funds.¹⁵ The Marco Polo II programme is able to fund the Motorways of the Sea and the Pre-Accession Structural Instrument (PASI) also has a role to play in the wider TEN-T context. These sources of funds all provide aid in the form of grants.

The rules governing the TEN-T budget line are summarised in Table 10 below. For the period 2000-2006, available funding was of the order of €600-700 million/year, whereas the priority TEN-T investment costs were estimated at €80 billion for the same period. The latest proposal (COM (2004) 0475), which has had its first reading in the European parliament, asks for a significant increase in funding to €2.9 billion/year for the period 2007-2013, in order to finance a larger proportion of investment costs. An agency would be established to manage the budget.¹⁶ Another proposal, COM (2003) 132 aims to implement some of the Van Miert High Level Group proposals: in particular how to encourage the involvement of private capital.

Member states present financing proposals to the Commission, which makes a selection based on the available resources and requirements of the TENs regulation (Turro 1999). According to Turro there are always many more applications than funds and the distribution of funds tends to be weighted demographically.

Countries whose per capita GDP is less than 90% of the EU average and who are implementing economic conversion programmes are eligible for help from the Cohesion Fund.¹⁷ Environment and TEN-T projects can be funded up to 85% of the total cost.

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¹⁷ As of 1/5/2004 Greece, Portugal, Spain, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia and Slovakia are eligible. (Previously Greece, Ireland, Portugal and Spain were eligible.)
Each member state is responsible for implementing the projects, managing the funds and meeting the timetable. For the period 2007-2013, the Cohesion Fund with be integrated into the Structural Funds and provide money for programmes rather than projects.

Structural funds from the ERDF are mainly available to “Objective 1” regions (NUTS II level) where per capita GDP is less than 75% of the EU average. The ERDF provides financial aid in the form of non-reimbursable assistance (grants). The aid is channelled through development programmes. The member states appoint management authorities which are responsible for implementing the programmes and selecting the projects to be funded. The programmes cannot be fully funded by the EU and have to be co-financed by other public or private money.

According to *Cohesion and Transport (COM/1998/806)*, in the period 1994-99, the ERDF allocated €13.7 billion to transport projects in Objective 1 regions, with 70% spent on roads and motorways and 16% on rail, while more than 50% of Cohesion funds were spent on transport. For the period 2000-2006, their joint contribution to TEN-T projects will be €20 billion (DG-TREN, 2005). PASI funding for same period is expected to be €1 billion.

Other sources of income include the EIB, which has loaned around €50 billion to TEN-T projects over the last decade and is expected to continue this rate of lending, although this has been predominantly to road. The latest publication from DG-TREN, ‘*TEN-T priority axes and projects 2005*’, supposes that 20% of funding could come from the private sector, with the remainder from national governments.

There are two pieces of legislation which are relevant to income from infrastructure. The first is the proposed amendment to the Eurovignette Directive (1999/62/EC). COM (2003) 448 has passed all legislative stages with some amendments but has not yet entered into force. The main conditions are that tolls can be levied on HGVs both on the TEN-Ts and on competing roads in the same transport corridor. The basic toll can include construction, operation and maintenance costs; accident costs were rejected during the legislative process, as were compensatory reductions in annual vehicle costs. In sensitive areas (i.e. mountainous regions) an additional 25% mark-up above the average toll can be charged in order to cross-finance transport infrastructure in that corridor/zone. The tolls can be differentiated (by distance, level of congestion etc). Revenue from tolls is to be used to pay for maintenance for the road it is levied on and ploughed back into the transport sector as a whole. The legislation also states that it is compatible with PPP (private-public-partnership) as a profit margin can be allowed.

The other directive (2001/14/EC) relates to rail infrastructure charging. This states that any infrastructure charge added to the surplus from other commercial activities and state aid must at least be equal to infrastructure expenditure. The infrastructure charge can include congestion, environmental and maintenance components and a mark-up can be levied if the market will bear it.
<table>
<thead>
<tr>
<th>Type</th>
<th>Period applicable</th>
<th>Financing rules</th>
<th>Other conditions</th>
<th>Legal base/source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant</td>
<td>1995-99</td>
<td>Total community funding max 10% total cost (including 50% studies)</td>
<td>Allows for interest subsidies on EIB or other loans. Fee contributions for EIF loan guarantees</td>
<td>Council Regulation 2336/95</td>
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<td></td>
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<tr>
<td></td>
<td>2000-06</td>
<td>Total community funding max 10% total cost with &gt;=55% rail, &lt;=25% road</td>
<td>Tighter controls - Project can be cancelled if not started with 2 years. Supply risk capital to investment funds (max 1%)</td>
<td>Council Regulation 1655/99</td>
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<tr>
<td></td>
<td>2007-13</td>
<td>Total community funding max 30% total cost or 50% for cross-border if started before 2010</td>
<td>Funding can be reclaimed if project not completed after 10 years. Guarantee fund(^{18})</td>
<td>COM (2004) 0475 (Commission proposal for Directive)</td>
</tr>
</tbody>
</table>

**Table 10  TEN-T budget line**

### 6.3 Experience from national infrastructure funding

A literature overview of financing mechanisms for transport infrastructure in Europe\(^{19}\) reveals a wide variety of approaches to the procurement of infrastructure, depending on the political system in the member states as well on as historical developments. For this project those mechanisms that are most relevant are those that attempt to address problems that have similarities to those faced at the European Union level. The following chapters summarise experiences with infrastructure funding in a federal system, with infrastructure funding agencies (funds) and private sector involvement in financing of transport infrastructure.\(^{20}\)

#### 6.3.1 Infrastructure procurement responsibilities in a federal system

In a review of transport infrastructure financing in Europe, Farrell (1999) distinguishes four basic organisation models of sharing responsibilities between central government and regional or local authorities: the Scandinavian (strong agencies and consensus), German (federal and co-operative), Mediterranean (centralised power and legislative decision making) and Anglo-Saxon (central funding and executive government) model. For our review of national experience, the German federal model of infrastructure procurement bears most resemblance to a potential European structure and has therefore been analysed in more detail in a case study. The main questions to be addressed were what the experience has been of:

\(^{18}\) Covers commercial risks specific to TEN-Ts in the post construction phase.

\(^{19}\) for an overview see Ragazzi, Rothengatter (2005) for motorways and Farrell (1999) for all modes

\(^{20}\) Additionally, two in-depth case studies are available in separate task reports for infrastructure procurement in the federal system of Germany and the M1/M15 project in Hungary as an example for an attempt at a complete privately financed road project with high European interest.
- how projects are planned and selected for federal funding;
- how investments are coordinated between states and central government; and
- how financial resources and expenditure are divided between the tiers.

Planning framework and project selection

In transport infrastructure procurement, the federal government in Germany is responsible for providing federal motorways and trunk roads (Bundesfernstraßen: Autobahnen and Bundesstraßen), federal railways (Deutsche Bahn Netz AG), and inland waterways. Airports and sea ports fall under the responsibility of the states (Bundesländer). The states administer the federal roads, i.e. they carry out the project planning, construction and operation on behalf of the federal level through their administrative bodies. The main instrument of federal infrastructure planning is the federal infrastructure master plan. This contains a list of priority projects for investments, ranked according to the results of a project appraisal. A quota system is then applied for the distribution of investments between the states. The states among other bodies issue lists of potential projects as an input to the transport master planning process, and they are consulted in the planning process after a first list of priority projects for transport infrastructure investments has been developed by the federal Ministry of Transport (see Rothengatter, 2005b). The division of powers between federal and state level in the road sector has raised several issues of criticism, including delayed planning processes, inefficiencies in the planning, and an excessive number of projects that have to be decided and financed at the federal level (see e.g. Beckers et al., 2005). Additional issues are the lack of synchronisation of infrastructure investments between the states and problems in cross-national planning (see e.g. Fabian, 2005). Potential solutions are to limit the responsibility of the federal level to the motorways with a parallel strengthening of federal administrative capabilities (Engels, 2004) and to establish a strategic planning approach at the federal level focusing on the federal planning objectives (see e.g. Wissenschaftlicher Beirat, 2000; Gühnemann et al., 1999).

A more complex procedure applies to national railway infrastructure projects, where investments are negotiated between the federal government and the infrastructure company of the German railways, DB Netz AG, a subsidiary of the German railway company, DB AG. The participation of the deregulated company has led to an improvement in efficiency of investments due to the profitability interest of DB AG (KCW et al., 2005), though part of investment cost is still paid for by the government at present as a result of heavy cost overruns on some projects (Rothengatter, 2005b). A further point of criticism is the vertical integration, introducing the potential danger of discrimination in favour of investment decisions which would primarily benefit DB AG transport services. Regional rail services have been transferred along with corresponding funds into the responsibility of the states and are tendered, which has led to a considerable increase in competition and transport volume in that market. However, DB Netz AG requested “infrastructure securing contracts” with the federal states, securing the provision of services and funding of reinvestments (see Booz Allen Hamilton, 2006).

Investments into inland waterways are entirely the responsibility of the federal level, which is also in charge of their administration. Because airports in Germany are mainly owned and regulated by the federal states and local communities and partly privatised, a general coherent investment strategy is lacking.
Fund raising methods
Infrastructure funding in Germany mainly occurs in the form of public budget funding and user charges. An initial earmarking of part of fuel taxes for road transport purposes has been broadened since 1973 to wider transport system uses. Motorways and federal trunk roads are completely funded from the federal budgets, while the states and communes receive tax transfers and can apply for special funds for transport infrastructure investments. Laaser and Rosenschoon (2001) analysed income from and expenditure in the transport sector. General (without external costs) revenues are higher than expenditure. However, even after transfer of funds between federal levels, states and communities show a deficit. Due to general budget restraints, new instruments, specifically the heavy goods vehicles motorway toll and two PPP models for federal road projects, have been introduced in the late 1990s in order to sustain transport investments into the long term. The revenues of the distance based HGV (net approximately €2.4 billion in 2005) contribute to the total federal budget for transport infrastructure investments (about €12.2 billion in 2005). They are not earmarked for investments in motorways but will be used for general transport infrastructure investments. An issue of concern for local communities and states is the partly occurring diversion of heavy traffic onto the minor road networks. The inclusion of these roads would require negotiations on the division of revenues between the political tiers.

Refunding of rail infrastructure investments is achieved through track charges, which are supposed to allow DB Netz AG to recover the annual depreciation of infrastructure investments. However, there is still strong public sector involvement in the rail sector through financial grants towards construction costs and to cover the losses of DB Netz AG. Furthermore, the federal states receive a transfer of funds from the federal general budget for the subsidisation of regional rail services (2002: €6.745 billion; increased by 1.5% p.a. from 2003 on) which include track charges. The Scientific Advisory Board to the Ministry of Transport cites estimates a gap in the cost recovery of €2.5 billion which DB AG demands as state contribution (45%) (Wissenschaftlicher Beirat, 2005).

Refunding of investments in inland waterways is partly through tolls and fees (e.g. for using locks), but mainly from the general federal budget. The refunding of airport investments is mainly through user costs (landing charges etc.) and airport services (rents from retail etc.). Hopf et al. (2003) estimate for the 17 international airports in Germany that for the year 2001 the infrastructure related costs of air traffic had in total been recovered from user costs.

Conclusions
These experiences from federal infrastructure planning and financing in Germany reveal the challenges that lie in the co-ordination of investment decisions between different tiers of political decision making and state institutions plus private actors such as the rail network companies and private investors. Therefore, clear rules are necessary in the selection of projects for investments and there is also a need for a clear division of responsibilities. Co-ordination between different organisations is essential. Following the subsidiarity principle, as many decisions as possible should be taken at the regional level, with the federal level restricting itself to more strategic goals leading to coherent investment frameworks and a selection of projects of strategic interest for financing. In particular in the road sector, this principle needs to be re-established, including a revised division of funding sources. A second major challenge is the shift from general public
procurement to a user charging oriented system. First steps have been taken with the introduction of the HGV motorway toll and the separation of railway network management and train operation, but there is still a heavy involvement of funding from public budgets.

### 6.3.2 Transport infrastructure funds

Several member states of the European Union have established transport infrastructure funds via financing agencies as a means of managing and providing infrastructure financing independent of public budgets. Prominent examples of such agencies have been established in Germany, Austria and France.

In Germany, a state owned multi-modal transport infrastructure financing agency **VFIG** (Verkehrsinfrastrukturfinanzierungsgesellschaft) was established in 2003. The major motivation for founding the VFIG was to create institutional structures that support transport infrastructure investments independent of the public accounting system. Its tasks are the financing and financial management of those aspects of transport infrastructure procurement that are the responsibility of the federal level, and the preparation and carrying out of PPP projects. VFIG receives the user charges from the HGV toll on motorways and inland waterway tolls which are collected by federal institutions. Three major issues are the subjects of current debate (e.g. BDI, 2005):

- the multi-modal character of the agency, allowing for transfers between modes according to political willpower, reducing public acceptance of user charging;
- whether the agency should be able to make recourse the capital market to raise funds; this issue is to be examined according to the coalition contract of the current government (CDU et al., 2005)
- whether the agency should have direct access to earmarked transport user charges.

However, there is little empirical evidence to date to assess the performance of the agency.

More experiences exist with the established Austrian agency, **ASFINAG** (Autobahnen- und Schnellstraßen-Finanzierungs-AG), a privately organised but state owned company with the right to collect tolls and the obligation to invest into the maintenance and enhancement of the Austrian motorway system. Investment decisions are taken via a consensus process between the federal government, the federal states and the company. ASFINAG obtains capital from the capital market, with the loans being guaranteed by the Austrian state. The refunding of the investments is done via user charges (a distance dependent HGV toll and a time dependent vignette for cars). In general the organisational structure of the Austrian fund and the earmarking of user charges for the road sector are regarded as the basis of an efficient and reliable system. One open issue is to grant ASFINAG the right to determine the rates of the user charges, which are currently determined by the federal government (Beckers et al., 2006).

In France, the transport infrastructure financing agency **AFTIF** (L’Agence de financement des infrastructure de transport de France) has been established based on a decision by decree of the council of ministers in 2004 and is in operation since January 2005. The main motivation for its implementation has been to foster the completion of a plan for 50 large infrastructure projects determined in 2003. The agency is multimodal and covers (large) road, (high-speed) rail, coastal and inland waterway shipping, seaport, combined transport and local transport infrastructure projects. It is not involved
in either the selection or planning process of projects to be financed, these are determined by three major initiatives:

1. a list of 50 large projects by the Comité interministériel d’aménagement et de développement du territoire (CIADT) (Inter-ministerial committee for regional development) as of December 2003. The selection of projects has been based on a strategic development vision;

2. regional infrastructure projects according to the Contrat de Plan État-Région (CPER) and the special investment programme for Corsica; these are agreements negotiated between the government and each regional authority setting out a multi-annual (currently 2000-2006) spending programme to be financed on a 50:50 basis;

3. local transport infrastructures projects according to the decision of the Comité Interministériel d’Aménagement et de Compétitivité des Territoires (CIACT).

The agency receives the revenues from state owned motorway tolls, regional planning tax, 40% of revenues from radar controls, and subsidies from public budgets. In 2005, the CIACT decided to accelerate the realisation of projects by providing an exceptional infusion in capital of in total € 4 billion from the privatisation of motorway companies..

The following table summarises the main characteristics of the three models for infrastructure funds in European countries.

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Austria</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>In operation since</td>
<td>2004</td>
<td>1982; 1997 in current form;</td>
<td>2005</td>
</tr>
<tr>
<td>Legal basis and</td>
<td>financing law VIFGG; parishment decision; no specific termination rules</td>
<td>contractual arrangement between company and federal government based on federal law (parliament decision)</td>
<td>decree by council of ministers</td>
</tr>
<tr>
<td>termination rules</td>
<td>state owned, privately organised as limited liability company by capital (GmbH);</td>
<td>state owned, privately organised as private limited company by shares (AG)</td>
<td>public administration institution</td>
</tr>
<tr>
<td>Organisational form</td>
<td>legal entity; supervisory board with members from ministry of transport; one managing director from ministry</td>
<td>legal entity, independent board of directors and managing directors; state is shareholder</td>
<td>legal entity, financial autonomy; under supervision of transport ministry, administered by council with one half state representatives</td>
</tr>
<tr>
<td>Level of autonomy</td>
<td>annual report to parliament</td>
<td>annual business report through administrative council</td>
<td></td>
</tr>
<tr>
<td>Monitoring and Control</td>
<td>Multimodal; federal projects;</td>
<td>federal roads</td>
<td>multimodal; federal and regional / local</td>
</tr>
<tr>
<td>Modes covered</td>
<td>financing and financial management of construction, maintenance and operation of federal transport infrastructure; preparation and carrying out of PPP projects</td>
<td>planning, financing, construction and operation of the federal road network</td>
<td>financing of transport projects of national and international importance, in particular in public private partnership arrangements</td>
</tr>
<tr>
<td>Tasks</td>
<td></td>
<td></td>
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</tbody>
</table>
Conclusions

Although there is hardly any experience with the French and German agencies, yet, some critical issues in the construction and operation of infrastructure funding agencies can be identified:

- **political autonomy:** a high degree of political influence might lead to an inefficient management of the fund; on the other hand, some political control mechanisms are necessary to avoid a monopoly situation and socially inadequate procurement of infrastructure (see Beckers et al. 2006); to increase social acceptance, Heggie (1999) suggests including representatives of road users and the business community in managing boards;

- **monitoring and control:** an effective control system has to be established to avoid mismanagement of the fund and the risk future public backing of debts (see also Molnar, 2003); usually, funds are subject to regular audits;

- **multi-modal or uni-modal character:** the multi-modal character of the German agency has been heavily criticised by industrial organisations due to its lack of user transparency and acceptability; in the Austrian example, a clear relation is established between user charges and investments in the sense of a collective club good (Beckers et al, 2006); cross-subsidisation of other modes for social benefits is still established via fuel taxation and public budgets;

- the possibility to borrow *external capital:* it offers the funds greater financial independence and multi-annual predictability, but it requires financial sovereignty and efficient management, monitoring and control of the fund;

- **the involvement in the project selection:** since commercial viability plays an increasingly important role in infrastructure procurement, the involvement of expertise from the infrastructure financing agency in the project selection process is

### Table 11 Infrastructure financing agencies

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Austria</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project selection</td>
<td>federal transport infrastructure master plan, formal appraisal and ranking method; state quota; parliament decision</td>
<td>consensus system between federal government, states, ASFINAG and other institutions; no formal consistent appraisal method</td>
<td>CIADT list of 50 grand projects; CPER arrangements; CIACT decision on inclusion of projects</td>
</tr>
<tr>
<td>Criteria for project selection</td>
<td>social cost benefit analysis plus additional criteria on environment, regional development, European interconnectivity, and intermodal integration</td>
<td>transport demand, project realisation costs, intermodal integration, regional development</td>
<td>strategic development goals</td>
</tr>
<tr>
<td>Agency involved in project selection</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Sources of finance</td>
<td>HGV tolls, inland waterway charges; funds are cleared through public budget</td>
<td>HGV tolls; car vignette, direct from operating companies; external capital</td>
<td>tolls, public budget, privatisation funds</td>
</tr>
<tr>
<td>External capital</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Right to propose toll levels</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Annual Budget</td>
<td>2005: € 2.4 billion planned, (net revenue from HGV tolls)</td>
<td>2004: maintenance and operation € 480 mill., investments € 650 mill., interest € 300 mill.</td>
<td>2006: € 2 billion</td>
</tr>
</tbody>
</table>
essential; however, as Beckers et al. (2006) point out for the case of road investments, two factors could lead to the agency proposing too many projects: (monopoly) access to toll revenues and the risk of pressure on the agency by lobby groups, e.g. construction industry;
- the right to propose toll levels: in order to achieve commercial sustainability of the fund, charges might need to be adjusted regularly to repay debts and meet expenditure targets. However, this needs to be controlled by a regulating institution to comply with given charging rules (Heggie, 1999, Beckers et al., 2006).
- their financial autonomy: on the one hand, the off-budget status of the funds might lead to a loss of government interest to provide for transport infrastructure as public goods (Molnar, 2003), on the other hand financial autonomy and direct accessibility of user charges for the fund are crucial if external funds are borrowed and for multi-annual predictability and planning.

6.3.3 Private sector involvement

PPP models
After initial enthusiasm a slowdown of private funding of new transport infrastructure can be observed internationally since the late 1990s (Molnar, 2003). Among the reasons for this development have been cost overruns, unfavourable risk sharing arrangements, lower willingness to pay for infrastructure use than expected and traffic developments falling short of expectations. Some lessons to be learnt from European experience (see e.g. Ragazzi and Rothengatter, 2005; Debande, 2002, Molnar, 2003) are
- The private sector requires an appropriate return on the capital it invests and borrows to invest.
- The main question is therefore whether the efficiency/cost gains outweigh the private capital risk premium which has to be paid.
- Private financing should not be used to overcome a public funding constraint.

Despite this, there is scope for private involvement in financing and in the procurement of transport infrastructure. Empirical experience from Great Britain, where PPP models for road procurement have been experienced more widely, suggests that private sector involvement is of greatest benefit for the management rather than the financing of road procurement (Mackie and Smith, 2005).

Presently, the involvement of private sector capital in financing cross-border transport infrastructures is constrained by organisational and legal problems that result from the application of a large number of national legislation. Some of these restrictions could be overcome by the recent possibility to establish a European Public Limited Company or 'Societas Europaea' (SE). This offers the advantage of a uniform accounting system and legislative structure, reduces administrative and legal costs and the necessity to establish subsidiary companies in the countries concerned (Fabian, 2005).

Full private financing
There are few examples of transport infrastructure investments in Europe which have been fully financed by the private sector. One of these examples is the M1/M15 project in Hungary, which was the first privately financed toll motorway project in Central and Eastern Europe and motivated by a lack of public money available for financing

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transport infrastructure in 1989 in Hungary. The awarding process was carried out in two phases: a prequalification and a tendering phase and was completed within two years. A concession company named SPV Elmka was created shortly after. The participation of EBRD was crucial in the finalisation of the concession contract to securing the foreign financed debt. Notwithstanding economic difficulties during this transition period, the construction then progressed and was finished according to programme and budget. At that time the M1/M15 project was considered a major success in achieving the goal of financing and building this motorway section in such a short time with virtually no cost overruns. However, during its operation, the development of traffic on the motorway section fell significantly short of previous expectations, partly due to over-optimistic forecasts of border traffic. Furthermore, in setting the toll rate, the SPV Elmka applied a revenue maximisation policy with a view towards revenue from the richer West European drivers. After a court judgement on a case initiated by the Hungarian Automobile Club, Elmka was obliged to pay back about one third of the toll, and the lenders reacted by declaring Elmka to have defaulted on its loans. Following negotiations on restructuring the company finances were unsuccessful, after three years of operation Elmka was superseded by a fully state owned company, leading to substantial financial losses to the shareholders of Elmka without compensation.

The fact that traffic is substantially below expectations does not mean that the project has become a “white elephant” – in fact it continues to form an integral element of the Hungarian motorway system. Indeed it is hard to see how this project might have been delivered if private finance had not been used. It is interesting to speculate whether the fact that the project had been 100% financed with private funds without any recourse to the state allowed the client to take a slightly ambivalent attitude towards the project. Although it is natural to focus on the differences between the traffic consultants’ forecasts and the over optimistic projections prepared by the macro economists, neither of these discrepancies would invalidate the viability of the concession. As it was the financial structure put up by the lenders and promoters proved to be relatively robust. It would even have allowed sufficient time to put a financial rescue package in place in the form of new cash from the shareholders and reductions in margins and increases in grace and maturity periods by the lenders. This case demonstrates that the most important success factor in is the commitment and full and sustained support of the client/principal.

Privatisation is an increasing source of financing of investments in airports. Fully privately owned airports are mainly found in the UK. Generally, the chances for success of privatisation are regarded as greatest for larger airports. However, there is felt to be some danger because larger airports can exercise their market power against the interests of their customers (airlines) (von Hirschhausen, 2004) and hence some form of price regulation seems necessary. Infrastructure developments at airports are still subsidised, however. This is in particular critical in the development and expansion of smaller regional airports competing for low-cost airlines. Heymann and Vollenkemper (2005) expect that most regional airports lack the critical mass to become profitable and will therefore swallow up subsidies in competition to attract airlines.
6.4 Conclusions

The experience with infrastructure funding in the European Union has revealed salient issues that will need to be tackled when introducing new schemes for funding the Trans-European Transport Networks:

→ Clear rules are necessary to determine whether transport infrastructure is eligible for funding, and the involvement should be restricted to projects that clearly fulfil trans-boundary transport functions benefiting European Union objectives in order to avoid over-subsidisation and excessive involvement in regional transport infrastructure investments.

→ There needs to be a clear division of responsibilities between the European and the member state level with control mechanisms installed over the whole procurement process to protect the interests of the financing actors.

→ An infrastructure fund promises more flexibility and higher stability of the investment budget than funding from general budgets. Currently there is no autonomous funding mechanism for cross-border infrastructures of European interest.

→ A future funding organisation is likely to contain elements of grant contributions from Government as well as funding from user charges and private sector involvement in financing and project delivery. The clear assignment of the powers and responsibilities of the parties within the model is crucial to efficient delivery.

→ There is a need not only for financial but also for organisational co-ordination of cross-border infrastructure procurement. First steps towards this have been taken by the introduction of European co-ordinators for the TEN-T priority axes.

→ The setup of an infrastructure fund needs to consider carefully whether a multi-modal approach is taken, revenues from user charges are earmarked and directly transferred to the fund, and whether the fund can borrow money from the capital market.

→ In the case of the private participation, rules are necessary to determine who bears the risk of cost overruns; experience shows that privately owned companies (and in particular railway network companies) need planning security and this issue must be considered in the financing rules of a fund.

→ Private involvement in infrastructure provision requires support in the form of long-term commitment of the public partner.

→ Assuming that the larger airports can recover their costs through user charges, privatisation of airports may require close monitoring / regulation of charges to prevent abuse of monopoly powers. Subsidising airports at the local / regional level needs to be closely monitored to prevent market distortions;
SURVEY OF US EXPERIENCE: FHTF

7.1 Initial political, economic and technical conditions

7.1.1 Pre-Interstate era

Federal aid to highways started over 100 years ago, at the end of 19th century. The Good Roads Movement connected the cyclists and the progressive minded federal engineers. Federal aid was in form of information and know-how, mainly documentation of roads and distributing information about road building techniques. Aid in the form of federal funding started small, and before the Interstate era it didn’t exceed 50% of the full cost of federally funded projects. (Weingroff)

In the early decades of the 1900s the program developed partly as an antidote to the extortionate policies of rail companies. The federal government saw that the overall efficiency of the transportation system would be increased by decreasing the market power of rail companies. The advancement of cars as industrially produced and affordable means of transportation provided a competitive alternative for rail transportation, which the federal government wanted to enhance. (Taylor interview)

Another motivation for the federal aid was the less than optimally hierarchical structure of the road network. The network consisted of many small local roads, but the interstate traffic was not adequately served as the network lacked properly connected major roads. The state politicians had faced hard political choices between alternative local roads to elevate into interstate roads, and welcomed the federal aid as an external driver to build a connected, more hierarchical road network. (Taylor interview)

7.1.2 Interstate era

The 1944 Federal-Aid Highway Act started the Interstate era by designating a 64,375 km network called the National System of Interstate Highways. At the initial stage of the Interstates, the political intentions about the funding sources and decisive powers were not fully settled. While President F. Roosevelt favored self-supporting toll roads, the Congress intended the highway program to be a federally assisted state program. States were supposed to give priority to the Interstate highway program in their general use of federal aid. Largely, this did not happen. Only a few miles of Interstate highways were built, except for the toll-ways that were constructed in the Northeast. (Weingroff)

President Eisenhower was a strong supporter of the Interstate program. His opinions had been influenced by his experiences moving domestic military convoys across the American continent in pre-WWII USA and the German autobahns during the WWII. (Weingroff). Also, there was a general recognition of two ideas: that individual states would benefit from better land connections across other states; and that some poorer states would not have the money to build the interconnecting links that were needed for a comprehensive network of interstate highways (GAO, joint interview). These factors made the federal arrangement of interstate highways politically acceptable.

In 1956 Congress approved the plan for the National System of Interstate and Defense Highways, and President Eisenhower signed the Federal-Aid Highway Act and the Highway Revenue Act. It was a compromise legislation that gave something to each
party. It met the president’s goal of avoiding deficit spending by including an anti-deficit provision. While taxes on truckers increased, they still supported the program, because it provided infrastructure and a means for increased income. Urban areas did not get the control they wanted, but the bulk of funding would be spent in the cities. And rural officials, who did not believe the interstate system would benefit them, received continued funding for federal-aid secondary roads. (Weingroff)

7.2 Task of the Fund

7.2.1 Initial task

The 1956 legislation started the Federal Highway Trust Fund (FHTF). The FHTF was set up to be a ‘pay-as-you-go’ trust fund 22, an accounting mechanism restricting highway user tax revenue to interstate highway purposes.

The legislation called for completion of the 41,250 miles of interstate highways. The interstate highways were to be completed during years 1957-1969, and the powers under the 1956 Act were set to expire in 1972. The Federal part of the finance was to be USD 25 billion, and was authorized to finance the 90% federal share of the system. The disbursement formula of the funds took into account factors like state area, length of road network, length of postal routes, and the number of motor vehicles. (Roth 2005 a,b, Weingroff).

7.2.2 Evolution of the federal funding

Funding for FHTF was initially covered by a federal gas tax of 3 cents per gallon, but today the taxes are more numerous. Table 12 summarizes the different highway user taxes and their magnitudes in 2001.

The Federal Highway Trust Fund dedication to fund the interstate system has changed many times during the years and reached considerable complexity. The original System of Interstate Highways was complete by 1992. A great part of the FHTF funds have since been used to finance other transportation related projects. In 2002, 19% of funds obligated for federal-aid projects occurred on the interstate system, while projects off the National Highway System 23 accounted for about 57% and projects on the National Highway System (noninterstate) accounted for 24% (GAO 2004). Table 13 shows a tabulated summary of the federal-aid highway grant programs and formulas applied in 2003.

22 The 'Lectric Law Library’s Lexicon (2006) defines government trust funds as “Funds collected and used by the federal government for carrying out specific purposes and programs according to terms of a trust agreement or statute such as the Social Security and unemployment compensation trust funds. Such funds are administered by the government in a fiduciary capacity and are not available for the general purposes of the government”.

23 The National Highway System consists of a much larger set of roads than the original National System of Interstate Highways.
Table 12 Excise tax rates and distributions of highway user taxes as of July 2001, cents per gallon.

Source: Federal Highway Administration FHWA

The United States Government Accountability Office report (GAO 2004) summarizes the evolution of the fund: "Since the Federal-Aid Highway Act was enacted in 1956, every time the Congress has reauthorized the highway program it has expanded either the size or scope, or both, of the federal-aid highway program. Since 1991, Congress has provided significant increases in federal spending on highways. ISTEA’s\(^\text{24}\) authorization of $121 billion for highways for the 6-year period from fiscal years 1992 through 1997 was a 73 percent increase over the $70 billion authorized in the prior 6-year bill, and TEA-21’s authorization of $171 billion for the federal-aid highway program from fiscal years 1998 through 2003 represented an increase of 41 percent over ISTEA’s authorization level. In 2004, the House and Senate each approved separate legislation to reauthorize the federal-aid highway program, increases of 32 percent and 50 percent over TEA-21, respectively [for fiscal years 2004 through 2009]. Despite these increases, numerous congressional transportation leaders stated that these increases were not enough, and that further spending was required to meet the country’s needs.” p.33-34.

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\(^{24}\) ISTEA is an abbreviation of the legislation for years 1992-1997 and stands for Intermodal Surface Transportation Efficiency Act. TEA-21 is an abbreviation for the legislation for years 1998-2002 and stands for Transportation Equity Act for the 21\textsuperscript{st} Century.
<table>
<thead>
<tr>
<th>Program</th>
<th>Purpose</th>
<th>FY 2003 funding (in billions)</th>
<th>Grant formula</th>
<th>Minimum apportionment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate Maintenance Program</td>
<td>Resurfacing, restoring, rehabilitating, and reconstructing most routes on the Interstate Highway System.</td>
<td>$4.2</td>
<td>Interstate System lane miles (33 1/3 %)</td>
<td>½ percent of Interstate Maintenance and National Highway System Apportionments combined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vehicle miles traveled on the Interstate System (33 1/3 %)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Annual contributions to the Highway Account of the Highway Trust Fund attributable to commercial vehicles (33 1/3 %)</td>
<td></td>
</tr>
<tr>
<td>National Highway System Program</td>
<td>Improvements to rural and urban routes that are part of the National Highway System (including the Interstate System) and designated connections to major Intermodal terminals.</td>
<td>$5.1</td>
<td>Lane miles on principal arterial routes, excluding the Interstate System (25%)</td>
<td>½ percent of Interstate Maintenance and National Highway System Apportionments combined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vehicle miles traveled on principal arterial routes, excluding the Interstate System (35%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diesel fuel used on highways (30%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total lane miles on principal arterial highways divided by the State’s total population (10%)</td>
<td></td>
</tr>
</tbody>
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Table continues on the next page.
<table>
<thead>
<tr>
<th>Program</th>
<th>Purpose</th>
<th>(in billions)</th>
<th>Grant formula</th>
<th>Minimum apportionment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Transportation Program</td>
<td>Projects on any federal-aid highway, bridge projects on any public road, transit capital projects, intracity and intercity bus terminals and facilities, and other uses.</td>
<td>$5.9</td>
<td>Total lane miles of federal-aid highways (25%)</td>
<td>½ percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total vehicle miles traveled on federal-aid highways (40%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Estimated tax payments attributable to highway users paid into the Highway Account of the Highway Trust Fund (35%)</td>
<td></td>
</tr>
<tr>
<td>Highway Bridge Replacement and Rehabilitation Program</td>
<td>Replacing or rehabilitating deficient highway bridges and seismic retrofits for bridges on public roads.</td>
<td>$3.6</td>
<td>Relative share of total cost to repair or replace deficient highway bridges (100%)</td>
<td>¼ percent (10 percent maximum)</td>
</tr>
<tr>
<td>Congestion Mitigation and Air Quality Improvement Program</td>
<td>Projects which reduce transportation related emissions in air quality nonattainment and maintenance areas for ozone, carbon monoxide, and Particulate matter.</td>
<td>$1.4</td>
<td>Weighted population in non-attainment and maintenance areas (100%)</td>
<td>½ percent</td>
</tr>
</tbody>
</table>

Table continues on the next page.
<table>
<thead>
<tr>
<th>Program</th>
<th>Purpose</th>
<th>FY 2003 funding (in billions)</th>
<th>Grant formula</th>
<th>Minimum apportionment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Guarantee Program</td>
<td>Funding to states based on equity considerations including specific shares of overall program funds and minimum return on contributions to the highway account of the Highway Trust Fund. A portion of the funds are distributed among core highway programs while remaining funds are eligible under the same rules as the Surface Transportation Program.</td>
<td>$6.4</td>
<td>90.5 percent of the percentage share of contributions to the Highway Account of the Highway Trust Fund from motor fuel and other taxes collected in that state based on latest available data</td>
<td>N/A</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>$0.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13 Federal-aid highway program grant programs and formulas
Source: GAO-04-802, initially from FHWA.

7.3 Impacts of the Fund
Once the federal transportation funds have been appropriated by the Congress, the states can prepare the transportation projects for obligation process. Obligation process offers Congress an additional policy variable, because Congress has applied caps on the yearly amount of obligations. Once the funds have been obligated to a project, they are ready for the state to spend on the project.

The federal matching grants for individual projects are based on technical criteria of the projects. The federal agency does not choose the funded projects: it only confirms that the project can receive federal funding if it complies with the criteria. Federal funding has developed into a direction where the states can use the federal funding for many types of transportation related projects.

7.3.1 Physical and social impact
One of the Interstate era criteria for funding was that the interstate highways had to form a network. This created a strong incentive for adjoining states to route the projects accordingly. As the pre-Interstate era 50-50 cost allocation between federal and state shares changed into the 90-10 allocation in the Interstate era, the “ten cent dollar” made extensive motorways an attractive option for the states. The infrastructure style chosen
was massive, because the initial legislation had mandated a clear length of the infrastructure to be funded by the 90% federal share, but it did not put limits on the total cost of any individual piece of realized infrastructure. (Taylor interview)

Consequently, the physical transportation network evolved from a non-hierarchical network of local roads to an extremely hierarchical network, concentrating traffic on the freeways. For interstate commerce this development was a boost, but at the same time the development distorted local traffic and caused local problems. The urban revolts against freeways in the 1950s and 1960s were the most visible realizations of those local problems. The Interstate program had also serious cost overruns immediately after it started, and needed additional legislation to regulate its implementation. (Roth 2005a,b, Weingroff).

7.3.2 Congressional voting power, common pool, and pork barrel

Voting power is distributed between different US states in a way that gives relatively more voting power to a voter from a less populous state. Krugmann (2005), Taylor (2006) and O’Toole (2006) all point out that the division of votes leads to the continuing red state – blue state division, which reflects the urbanized state – rural state division. Most of the GDP is produced in the populous, urbanized states. The urbanized states have a relative under-representation in the Congress, while the rural states have a relative overrepresentation. Thus states like Alaska have been able to constantly receive more of the FHTF monies than its residents have contributed to the fund.

One can conclude that the same donor – receiver situation would most likely also happen in the EU, since EU has a similar vote structure for member countries. The opposite outcome could be realized if EU’s constitutional contract about voting rights would not hold when it produces negative outcomes for the more powerful EU states, i.e. if the more powerful states could negotiate a more advantageous outcome for themselves in such a situation.

Taylor points out that the current U.S. system of first creating a “common pool” of infrastructure money and then making the states compete for the money creates incentives to build transportation systems that are too capital intensive. It is hard for the politicians to answer the accusation that they have “lost” public money if they haven’t fought to get the maximum amount of it spent in their home state. Thus it is not in the interest of the politician to first make sure that the money is spent in most welfare generating way, but that it is spent in the politician’s home state. Roth (2005a,b) testifies to the same effect: the lengthy and costly negotiations over every five year period of the federal transportation monies is overwhelmingly about division of money between states and not much about efficiency of the federal monies in producing welfare. Also GAO has reached the same opinion. (GAO interview).

Knight (2004) found common pool interests in his empirical study: the senators voted against projects that increased the total spending, but voted for projects that increased spending in their home state. Knight’s results suggest over-spending in the aggregate, especially in politically powerful districts, and large associated deadweight losses.

Shirley and Winston (2004) states that the highway impact on economic productivity has decreased since the 1970s. They list as reasons the delayed political adjustment to
spatial changes in infrastructure demand, the shift of emphasis from building infrastructure to maintaining it, and the increasing effect of pork barrel that goes with the public allocation process of the federal transportation funds. One such mechanism, started in 1982 legislation, is the ability of Congress members to name specific projects, the “demonstration projects”, as conditions for supporting the legislation.

GAO refers to the “demonstration projects” as “earmarks”. In 1987 President Reagan vetoed the transportation bill because it came with 250 earmarks. The current bill, which was finally realized two years after the end of the last bill, came with 6000 earmarks. GAO has expressed a concern that the current system creates a costly and inefficient way to deliver the federal funding (GAO joint interview).

### 7.3.3 Stability of the appropriations formula

Once a division outcome for the federal money has been established, the receiver states have a strong incentive to maintain their receiver status. The Congress representatives have done this by adding provisions to the renewed appropriations calculations in such a way, that the outcome is guaranteed to deliver more or less the same amount of monies to the home state than before the change of the appropriations formula.

The GAO (1995) report summarized this Kafkaesque outcome of the appropriations calculation formula as follows: “The formula for apportioning federal highway funds among the states derives from a complicated set of calculations involving consideration of 13 specific funding categories. In some cases, these complex calculations can prove to be an essentially meaningless exercise. One prime example is the treatment of the four major highway programs (the Interstate Maintenance, Bridge Replacement and Rehabilitation, National Highway System, and Surface Transportation Program), which together accounted for 70 percent of all the funds apportioned in fiscal year 1995. Separate calculations are used to determine each state’s share of funding for each of these four programs. However, the outcome of each separate calculation is obscured because an adjustment is made for the Surface Transportation Program in each state’s apportionment. The result of this adjustment is that each state’s total share of funding for these four programs must equal the adjusted share of funding that the state received for the programs’ predecessors in fiscal years 1987 through 1991. A further concern with the existing formula is that irrelevant or outdated factors underlie the funding calculations for certain programs. GAO reported in 1986 that two of the factors that underlie certain key decisions about apportionment—postal road mileage and land area—were irrelevant to either the extent or use of the modern highway system. ISTEA restructured the major highway programs, but the states’ funding for the two largest programs—the National Highway System and Surface Transportation Program, together accounting for 40 percent of all the apportioned funding—remains linked to these irrelevant factors. Near the end of the apportionment process, most states’ total funding is increased through various funding categories known as equity adjustments. In fiscal year 1995, 41 states and the District of Columbia received a total of $2.8 billion in funding for equity adjustments. This funding represented 16 percent of the approximately $18 billion apportioned to the states that year.”

Johnson and Libecap (2002) studied the stability of the federal funds over the existence of the federal highway funding from the 1916 predecessor of the FHTF until 1997. The authors found large stability in states’ positions as “net donor” or “net receiver” states.
over the years. They also found that even though the appropriation rules of the FHTF have been changed, the initial appropriation rules could explain much of the donor/receiver rations of the later periods. Thus the change of appropriation rules had little impact on the allocation outcome.

Johnson and Libecap (2002) argue that the transactions costs of building a new winning coalition is high enough to promote the status quo in federal programs in general, and the FHTF is an example of such behaviour. This effect counters the theoretical public choice literature predicting cyclical majorities, short term programs and highly skewed distributions of program benefits. Johnson and Libecap (2002) refer to Tullock (1981) in their claim that programs are more stable and allocations more equal than the theory suggests.

To see if the stability of donor/receiver ratios would be counterweighted through pork barrel of other federal programs Johnson and Libecap examined the federal aggregate expenditures and taxes across the states. Also this calculation revealed high stability.

7.3.4 State response to federal grants

Gamkhar (2003) summarizes that the primary justification for using a matching grant in the federal highway program is that the construction of highways, particularly interstate highways, creates benefits that are not entirely internalized by the jurisdiction constructing the highways. The federal matching rate is expected to essentially lower the price of highway construction, to compensate the jurisdiction constructing the highway for the marginal external benefits it creates. Consequently, the federal matching rate should be about equal to the marginal external benefit from highway construction. The federal matching rate varies by type of project, with the federal share of 70-90%, usually 80%.

Gamkhar’s empirical work provides evidence that state and local governments are spending more than the maximum required to match limited federal highway grants. Therefore, the matching rate on these grants is, on the margin, not providing any additional incentives to the grant recipients. Gamkhar suggests that future research could examine whether the existing matching rates are higher than justified by the magnitude of the external benefit from highways to make a case for lowering the matching rates on highway programs.

The GAO (2004) report found that the states and localities invest more in highways than the federal government, even though recent federal investment has increased more rapidly than state and local investment (p.20, GAO-04-802). GAO found evidence that federal highway grants have increasingly been used to substitute for rather than supplement spending from states’ own resources. GAO notes that this substitution may be limiting the effectiveness of strategies to accomplish the federal-aid highway program’s overall goals.

7.3.5 Viewpoints about organizing the administering of federal funds

For Taylor, the most efficient allocation process would be a system where the federal state names criteria for the projects in terms of network and level-of-service properties and sets technical standards that need to be matched in order for the projects to be
eligible for federal funding. Taylor advises against the idea of a federal authority naming the projects to be funded (Taylor interview).

O’Toole (2006) suggests that the administration of monetary funds should be reorganized according to end user interests, instead of according to transportation systems, which reflect the production technologies. According to O’Toole, the current organizational system muddles the effective comparison and choice of alternative investment and maintenance options.

Roth (2005b) points out that a government trust fund like the FHTF has never been and cannot be a real trust fund in the sense that the guardians of the fund would be held accountable for looking out for the best interest of the beneficiary. Because this trust is not enforceable, the FHTF has never been a trust fund in the actual sense of the term. This unenforceability can be seen as a reason for the inefficiency of public trust funds.

GAO supports two somewhat conflicting views about the dedicated trust funds. GAO supports the “user pays” –idea, which a dedicated trust fund like the FHTF purports to do. On the other hand, GAO is against trust funds on the basis that they limit the overall efficiency of national government by preventing the transfer of monies between the funds. (GAO joint interview).

GAO (2004) identified following options to design and structure the federal-aid highway program:

1) Improving the efficiency of the federal funding:
   i) Revising federal matching requirements to increase the percentage of projects’ costs that must be paid for with state and local funds.
   ii) Instituting the use of funding formulas that reward states that increase state and local highway funding by increasing their federal funding, while reducing the federal funding of those states that do not.
   iii) Adding a requirement that states maintain their own level of highway spending effort over time in order to receive additional federal funds.

2) Alternatively, GAO suggests accepting the trends and changing the role of Federal Highway Administration (FHWA) to allow states more independence. Considering the program’s return-the-collected-funds-to-origin features, the federal-aid highway program is currently functioning as a cash transfer, general purpose grant program. If these functions were removed, the nation could save considerably by reducing the size of FHWA and the federal effort of collecting and accounting for the motor fuel taxes and other highway user fees. pp.40-43.

3) As a third option GAO (2004) recommends reconsidering whether a different program structure and different financing mechanisms could be used to target funding and more closely align resources with desired results. In doing that the role, organization, mission, and concrete goals of different actors in federal funding should be thoroughly re-evaluated.

GAO (2005) conducted a study on FHWA and suggests that the agency needs a comprehensive approach to improve project oversight.
7.3.6 Economic benefits of federally financed transportation projects

The reason for federally funded transportation infrastructure is the spillover benefits. Therefore one would expect to find a link between the amount of federal funding and the measured federal level benefits of the funded projects. However, GAO has not found that the impact analyses conducted before a given federally financed transport project consider economic efficiency, as the mandatory impact analyses limit their scope to impacts on nature. Also, GAO has not found ex post economic benefit studies on the completed infrastructure (GAO joint interview).

Taylor points out that it is very hard to estimate even the overall costs and social benefits of the total Interstate system, because the current system subsidises heavy trucks due to the fees levied on total weight of truck and number of axles, instead of axle weights. Another factor making benefit calculations difficult are the nonoptimal building standards of the roads. However, Taylor points out that the transportation corridors create notable local disutilities. These disutilities are created from the concentration of large traffic volumes that create negative net benefits for the functioning of the local economy.

Both GAO researchers and Taylor are of the opinion that there are no studies measuring the share of spillover benefits from Interstate Highways. Both gave an educated guess that only a very small fraction of the benefits from federally funded projects were non-local.

Johnson and Liebecap (2002) argue that since the federal funding decisions are done for other reasons than overall economic efficiency, “[…]any direct cost-benefit gains [from federal transportation programs], in the traditional sense, may be little more than coincidental.” (p. 29).

7.3.7 New revenue sources

There seems to be a growing consensus that the political process is unable to increase gasoline tax and therefore to increase traditional funding for the upkeep of the interstate system, while the expenditures of the fund are expected to exceed the accumulated funds and revenues of the FHTF in 10 to 15 years. This trend is exacerbated by energy-efficiency of vehicles and the increased price of gasoline, which in turn invokes interest in new types of revenue generation. (IBTTA 2005, TRB 2006)

However, GAO points out that if the highway user taxes were restricted to finance only highways, the financing would be adequate. The looming finance crisis of highways is connected to the use of highway user tax funds for other purposes than highways (GAO joint interview).

7.4 Recommendations for the choice of case study design dimensions

Persson and Tabellini (1996, p.624) characterise the differences between US and EU systems as follows: 1) the US federal government redistributes directly between individual citizens, whereas the EU has mainly a system of intergovernmental transfers; 2) the US federal government is directly appointed by and accountable to individual voters, whereas political appointments and accountability are only indirect in the EU;
and 3) the US federal government controls a wider set of policy instruments than the EU.

When any recommendations from the US federal highway funding are applied to the EU infrastructure funding, they should be subject to these three differences. The first two characteristics, i.e. the verticality of EU governance, accentuate multi-level agency problems, which the more horizontal governance of US can better mitigate. However, as the agency problems are already a problem in the US, they can be expected to form a substantial risk in the EU context. EU’s federal level ability to efficiently reach any specific policy outcome is further limited by a narrower set of policy instruments. Therefore one of the design dimensions to consider in the current case studies should be the choice between the federal government specifying the performance criteria of the potential federal investment versus the federal government identifying the transportation investment projects. The choice trades off concretely identified, but less transparently evaluated investments against less concretely specified but more efficiently evaluated investments.

For the purpose of the study at hand, maintaining this design dimension will make it possible to study if the particular transportation corridors studied in this project are investments that the explicit performance criteria would promote. This is valid information for individual EU states when they determine whether they would like to support formation of any potential federal government infrastructure fund.

Whether the federal level sets the performance criteria of investments or selects the investment, the distribution of votes among the states will have an effect on the federal level decisions. The most likely vote distribution of the potential fund will favour the periphery states, while the flexibility of contracts gives negotiation power to core states. A design dimension along the degree of sanctity of the voting rights on any potential infrastructure fund would be a useful design dimension for the case studies.

Of the funding share and type, the US experience would support a higher than current state share in the federally funded projects (i.e. projects funded at the EU level). There don’t seem to be studies that would evaluate the out-of-state versus local benefits from federally funded infrastructure but the assumption of US researchers is that the federally funded infrastructure benefits overwhelmingly the local interest (GAO joint interview, Taylor interview). However, tying the EU share of project funding to the spillovers of utility is attractive on theoretical grounds, and should be considered as a case design dimension. This is supported by the fact that if there is centralized federal infrastructure funding for different transportation modes, the comparability of the benefits from different types of infrastructure investments is important. The explicit connection would also concretize and make transparent the benefits of EU-level infrastructure funding.

An issue related to both the vote distribution versus negotiation room of the states and the experienced benefits from the realized projects, is the status quo bias of outcomes. The stronger the status quo bias, the more likely the fund allocation outcome is to stay favourable to the initial receiver states. As the vertical structure of governmental institutions decreases the attainable efficiency of any policy, risk of this bias should be expected to remain high in the EU context. To counteract this risk, the case studies should contain a dimension that measures voluntariness of membership: whether or not
a state has an option to leave the fund with a return of contributed funds from say last ten years of the fund membership, if the state can show that the benefits it received did not match the payments it made. Such an option would increase transparency of the funding decision, as the rest of the Fund members would carry the risk of having to remunerate overall non-beneficial projects, projects that do not generate EU-wide benefits, or projects that systematically abuse or favour certain members of the fund.

There is an increasing interest in private partners as long as the private partner will carry their share of the risks of revenue. Both the presence of private partners and the political unattractiveness of gasoline tax hikes increase the attractiveness of tolls as a revenue source. The share of tolls versus taxes should therefore be one of the case study design dimensions.
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APPENDIX: THE STRUCTURE OF THE MOLINO II MODEL

Introduction
To judge a TEN-T investment proposal and its funding alternatives, we need to pay attention to many problem dimensions. There are the usual benefits for the users and the project investment and running costs but there is also the competitive behaviour of local governments and private firms that make pricing and investment decisions that serve their own interests. In addition there is the risk dimension and the cost of different sources of funds.

In FUNDING we will use a combination of a micro model “MOLINO II” and European wide network models for freight and passengers to analyse the funding of several i projects. The purpose of the MOLINO II model is to focus on one project in detail and examine timing, financial structure and risk aspects.

In this appendix we briefly sketch the structure of MOLINO I and the main amendments that are made to accommodate the requirements of FUNDING. The three main amendments concern the structure of the network and the type of users, the treatment of risk and the software.

MOLINO I
The MOLINO I model was recently developed as part of the European-Union funded REVENUE project to assess transport pricing, investments and regulatory regimes with emphasis on the allocation of revenues from user charges. The model has been used in the REVENUE project for a variety of case studies that involve several modes. Since the model has to be applicable to many diverse problems, it is kept rather abstract and general.

The MOLINO I model is a policy assessment model, not a forecasting model. It is calibrated to an exogenous transport baseline that can be developed with any transport forecasting model. The time horizon, which can be chosen by the user, typically covers 10 to 50 years. MOLINO I is a partial equilibrium model of the transport market: income levels of the private transport users, and production levels of the firms using freight services as input, are taken as given. The model includes separate modules for demand, supply, equilibrium, and the regulatory framework. In its present form the model contains two transport modes (two parallel roads, road and parallel railway, railway and competing air link, etc.).

The demand module for passenger transport features an aggregate nested CES utility function with three levels: choice between transport and consumption of a composite commodity, choice between peak and off-peak periods, and choice between the two transport alternatives. Elasticities of substitution at each level are parametrically given. Passengers can be segmented into classes that differ with respect to their travel preferences, incomes and costs of travel time. The demand module for freight transport is based on an aggregate CES cost function (production levels are given) and also features three levels. The first level encompasses choice between transport and other production inputs, and the second and third levels are the same as for passenger transport. Freight transport can be segmented into local and transit traffic.

Transport users pay a generalised cost that contains several components: a resource cost (say fuel for a car), taxes levied by central and local governments (say fuel taxes and car...
taxes), a user fee (toll or rail fare) and a time cost. For a given infrastructure, travel time is assumed to be a linear function of traffic flows.

For each transport alternative a distinction can be made between an operator who takes care of maintenance and can set tolls or user charges, and an infrastructure supplier who decides on capacity extensions and on infrastructure charges. The costs of the operator have a linear structure: a fixed cost, constant variable maintenance and operation costs that depend on the type of vehicle or load, and finally a payment for infrastructure use that can be specified in different ways. The infrastructure provider also has a linear cost structure where the main costs are the investment and associated financial costs for the infrastructure. Operator and infrastructure suppliers can be private or public agents, and the cost level can depend on the contractual form.

The model includes a local and a central government that can pursue different objectives and control different tax and subsidy instruments including fuel taxes, public transport subsidies and profit taxes. Given the demand and cost functions, and the regulatory framework (see below) that specifies the behaviour of the governments, operators and infrastructure suppliers, the equilibrium module computes a fixed-point solution in terms of prices and levels of congestion for the two transport alternatives. In its present version the model has myopic expectations and is solved year by year.

It is the exogenous regulatory framework that stipulates the rules of the game and the ultimate outcome. This exogenous framework specifies for each alternative the objective functions of the governments, operators and infrastructure managers (public or private objectives), the nature of competition, procurement policies, the cost of capital, and the source and use of transport tax revenues. Various market structures can be modeled, including no tolls (free access), exogenous tolls, marginal social cost pricing, private duopoly and mixed oligopoly. Public decisions can be made either by local or central governments that may attach different welfare-distributional weights to agents (e.g. low-income vs. high-income passengers, or local vs. transit freight traffic) as well as different weights to air pollution and other (non-congestion) external transport costs. Primary outputs from MOLINO I are equilibrium prices, transport volumes, travel times, cost efficiency of operations, toll revenues and financial balances, travellers’ surplus and social welfare.

**MOLINO II: Extension to any serial and parallel network**

MOLINO I could only handle the competition between two alternatives (say two roads or road versus rail between one OD pair). In this FUNDING deliverable (see Chapter 3) we have shown that in the case of “corridor” TEN-T projects that run through different countries or regions, specific pricing and investment inefficiencies can result. This requires a model that can handle “serial” competition: where the transit traffic has to make use of two infrastructures that are each controlled by a different operator. For this reason, the MOLINO II model now allows the representation of any network. The network is now defined by a set of OD pairs, links and paths. For each link one defines capacity, operator and infrastructure manager. A path is then a combination of links that join a given OD pair. An example is given in Figure A1.
Network representation: example

Step 1: OD pairs (MO-MA, MO-LI, etc.)

Step 2: add links of potentially competing routes or modes

Step 3: Define paths, combining links that bring you from O to D
Path is defined $P_x(\text{link1,link2, ...})$

Legend Figure:  
- Black = rail $Rx$
- Green = air $Ax$
- Blue = road $Rx$

Figure A1 Example of network representation in MOLINO II

Once the network is determined, one defines for each OD pair and for each class of users a utility function or cost function over alternative paths. For passengers one can now differentiate in terms of the motives of travel, for freight one typically distinguishes between categories of goods. The distinction between local and transit traffic is now already present in the definition of the OD pairs.

Treatment of risk
The sources of variability in the MOLINO II model are:
- The demand parameters: elasticity of substitution, value of time, total demand, etc…
- The supply parameters: free-flow travel time, capacity of the infrastructure, etc…
- Macroeconomic parameters (interest rate, social cost of public funds, etc…)

Besides these sources of variability, random errors can be added at strategic places in the procedure in order to reflect the impact of approximating reality by parametric models. This error term should also reflect the individual heterogeneity which is not included explicitly in the model.

The average parameters are provided by the MOLINO II calibration module (deterministic model). The distribution of parameters around the average values has to be provided by the user of the model. However, it may be more convenient for the user to give the distribution of some input variables (such as travel times) instead of the distribution of the calibrated parameters. In that case, the MOLINO II calibration model computes the distribution of the calibrated parameters from the distribution of the input variables. For each set of calibrated parameters, the $NPV$ of each project can be computed. Proceeding this way, we obtain the required distribution of $NPV$. From this distribution, we can compute the average $NPV$, variance of $NPV$, $VaR$ and $CVaR$, and therefore compare projects. Note that the marginal distribution of each parameter is not
enough to compute the distribution of the NPV, which depends on the joint distribution of the calibrated parameters, and in particular on their covariances.

Once the joint distribution of the calibrated parameters is entered (or computed from the distribution of the input variables) in the MOLINO II model, Monte Carlo simulation can be used to compute the distribution of the NPV of each project. For each set of calibrated parameters, the corresponding NPV of each project is computed by the MOLINO II model. Given the complexity of the joint distributions, and given that we are interested (for computing the VaR and CVaR on the NPV of each project) in the tails of the distributions, a large number of random draws (at least 10,000) is necessary to compute the distribution of the NPV of each project. It is therefore fundamental that the MOLINO II model is able to compute the NPV in a very efficient and fast way. Note that random draws in the entire distribution of calibrated parameters are necessary to compute the tails of the NPV distribution.
SUPPORTING DOCUMENTATION

Task Report: Strategic investment and pricing decisions in a congested transport corridor
Task Report: The interaction between tolls and capacity investment in serial and parallel transport networks
Task report: Mark-up rules for funding investments
Task Report: Case study on infrastructure funding in Germany
Task Report: Case study on PPP in Hungary

The task reports are available on the FUNDING website: http://www.econ.kuleuven.be/funding/.