4. PRINCIPLES FOR EFFICIENCY IN THE PROVISION OF SURFACE TRANSPORT INFRASTRUCTURE

4.1. Introduction – What is efficiency?

It has already been emphasized that efficiency should be the primary justification for choosing any particular investment of society's resources over another. This chapter provides a working definition of this fundamental concept, and describes the factors that contribute to it.

For the purpose of this report, *efficiency* is taken to mean some combination of *reduced costs* and/or *increased benefits* to society (Virtuosity Consulting, 2005). More specifically, this translates into any of the following:

1. Reducing inputs (i.e. money, people, assets) for the same outputs.

2. Obtaining more outputs or improved quality for the same inputs.

3. Obtaining proportionally more outputs or improved quality in return for an increase in resources (ODPM, 2005).

However, if input prices – *i.e.* the rate of return paid on capital or the labour costs – are reduced without affecting output, this does *not* improve efficiency from a social point of view. The reason is that the lower price of, for instance, labour (*i.e.* a lower wage) is beneficial for one party (the employer) and negative for another (the employee) and these two effects cancel each other out.

The efficiency concept has different dimensions and, for each, it is feasible to define more or less precise tests to assess whether or not an organisational model meets the respective efficiency targets.

The first dimension involves ensuring that "the right things are being done" so that society's resources are directed to the uses that provide the maximum level of welfare. This is referred to as *allocative efficiency* and is further discussed in Section 4.2. The second main concept is referred to as *productive efficiency*, and concerns cost minimisation – *i.e.* carrying out activities at the lowest possible cost. This is addressed in Section 4.3.

4.2. Allocative efficiency

Allocative efficiency comprises two dimensions: First, it must be ensured that new infrastructure is added when, and only when, necessary. Secondly, it is important to make sure that existing infrastructure is efficiently used; to this end, prices for using this infrastructure should be appropriately set.

4.2.1. Investment

Spending on new or upgrading the standard of existing roads or railways will be efficiency-enhancing if infrastructure investment – building a new bridge, for instance – reduces society's costs for travel and transport, compared with not making the investment. A project may also enhance the benefits of the existing transport system, such as by opening up new ways to travel and transport or improving the quality of the system. If the cost savings and benefits of a project, taken over its lifetime and net of maintenance and operating costs, exceed the costs for having it built, then the project will add to the welfare of a society. This is often referred to as the project having a positive *net present value* (NPV), a concept described in Box 4.1.

Allocative efficiency therefore requires that all investments should have a positive NPV in order to be built. The obvious corollary is that projects that cost more than the benefits that they add should *not* be built.

Organisational models that make it reasonably certain that projects with positive NPV are built, and that projects with negative NPV are not, will therefore add to allocative efficiency. This also means that the dynamic efficiency of society improves, as money today is motivated by future increases in benefits and/or reductions in costs. Society will, over time, be successively more well-off if such assets are constructed.

There are well-developed methods for calculating the net present value of infrastructure investments using social *Cost-Benefit Analysis (CBA)* techniques. A project sponsored by the EU has reviewed the state of the art of applications of CBA within the transport sector, and has come up with suggestions for calculation principles and parameter values, such as value-of-time savings, accident reduction, improved environment, *etc.* (HEATCO, 2006).

To be able to calculate NPV, the potential project must be appropriately described and designed. The project's *a priori* design specification may be decisive for whether its NPV is positive or not. There are two design features that warrant particular attention:

1. *Technical design:* Assuming that a current road, railway or waterway between two cities is of inferior quality, it must be decided how this deficiency will be rectified. Should an existing road be upgraded to motorway standard, or is it sufficient to just add a new lane? Should a railway line be straightened or should an additional track be added in order to facilitate train meetings? Should a new type of lock be built in a canal or should the old one be renovated? Each choice of technical design should, in principle, be subject to economic analysis in order to identify which solution provides the highest NPV.

2. *Pricing or not:* Given that new infrastructure is to be built, should it be paid for by user charges or by tax revenue? To answer this question it is necessary to analyse the project's NPV with and without user charges, noting also the principles discussed in Chapter 7. The no-charges case must, however, also comprise due attention to the social costs related to "standard" (tax) financing; even if a user charge does not reduce the NPV of a project it may induce lower social costs than the distortions caused by taxation.

The overall recommendation is therefore that projects with positive NPV should be built, as they provide more benefits in return for the costs initially spent. Of course, this is subject to the limits of available resources. For each project chosen, the design that results in the highest NPV should be selected. This is true with the exception of the pricing aspect, since a toll may reduce NPV compared to a no-toll solution, but may still be better than funding by way of taxation.

Particularly where PPPs are concerned, much emphasis is placed on *ex ante* value for money (VFM) estimations. One tool that is regularly employed is the "public sector comparator" (PSC), which compares the costs and benefits of a non-traditional model for infrastructure provision (*e.g.* PPPs) with those of employing traditional methods (*i.e.* direct government provision of infrastructure). This is discussed in greater detail in Section 5.4.

Box 4.1. Definition of net present value

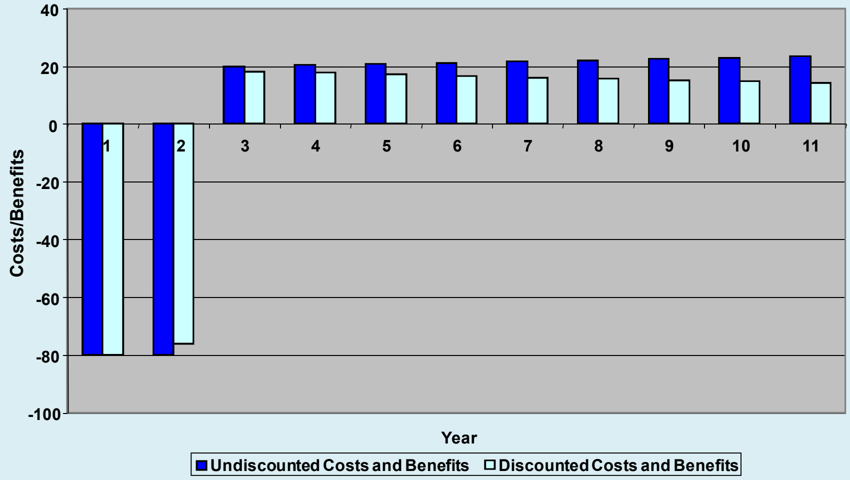
Assume that the costs for undertaking a project are 160 – 80 in year 1 and 80 in year 2. After having been built, the project will generate benefits of 20 in year 3. The benefits grow by 2% per year after that, until the investment must be scrapped after year 11, i.e. after 9 years of use. Adding these costs and benefits provides a net value of almost 35.

But costs and benefits in the future are worth less than costs and benefits "today". One technical method of incorporating this consideration into cost-benefit analysis is to discount future costs and benefits with a discount factor, in this way reducing their value. The below equation expresses the Net Present Value (NPV) of future benefits (B) and Costs (C), for all years (i) of a project, from its first (i=1) to its last (n=11 in the above example). The expression $(1+r)^i$ is the discount factor. If the discount rate (r) is 5%, the costs or benefits in year 2 will be divided by 1.05, and in year 6 by 1.28 ($=1.05^5$).

$$NPV = \sum_{i=0}^{n} \frac{(B_i - C_i)}{(1+r)^i}$$

Discounting benefits and costs in this way means that the Net Present Value of the above example project is close to -11. This means that the project generates fewer benefits than it costs to construct and should not be built. This is a different result than if no discounting is applied and can be explained by the fact that early costs are not reduced as much as are future benefits. Figure 4.1 demonstrates the way in which undiscounted and discounted benefits and costs develop over time.

Figure 4.1. **Hypothetical Demonstration of Undiscounted and Discounted Costs and Benefits**



The NPV is of course strongly affected by the parameter values. If, for instance, the discount rate were 3% and the value growth 5% per year, NPV would be 26 and the project would be worthwhile to undertake. A first year benefit of 25 rather than 20, which grows at 2% per year and with a discount rate of 5% would also generate a NPV of close to 26.

4.2.2. Pricing

A key issue with regard to the extent to which an infrastructure investment will produce more benefits to society than another use of the same resources is how the resulting asset is used. This is particularly important given that the use of that infrastructure can produce significant costs to society – in terms of environmental degradation and traffic crashes, for example – as well as benefits.

One potent means for affecting efficiency in resource use is the price, since the price charged affects the extent to which an asset is used. In particular, economic theory tells us that efficiency is maximised when users are charged the marginal costs generated by their use of the infrastructure.

This issue is dealt with extensively in Chapter 7. Furthermore, as noted in Chapter 1, for the most part, there is no intrinsic link between the various models for providing infrastructure, on the one hand, and specific pricing mechanisms, on the other.

4.3. Productive efficiency

Once it is decided that an initiative is to be carried out, this should be done in the cheapest possible way. For an investment project, this means that methods should be selected that provide for cost minimisation. The combination of equipment, material inputs and labour should be chosen such that no more resources than necessary are employed in the process.

A primary argument often put forward for the delegation of responsibilities for infrastructure to the private sector is that private companies are capable of greater efficiencies than the public sector. This argument is further discussed in Section 4.3.1. Section 4.3.2 then addresses the issue of costs of construction and maintenance from the life-cycle cost perspective. Section 4.3.3 discusses the importance of not jeopardising quality in the pursuit of low costs. Finally, Section 4.3.4 emphasizes public tendering as the ultimate tool for achieving the lowest possible costs.

4.3.1. Is the private sector more efficient? The principal-agent problem

There are a number of common assumptions regarding why the private sector may be more efficient in carrying out a given project than the government. The European Union's *Guidelines for Successful Public-Private Partnerships* (EC, 2003a), for instance, note the following outcomes as indications of successful PPP projects:

- Acceleration of infrastructure provision.
- Reduced whole-life costs.
- Better risk allocation.
- Better incentives to perform.
- Improved quality of service.
- Generation of additional revenues (e.g. more commercial development, leveraging of private funds).
- Enhanced public management.

Similarly, PricewaterhouseCoopers (2001) put forward the following objectives for projects under the UK's Private Finance Initiative (PFI):

- Construction on-plan, on-time and on-budget.
- Better quality of design and construction relative to traditional procurement.
- Whole-life-cycle approaches to deliver value and reducing costs.
- Early delivery of quality infrastructure providing wider social benefits.

There are various reasons why private sector entities may be more apt to maximise the various types of efficiency. The following list provides some examples:

- The private sector is usually more experienced in optimising the use of assets and their revenues (Freehills, 2002).
- The focus on profit maximisation and shareholder value results in better financial discipline and accountability than would be found in government (Arndt, 1999).
- Innovative design, and better construction methods and materials may be combined with efficient operation, adequate maintenance and low life-cycle costs (Harris, 2004).
- Private entities may benefit from more flexible labour management practices than public ones.

As relevant as these arguments may be, they do not offer a comprehensive and convincing logic for the private sector's supremacy. In contrast, the principal-agent paradigm offers such an argument. This theory is based on a two-step line of reasoning:

1. Any production process is plagued by incentive problems between one party that decides what should be done – the principal – and another party that actually does the job – the agent.
2. There is reason to believe that it is easier to overcome these agency problems when contracting with a private firm than within the public sector.

Two features constitute the core of the principal-agent problem:

A. *Information:* One party to a deal to provide a service, such as building new infrastructure, is typically better informed than the other. The agent sits closer to the activities that are to be undertaken and knows more about the details of the job than the principal; this is indeed a chief reason for employing an agent.

B. *Different goals:* The overall objective of the government is to maximise social welfare. In contrast, a commercial agent is focussed on maximising profits. These two goals may conflict with each other.

It is the combination of information asymmetries and divergent objectives that places the agency problem at the core of current microeconomic research. The fundamental challenge in creating an effective governance framework for any model for infrastructure provision is to ensure that the agent (the infrastructure provider) will perform in the interest of the principal (the entity requiring the infrastructure).

It is important to acknowledge that the agency problem exists in any model for providing infrastructure, including all of those described in Chapter 1, and that there may be various levels of principal-agent relationships. For example, where public entities are responsible for delivering infrastructure, ultimately, the general public is the principal, entrusting important choices to elected representatives. Legislators, and particularly ministers are, in turn, in a sort of principal-agent relationship with the country's bureaucracy. Within the government, the principal role may be played by central ministries responsible for overall decision-making, such as the finance ministry, with the agent role being played by the ministry responsible for infrastructure delivery. Alternatively, the agency role may be delegated to a government agency, with the principal role being played by a ministry that oversees its activities, such as the transport ministry.

Where responsibilities for providing infrastructure are outsourced or devolved, the independent entity responsible for providing infrastructure (or elements of that task) will play the agent role, while the government, usually represented by a particular ministry, is the principal, acting on behalf of the taxpayer. In such instances, the agent could be the state-owned enterprise, private infrastructure provider, special purpose vehicle, *etc.,* while the principal would be the public sector, represented by some specific ministry.

Within organisations, the agency problem takes the form of divisions between governing bodies and management. For example, within a ministry, the minister takes on the role of principal, representing the elected government, while public servants will be closer to the actual delivery of services and thus play the role of agents. In the private sector, these roles are divided between the shareholders, represented by the board of directors, and the firm's management.

There are several possible reasons for assuming that the agency problem is better managed when employing private entities. To a large extent, these revolve around the clarity of purpose afforded to organisations that have limited and uncomplicated mandates, focused on tangible and measurable outputs.

The public sector is by nature driven by objectives that are relatively abstract, largely defined by the pursuit of the common, public good, meaning that it is more difficult to measure performance. It also has an enormous "clientele" to please, composed of citizens, communities, states, regions, businesses, special-interest groups, *etc.*, many of whom will have conflicting demands. In contrast, a private firm is typically managed to maximise profits, which can be relatively easier to measure. Moreover, it often has only a few owners, or at least fewer than in the public sector.

The public sector principal tends to be more heterogeneous, simultaneously involving central ministries (*i.e.* the finance ministry), ministers with diverging mandates, cabinet, parliament, the head of the government and, ultimately, the voting public. This means that the agent must try to appease the concerns of all of these, while also trying to meet users' needs. In contrast, a private firm usually has few owners and a (relatively) homogenous management board.

A public sector agent is also more likely to face "soft" budget constraints. Since it is not driven by a profit motive or the threat of bankruptcy, it may be easier for the public sector to make extra money available after budget overruns. In other words, public organisations are less likely to feel the consequences of inefficiency, as these are typically absorbed by the taxpayer (Kain, 2002). An official who knows this may be less prone to take painful decisions to cut costs, than if the budget constraint is absolute. Budget discipline may, in this respect, be stricter in the private sector organisation.

Taken together, these reasons explain why it may be easier to induce a private agent to reduce costs. This also explains many of the assumed benefits of using private service providers, which were outlined at the beginning of this section.

However, it is also useful to repeat that the public and private sectors pursue different objectives. These are the source of potential conflicts, which can be exacerbated by the agency problem. Kain (2002) notes that poor productivity on the agent's part may be very difficult and/or costly to substantiate, which naturally leads to the temptation to pursue profits at the expense of the principal. This, in turn, is a basic justification for the PPP model – by assuming risk, the private partner (agent) also takes on the financial consequences of its own productivity in carrying out the work. For this to be effective, strong competition in the tendering process is required, resulting in bids that are as close as possible to production costs. Furthermore, the contract regulating what the agent should do must build in provisions to prevent reducing costs by sacrificing quality and wider social objectives.

Furthermore, some of the constraints of public sector management may be overcome by devolving responsibilities for developing and managing infrastructure to entities that are – while not fully private in terms of their ownership – more strictly focused on the task of infrastructure provision, and independent to varying degrees in their decision-making; these organisations thus take on the role of agent, vis-à-vis the public principal. This option is covered in the next chapter.

It is therefore the manner in which an agent and, in particular, the private sector is involved that will determine the extent to which its inherent profit motive results in overall efficiency gains. The relationship between principal and agent is typically codified in a contract, so the key task is to design this contract in a way that makes it reasonable to believe that costs for doing the job will be minimised.

Two features of this contract will be detailed in the next sections, namely the life-cycle nature of the agreement and the need to safeguard quality. Contracting issues are also addressed in Chapter 6, dealing with risk, and Chapter 9, dealing with the importance of appropriate procurement mechanisms.

4.3.2. Cost efficiency and life-cycle budgeting

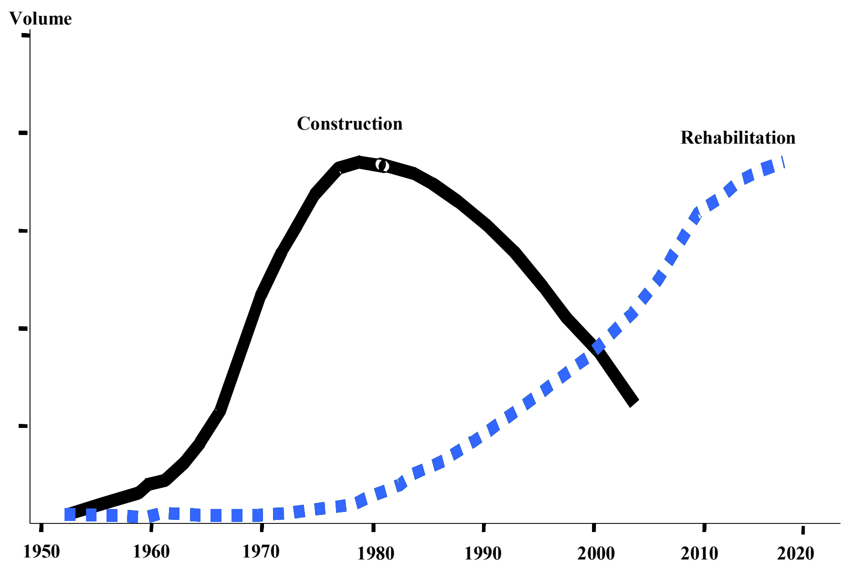
The aggregate maintenance and construction needs of transport infrastructure are characterised by cycles spanning decades. Obviously, the construction of new assets will generate future maintenance needs. The need for future maintenance funding can therefore be planned and justified on the basis of asset management systems, by making *ex ante* estimates of the wear and tear of fixed assets. The relationship between construction and maintenance is shown graphically in Figure 4.2.

It has already been noted that government budgeting processes may disconnect investment in new infrastructure and the subsequent needs for maintenance spending. Construction may, for instance, be more politically expedient than maintenance, in that the provision of new infrastructure may be rewarded with votes from those who benefit from the assets, or may result from promises made during elections. The political payoffs from decent maintenance standards are far less, and thus investments that build capacity are also often prioritised over those that maintain it.

This can be particularly problematic given that the current development of new infrastructure, benefiting the present government, creates a need for maintenance that places financial burdens on future governments. Furthermore, insufficient maintenance in the short term translates into more expensive maintenance in the longer term and increases the need for funding in the coming years that – again – will have to be paid by future governments.

Alternative models for the provision of infrastructure may to some degree alleviate this problem. With a "single entity" approach to designing, constructing, operating and maintaining an asset (Freehills, 2002), and an independent agent that is made responsible for all aspects of an asset, the contract can be signed on the basis of a long period, safeguarding future maintenance volumes. Provided that the contract is appropriately designed, the independent infrastructure provider is rewarded into taking decisions that create better results in the long run. In particular, it would balance the costs for different construction methods against costs for future maintenance in order to establish the appropriate initial design that will result in the lowest overall costs (EC, 2003a). It should, at the same time, be acknowledged that such long contracts will reduce the possibility for future governments to rebalance spending away from maintenance.

Figure 4.2. **The cyclical nature of transport infrastructure construction and rehabilitation**



Such an arrangement could involve creating a package of services covering the construction, capital funding, maintenance and operations (or some combination of these) over an extensive period. More spending during the investment phase may save on future maintenance costs. Alternatively, cheaper investments and more expensive maintenance may, in present value terms, be the preferred option. A cost-efficient project design is therefore one that delivers *the lowest life-cycle costs*.

Irrespective of which solution is chosen by the entrepreneur, life-cycle cost management also creates incentives for innovation, inasmuch as resulting cost reductions are translated into profits (or lower losses). The very fact that the contract is for a long period of time means that the benefits of appropriate inter-temporal tradeoffs are reaped by the innovator itself, *i.e.* the contractor.

A key element in success is ensuring the existence of appropriate incentives for this to happen. Cost efficiency therefore requires contracts that span long periods of time.

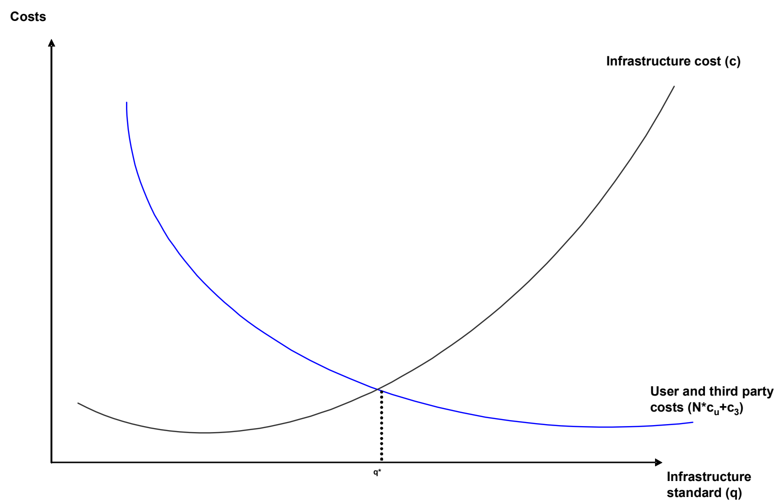
4.3.3. Cost efficiency and quality

Different technical solutions and designs chosen for a project will affect future costs and benefits. An obvious risk in this is that short-term cost savings may jeopardise future quality, which would spill over in the form of higher costs to users for using the facility (*e.g.* as a result of wear and tear on vehicles, longer travel time, *etc.*).

For this reason, a project contract should be designed to provide services at the lowest possible *social* costs. Higher infrastructure "quality" – smoother and safer roads and railways – is typically more costly to build and maintain than infrastructure with a lower standard, although higher quality will reduce users' costs at later stages. The costs to users of poor maintenance are potentially very large. For example, road users' vehicle costs on well-trafficked inter-urban roads (taken as an aggregate) can be between 10 and even 100 times higher than the costs for maintaining a road (Newbery, 1988, cited in Kopp, 2006).

However, there is still a point where the additional costs of building better infrastructure do not translate into commensurate benefits to users in terms of lower costs for using it. Cost minimisation must therefore seek an optimal balance between the counteracting components of the costs of investment and the costs resulting from under-investment. This point of balance is depicted in Figure 4.3 as q*. Efficiency calls for balancing the agent's own (higher or lower) maintenance costs, resulting in better or worse infrastructure quality (q), against (lower or higher) costs for users and third parties. In reality, the exact point where the sum costs to users and infrastructure providers is lowest may vary somewhat from the intersection between the two curves, depending on the shapes of these curves (see, for example, Austroads, 2006, Figure 2.4).

Figure 4.3. **Balancing the agent's investment costs against costs for users and third parties**



In particular, the following quality aspects must be accounted for in order for the contract to deliver efficient services:

- *Availability:* The purpose of infrastructure is to facilitate transport. Payments from the principal to the agent for new infrastructure must therefore be conditioned on lanes or sections becoming available for use. In addition, lack of availability due to maintenance activities or because of poor maintenance (*e.g.* inappropriate ploughing during winter, *etc.*) should affect the payment for services. Appropriately designed availability clauses could also provide incentives for undertaking maintenance activities during off-peak periods of the day or of the year.

- *Physical Quality*: The quality of travel deteriorates when physical quality gets increasingly uneven. This includes consequences for the time of a journey, for vehicle operating costs, riding comfort and safety. The contract must make sure that the contractor accounts for these aspects when considering alternative maintenance standards.

- *Safety*: Other parameters controlled by the contractor may also affect safety; examples include snow clearance, maintenance of street lights, signage markings and side-rails, and clearing side areas in order to reduce the risk of wildlife accidents. One way to handle this aspect is to specify tasks in the contract. In addition, it is feasible to benchmark observed accident risk against other, similar infrastructure specified in the contract, in order to penalise below-target performance and remunerate good behaviour.

- *Environmental concerns*: How infrastructure is constructed affects its impact on the environment. For example, the choice of material for a road's top layer may have consequences both for noise from traffic and the extent of particles worn off by studded tires. To the extent that the principal has information about these and other environmental externalities, these concerns should be included in the contract. This could be achieved either by way of direct instructions or with bonus/penalty conditions linked to the annual remuneration.

- *End-of-period standard*. When infrastructure is to be handed back to the principal after many years, it is important that it has been appropriately maintained. The original contract should account for this by stating some sort of functional quality at the time of return in order to curb the risk that the contractor would otherwise save on maintenance during the final years of the contract.

Section 9.4 addresses the importance of designing contracts in order to ensure that quality standards are maintained throughout the project.

4.3.4. Tendering to achieve cost efficiency

Any potential road builder can calculate the costs for a pre-specified project, but there is no straightforward way to say beforehand what the cheapest way to have it built is. In particular, different builders may suggest different cost levels and it is typically not straightforward to tell in advance what makes the best cost estimate.

The chief mechanism for cost minimisation is therefore to employ a competitive procurement mechanism, which should result in the project being contracted to the bidder that is willing to implement it at the lowest possible cost. A bid is, in reality, a commitment to undertake the pre-specified task at the amount submitted. It therefore provides relevant information about the cheapest way to have the project built.

Cost minimisation by the private sector is thus intrinsically linked to competition. There must be a "sufficient" number of participants in the process in order to discipline bidders to really press down their costs as far as possible.

To ensure cost efficiency, the production process must be adapted over time. One reason is that relative prices may change, making it necessary to use more plant and less labour, or vice versa. Another reason is that technological changes may occur that should be incorporated into the process. And a third reason is that a specific project may provide information about better ways to handle the production process in future.

There is, therefore, a strong element of innovation inherent in the search for cost-efficient ways to undertake projects. This is particularly so when a bid is being prepared for submission, as each bidder is seeking to get the upper hand in the competition and the procurer will thus benefit directly from the cost pressure. But it is also the case during the implementation and maintenance phases, when new methods may be developed. In these respects, the procurer does not directly benefit from the costs savings, but these primarily materialise as a higher profit (or possibly a lower loss). The procurer would, however, benefit by having access to better and cheaper ways to carry out future projects.

The presence of private financing may provide an additional incentive for cost minimisation, as private lenders – banks and other financial institutions – are likely to scrutinise the project in order to ascertain that the bidder is careful when preparing the bid and in carrying out the work as effectively as possible.

4.4. Summary

The primary justification for the use of one model for the provision of inland transport infrastructure over another is the extent to which it provides for greater allocative and productive efficiency.

Having defined the meaning of efficiency we now look at what qualities the different models identified in Chapter 1 have in this respect. Chapter 5 reviews these models against the normative framework given in the present chapter.

KEY CONCLUSIONS

- The key justification for the use of any alternative financing mechanism is the extent to which it provides efficiency gains, in comparison with other financing mechanisms.

- Government's first concern must be for ensuring that the model chosen for delivering infrastructure provides for relative allocative efficiency, in terms of the best overall use of resources. Investments should be undertaken when a project's benefits, taken over its life length, exceed the costs for building and maintaining the facility, i.e. when their Net Present Value is calculated to be positive.

- The aforementioned points mean that rigorous ex ante cost-benefit analysis should be applied to potential new initiatives, examining whether these expenditures provide greater net benefits than other potential uses of resources, the costs and benefits of different means of carrying out the projects, and the impact of different pricing schemes.

- Furthermore, to achieve productive efficiency, contracts should include both upstream (design and construction) and downstream (maintenance and operations) aspects of the project, and cover a long period of time, sometimes referred to as a lifetime contract

- The quality of the service to be provided must also be safeguarded. There is otherwise a risk that low costs will be achieved by reducing the standard of the infrastructure to the disadvantage of future users. Quality, in this sense, refers to availability, general standards, safety and environmental implications.

- Competitive procurement is the most effective means of ensuring productive efficiency where PPPs are concerned.

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Nils Bruzelius (2005), The Impact of Legal/Regulatory Frameworks on Transaction Costs for Private Sector Involvement in (Transport) Infrastructure Funding.

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In addition, working group members provided detailed presentations on themes associated with this project at various international sessions. These are also available on the Transport Research Centre's web site, at www.internationaltransportforum.org/jtrc/index.html

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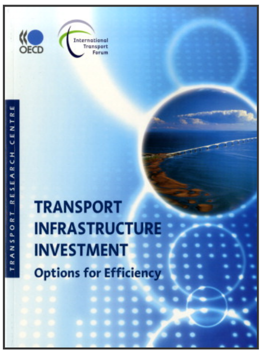

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