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Public and private roles in road infrastructure

An exploration of market failure, public instruments and government failure

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Abstract in English

Starting with a ‘greenfield’ situation, we discuss reasons for market failure in road infrastructure provision. We show why it may not be optimal from a welfare perspective to leave road provision fully to the market and government intervention in this sector can improve welfare. Government intervention comes in different forms, such as financial intervention (taxation, subsidies), regulation (price, quality, environmental), and public provision of roads or road services. The analysis of the literature regarding government instruments allows us to establish a correspondence between different forms of market failure and instruments. Several case studies of particular road infrastructure projects are included to illustrate the use of government instruments.

Key words: road infrastructure, government policy, public-private partnership (PPP)

JEL code: L92, L98, H4

Abstract in Dutch

Aan de hand van een ‘maaiveld’-situatie bespreken wij redenen voor marktfalen waardoor de voorziening van weginfrastructuur door de markt mogelijk niet optimaal is vanuit een welvaartperspectief. Overheidsingrijpen kan dan de welvaart verhogen. Wij onderscheiden de volgende vormen van overheidsingrepen bij de weginfrastructuur: financiële instrumenten (belastingen of subsidies), regulering (prijs, kwaliteit, milieuregels) en publieke voorziening. Uit de analyse van bestaande literatuur over de overheidsinstrumenten volgt welke overheidsinstrumenten bij welk marktfalen horen. Het rapport bevat enkele casestudies van afzonderlijke infrastructuurprojecten ter illustratie van het gebruik van overheidsinstrumenten bij marktfalen.

Steekwoorden: wegeninfrastructuur, overheidsbeleid, publiekprivate samenwerking (PPS)

Een uitgebreide Nederlandse samenvatting is beschikbaar via www.cpb.nl.

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Preface

This CPB-Document reviews economic arguments concerning the role of the government in road provision. In the Netherlands, the government has always been playing a major role in the planning and provision of the road infrastructure. This basic principle has not been debated until recently; however, recent papers and reports[1] introduce the idea of a larger role for market mechanisms in this sector of the economy.

Starting with a 'greenfield' situation, this CPB-document discusses the public and private sector roles in the provision of roads. In the case of road infrastructure, the term 'greenfield' may be taken quite literally. Therefore, the main line of the document is built around an example literally consisting of a green field, in which farms, mills and villages are connected by roads in order to produce and trade. This easily accessible example illustrates main economic concepts and arguments behind government intervention in road provision, as well as respective government instruments, while more complex technical issues are confined to text boxes accompanying the main text.

The report has been written by Mark Lijesen (project leader) and Victoria Shestalova. The authors benefited from many useful comments and suggestions of the project 'feedback group' that included both policy makers and researchers: Rosemarie Bastianen, Roger Demkes, Edward van Os and Pim Warffemius from the Ministry of Transport, Ivana Gomesdurao from the Ministry of Finance, Joost Passenier from the Ministry of Economic Affairs, August Mesker from VNO-NCW, and Erik Verhoef from the Free University of Amsterdam. The authors also acknowledge helpful comments of Joost Poort from SEO and CPB-colleagues Paul Besseling, Paul de Bijl, Casper van Ewijk and Rafael Saitua Nistal. The responsibility for this publication rests entirely on the CPB.

Coen Teulings
Director

[1] See e.g. the document 'A different way to pay for mobility' published by a governmental commission.

Summary

The document reviews economic arguments concerning the scope for the government in road provision. Starting with a 'greenfield' situation, we analyse possible reasons for market failure in road provision, explaining why the government may need to intervene in this sector of the economy. Market failures in road provision can relate to (a) public good features such as non-excludability and non-rivalry; (b) market power of the owner; (c) external benefits, such as positive effects on labour mobility and economic growth; as well as (d) external costs, including congestion, pollution, and other environmental damage.

Government intervention comes in different forms, such as financial intervention (taxation, subsidies), regulation (price, quality, environmental), and public provision. The analysis of the literature regarding government instruments allows us to establish a correspondence between the forms of market failures and instruments.

Financial intervention

Subsidies (compensating the owner for the external benefits that a private road delivers to the society) are the least intrusive form of government intervention to encourage optimal investment. While subsidies are used to internalise external benefits, taxes work in the opposite way, providing an instrument to internalise external costs. However, not all types of market failures can be dealt with by financial instruments, e.g. financial instruments cannot prevent market power of the private owner. Besides, information asymmetry may make it difficult to calculate optimal subsidies and taxes.

Regulation

Regulation is generally more intrusive than subsidies. However, one of its forms, called 'universal service obligation' (USO), works in economic terms similarly to subsidies, as the compensation of the cost of USO involves cross-subsidization. Price regulation such as restrictions on tolls can prevent excessive pricing by private owners. Historically, cost-based and price-cap regulation models have been used in regulatory practices. However the modern theory and practice (from other sectors of the economy) point towards the use of more market-oriented regulation models, such as 'yardstick competition' and competition for the market, for example, through procurement auctions.

Quality regulation can take a form of quality standards, e.g. with respect to safety and design. Such standards can be complemented by economic incentives, which can be created by integration of price and quality regulation. Environmental and safety norms can affect the design and location of the roads. Examples include norms on noise, norms restricting the distance of roads from residential houses, safety norms and so on.

Public provision

From the economic theory perspective, as long as quality is contracted, both private parties and government organisations should be equally able to deliver public goods and services. However, the outcome may be different in the case of non-contractible quality. In particular, private ownership is not optimal in the case of a large detrimental effect of cost reductions on non-contractible quality. In such a case the government should have more control over the asset and service provision.

Uncertainty about future developments may be another reason for the presence of the government in the road sector. Since the geography of the regions changes with time, so does the road infrastructure. As it would be too costly to predict all possible contingencies that may be relevant for the development of the road infrastructure in the future, contracts with private providers are inheritably incomplete. Therefore, contractual design should not neglect the uncertainty regarding future changes.

Economic literature also warns that government failure may arise when governments intervene. Government failure may be associated with information asymmetry, X-inefficiency (especially under full government provision), lobbying, a short-term horizon of government officials, regulatory capture and corruption. Therefore, policy makers should take these risks into account when choosing the degree of government intervention. The welfare loss due to government failure should be weighed against the welfare loss of market failure.

Case studies

The case studies included in this document highlight the importance of contractual design. The experience of the privately owned State Route 91 in California shows potential market power problems that can result under full private ownership because of contractual incompleteness. Government participation in the infrastructure provision, for example in the form of a public-private partnership, leaves the government with more control over the situation than in the case of fully-private provision. However, here again, flaws in contractual design may lead to excessive rents to the private party. So in the case of the Wijkertunnel, the contractual design was such that the payment to the private party by the state appeared to be sensitive to the changes in assumptions, in particular, those related to traffic volumes. The rents of the private providers have increased substantially with the increase of traffic volumes.

With respect to congestion issues, we observe (based on theoretical and empirical literature) that flexible time-varying tolls work well solving congestion on the tolled road, hence, market mechanisms are capable of solving this problem.

1 Introduction

Throughout the larger part of the twentieth century, governments were seen as the obvious providers of road infrastructure. This role is no longer taken for granted. Favourable experiences with private involvement, as well as technological change ask for a reconsideration of institutional arrangements regarding road infrastructure.

A brief history

Roads have been around for six thousand years now, the oldest paved roads dating back to 4000 BC in the Indus valley. The Roman Empire was famous for its vast road network, but many other civilizations (Chinese, Mayas, Incas, and Persians) had similar networks. The Roman road network was under the responsibility of the empire's army, though civilians were allowed to use them.

Road construction and maintenance outside or after the Roman Empire was traditionally organized by local communities. Such communities, dating back to the Iron Age, still exist in Sweden. In Britain, so-called 'Turnpike Trusts' started toll-financed road construction and maintenance from the start of the eighteenth century, but the system was abolished in 1844 after violent protests over the height of the tolls.

In the twentieth century, road construction and maintenance was mainly in the hands of governments, with the rapid development of the German Autobahn-network as a noteworthy example. By the end of the twentieth century, the role of the private sector gradually increased, gaining momentum with the privatization wave started by the Thatcher administration in Britain.

Research goal

Like in other countries, the dominant role of government in road infrastructure in The Netherlands is subject of debate. In their latest policy paper on mobility, Dutch government promised to initiate a research project aimed at exploring other ways to organize road infrastructure. This project is now well under way and has some obvious common ground with the study presented in this document.

Although many economic studies have been conducted regarding institutional arrangements concerning road infrastructure, we note that a straightforward survey of market failure and government failure seems to be lacking. This document tries to fill that gap, thus defining the research purpose as *an exploration of the (economically) optimal role of government in the supply chain of road infrastructure provision.*

Research definition

The research presented here is merely a primer, discussing the basic theoretical notions behind road infrastructure institutions.[2] This implies that we ignore many details and complexities that are related to the topic. We briefly discuss the most important ones below

Road infrastructure is strongly linked to government through *spatial planning.* We touch upon this subject when discussing external costs, but leave a great number of aspects undiscussed. Spatial planning of road infrastructure requires an integral appraisal of many aspects and interests, one of which is the role of the land owners. They would theoretically be able to block roads if governments would not have the means to enforce spatial policy.

In this study, we treat roads as just roads. In practice, roads come at different *hierarchy levels* and with *different functions*. Roads with different hierarchy levels (e.g. a trunk road versus a highway) are often complementary and sometimes (imperfectly) competing at the same time. One might for instance cross France from North to South without paying toll by using secondary roads. Interrelations between roads from different hierarchy levels may be important in the presence of market power for instance, or if they have different owners. Roads of a lower hierarchy often have other functions than transport alone. Especially urban roads are often also used for vending, recreation and so on. As we ignore these other functions in our analysis, we implicitly limit the relevance of our analysis to high hierarchy roads.

One other element we (almost) ignore is the fact that roads are part of a network. Several issues related to the network character of roads, such as network spillovers, demand uncertainty and complementary versus competing roads, are merely touched upon and not treated in depth.

A final important point to be mentioned is that distributional considerations are neglected in our paper. In this respect, our research differs from more integral approaches like the one adopted by Teulings *et al.* (2003). In the case of roads, regional distribution is probably more important than income distribution, although the latter may not be trivial in practice, and may indeed form a motive for government intervention.

[2] Studies that provide similar basic insights on the related topic of public-private partnerships include Bartelsman *et al.* (1998) and Grout (1997).

2 Approach

2.1 Market failure, government failure and the greenfield approach

One of the central theorems in welfare economics is that under certain conditions markets, if left to themselves, render socially optimal outcomes. The conditions however may be restrictive. They require that first, every relevant good should be traded in a market at publicly known prices; and second, households and firms act perfectly competitively, in other words, each individual firm or consumer cannot strategically influence the price, and is therefore considered a price-taker (Mas-Colell et al., 1995). In this case the 'invisible hand' of the market should guide the outcome towards the optimum.

Marginal cost pricing and cost recovery

Perfect markets are generally associated with marginal cost pricing, i.e. prices exactly equalling marginal costs, so that the price covers the cost of producing one extra unit of the product. In theory, such a pricing mechanism delivers an efficient level of production. However, it can almost never be applied in reality because of the cost recovery problem.

Roads, as well as other infrastructure, exhibit high investment costs (both sunk and fixed) and relatively small production (or variable) costs. Therefore average costs typically exceed the marginal costs of provision, so that systematic losses would be incurred with marginal cost pricing, which would make provision of such goods impossible. A lump-sum subsidy covering fixed costs can make sure the revenue requirements are met. When a lump-subsidy is not an option, a 'second-best' pricing option can be developed. In particular, Baumol and Bradford (1970) proposed 'optimal departures from marginal cost pricing' in the form of so-called 'Ramsey pricing' (owning to Ramsey, 1927). These prices are based on marginal costs, but are adjusted so that total revenues cover total costs. The adjustment takes account of the different price elasticities among consumer groups. A higher price is charged to consumers with more inelastic demand and a lower price to those with more elastic demand. This reduces distortions in consumers' choices.

In the case of roads, markets do not always exist and 'prices' in terms of costs and benefits of the road players are not transparent. Where the market exists, price-taking behaviour is rarely the case, because the (unregulated) road owner has all control over the prices. Hence, the welfare theorem does not guarantee optimality. When the market fails to deliver an optimal allocation, government intervention may help to counteract these market failures. Note however that governments, like markets, can fail, and the welfare loss due to government failure should be weighed against the welfare loss of market failure.

We use a so-called greenfield approach to identify possible sources of market failure in the provision of road infrastructure, meaning that we define a virtual situation without any government intervention. Starting from this situation, we "sit back" and look what happens. Will the market produce the optimal outcome, or will market failure arise? And if market failure arises, what form could it take, what possible instruments for government intervention are available and what types of government failure may arise when the government intervenes?

This greenfield approach may look unrealistic to some people as government intervention is very common in road infrastructure. This may seem a disadvantage of the approach, but it is an advantage at the same time. Analyzing this issue while ignoring current institutional settings helps us distinguishing economic arguments from those partly motivated by other considerations. Note that in modern day society, governments inevitably intervene in spatial planning, thus establishing a *de facto* role for government in road infrastructure. The debate should therefore focus on the scope of government intervention, rather than on arguments in favour and against government intervention.

In the case of road infrastructure, the term greenfield may be taken quite literally, as we will do in our analysis. We use an example, literally consisting of a green field, in which farms, mills and villages are connected by roads in order to produce and trade. The example illustrates possible sources of market and government failures, and is accompanied by text boxes discussing each of the issues from a theoretical perspective. These text boxes also supply the reader with references for further reading.

2.2 The chain approach to road infrastructure

A common way to analyze an industry or a production process, is to define it as a chain of activities, at the end of which a product or service is delivered. Economic literature on public-private partnerships in infrastructure (e.g. Hall, 1998; Fernandes and Viegas, 1999) often applies this approach, distinguishing between the major activities labelled design, build, finance and operate. This distinction is often referred to as the DBFO-chain.[3]

[3] Several other abbreviations, using these terms, also exist. Other terms, such as bid, transfer and own are sometimes included, reflecting differences in the project organisation and ownership pattern. Also see the appendix.

3 Market failure

3.1 Introduction

We use a simple example to illustrate our theoretical findings by. This simple example literally consists of a green field. Somewhere in this field lies a wheat farm, and a little further we recognize the distinct features of a grain mill. To produce flour, the farmer needs to transport wheat to the grain mill. It is in the common interest of the farmer and the owner of the mill to build a road between the farm and the mill, and the question who pays and owns the road is merely a matter of welfare distribution.[4]

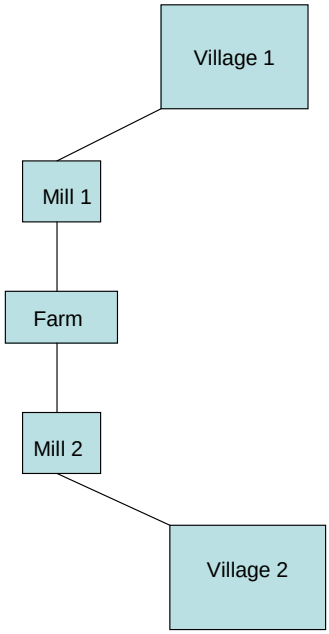
A little further in the field lies a village with a bakery. The owner of the mill would like to transport the wheat to the bakery, and again it is in the common interest of the baker and the miller to build a road.

In a complete contract world, the private sector has no problem in financing, building and operating roads. Should either the farmer, the miller or the baker have insufficient funds to build one of the roads, then we can only conclude that the value of their production is insufficient, and not producing, hence not transporting, the good is optimal from a welfare point of view.

Now let us complicate things a little. First, we mirror the situation we reached so far. Let us say the farm is so large that it needs two mills and two bakeries to process its production. The total network now looks like this:

[4] Here, we speak about a world of complete contracts. Contracts are complete, if the parties to an agreement could specify their respective rights and duties for every possible future state of the world, i.e., there are no gaps in terms of the contract. However, because it would be prohibitively expensive to write a complete contract, contracts in the real world are usually incomplete.

Figure 3.1 Base network



Still, the private sector has had no problem in financing, building and operating roads. After all, nothing fundamental has changed in comparison to the situation before we mirrored the network. There is a difference though, since the roads now connect two villages. Apart from facilitating the transport of wheat and flour, the roads facilitate all kinds of transport between the two villages. A potential source of misallocation arises, because travellers between the villages use the roads without having to bear the costs they impose. This implies that travellers may use the road even if this would be economically unviable. It also implies that there is no incentive for the road owners to expand the capacity, even if the volume of economically viable trips urges them to do so. Furthermore, the incentive for the villagers to build a direct road between the villages is weakened, since they can use the village-mill-farm-mill-village road at no cost.

3.2 Public goods

These problems can easily be solved without government intervention, as long as sufficient institutional arrangements are in place to allow for a market for road usage.[5] The road owners can now set a price for road use, imputing costs on the use of the road and creating a reward for expanding capacity in case this is needed. Introducing a market also implies the possibility of the introduction of market failure, however. Notably, the costs of collecting payments for road use may be high relative to the marginal cost of road use itself. So transaction costs are a potential source of market failure here.

[5] These institutional arrangements include basic institutions like property rights, law enforcement and the existence of means of payment.

Are roads public goods?

In the literature, roads (as well as other types of transport infrastructure) are often seen as public good, justifying government intervention in this sector. (See Klein, 2002.) Free access roads, which are characterised by non-excludability and non-rivalry, are indeed a typical example of public good. However, this argument does not hold for private toll roads. Numerous examples of the latter show that there is a practical way to overcome non-excludability at a reasonably low cost and that toll roads can be privately operated and financed.

The use of uncongested roads is non-rival. Non-rivalry in consumption implies that for optimality the marginal cost of the good provision should equate the sum of the marginal willingness to pay summed over all consumers. Under information asymmetry on both supply and demand sides, markets, as well as a central planners, may fail to provide an efficient amount of roads.

On the demand side, the main trade-off is between efficiency and minimum rights (Martimort et al., 2005). This trade-off gives a theoretical foundation to the famous free-riding problem for a public good: large groups of individuals will underreport their value of the good and hence their willingness to pay, which will lead to underprovision compared to the optimum. On the supply side, the main trade-off arises between efficiency versus rent extraction. If a central planner pays for the road provision from the tax revenue and cannot observe the type of provider, an efficient provider is able to collect the information rent.

Note that non-rivalry occurs for part of the day only, which allows for peak load pricing. As Boiteux (1961) shows, peak load pricing is welfare optimizing under normal economic assumptions, thus overcoming the non-rivalry problem.

Still, public good considerations can not always be dismissed, since private toll collection sometimes can be infeasible or costly. The reasons are either legal or economic: for instance, tolls can be prohibited or restricted by law, or alternatively, tolls' collection costs can be relatively high for certain roads. See examples in Klein, 2002, and Ivarsson et al., 2003. Curiously, even for free (or almost free) access roads, history provides examples of private financing, such as private financing of Turnpike roads in early America and private provision of local roads that still exists in Sweden. In both examples, financing comes from people living in the neighbourhood of the road and benefiting from the presence of this infrastructure the most.

Klein (2002) discusses the American experience with Turnpike companies, most of which were privately financed (by private subscription to stock). These companies started in the 1790s and mostly declined in 1830s. Legal restrictions on toll collection have made these roads be characterised by non-excludability. People using the road did not pay (or paid very little) for the use, nor people living in the neighbourhood paid for the benefits that they had. Therefore, the turnpike roads were not profitable. Stock subscription was the means to pay for the road benefits. Speaking theoretically, such a model of financing should have met an unavoidable free-rider problem. However, early Americans appeared to be very cooperative and were willing to contribute to the roads much more than a simple theory would predict: social pressures and 'selective' incentives (i.e. incentives of an individual who feels as a part of a group) played a huge role in overcoming the free-rider problem.

3.3 Market power

Another type of market failure that we may encounter is that of market power. In the current lay-out, there is only one road between the villages, leaving travellers no other choice than to use that road or not to travel at all. This leaves the owners in the position to charge road prices far above the cost level, which will lead to the cancellation of trips that would have been economically viable, and hence to a loss of welfare. A way around this would be for the villagers (or in fact, for any entrepreneur) to build a second road between the villages, so that competition would reduce market power.

Even if the villagers would not build the second road, the mere (credible) threat that they might could force the road owners to refrain from abusing their market power. This phenomenon is known as contestability of a market. For a market to be contestable, barriers to entry should be absent, which is not the case for most routes. Barriers to entry may either be legal, or follow from the nature of production.

More on market power

In contrast to the previous type of market failure that arises under non-excludability, market power can arise for limited access roads. Because of large fixed costs and economies of density, building several parallel roads would generally be inefficient. (Baumol et al., 1982.) Although there are sometimes alternative ways of travelling between two places, most roads are generally not perfect substitutes, and do not face sufficient competition from other roads or other transportation modes, such as air or rail transport. This monopolistic character of the road infrastructure provision can lead to rationing and excessive prices. Finally, lack of competition reduces incentives for cost-efficient road infrastructure provision.

Market power may arise at different stages of the DBFO-chain. In the Design-phase, land-owners have considerable market power. Even if imperfect substitutes (e.g. a different route, crossing someone else's land) are available, the impact in the planning phase of a road can be substantial. Market power in this phase is one of the reasons why governments play a strong role in spatial planning, which is beyond the scope of this study, but can not be left unmentioned in any study concerning the role of governments in road infrastructure.

In the Build-phase, builders may have market power if scarce knowledge is required in this phase. The more complex the building project, the more likely the occurrence of this type of market power is. Note that market power in the build phase may partly be prevented in the Design-phase, by choosing a design that does not require scarce knowledge. Obviously, costs and benefits of the alternative design should be weighed against each other.

Finally, in the Finance and Operate phase, the road owner may have market power vis-à-vis road users. This is the type of market power that we refer to in the text of this section.

In the case of roads, duplication of the network will probably be inefficient as long as the network is not at or near full capacity. Road networks, like many other networks, have relatively large fixed costs and using them more intensively brings down the costs per user. These scale economies – or more precise: economies of density – may even be so large that monopoly provision is more efficient than provision by multiple suppliers, in which case a so-called natural monopoly arises.

3.4 External costs

Now let us return to the farmer who started the road network. The road running by his farm facilitates his own traffic to both mills, but it also facilitates traffic from village 1 to 2. All these vehicles running past his farm are starting to annoy the farmer. Furthermore, with increasing traffic it is getting harder for the farmer to reach his fields on the other side of the road. This phenomenon is known as external effects, the economic definition of which is that they are effects caused by an economic transaction and imposed on parties that have no part in the transaction. Negative external effects are also labelled external costs.

The main problem with external effects is that they are not taken into account when someone makes a decision, since the effect is imposed on someone else. Suppose that one of the villagers in village 2 is planning a trip to either one of the other villages. Before going on this trip, the villager weighs the costs of the trip against the benefits and finds that the benefits are slightly higher. If the villager were to consider the nuisance imposed on people near the road as well, he might decide not to make the trip, as the costs would be slightly higher than the benefits. But because these costs are external, the villager will not take them into account, and he will make a decision that increases his own welfare, but decreases total welfare.

Note that most of the external costs of road transport are related to road usage rather than to roads themselves. The exceptions are visual nuisance of the road itself and the fact that a road may act as a barrier, either in social traffic (think of two neighbourhoods, separated by a busy road), or in ecological traffic. In the latter case, road use is still the main driver for the external effect, as an unused road hardly constitutes a barrier.

More on external costs

External effects (also: externalities) are defined as situations in which the private costs or benefits to the producers or purchasers of a good or service differs from the total social costs or benefits entailed in its production and consumption.[6] In particular, an externality arises whenever the actions of one party affect the well-being of another party. The effect can be positive and negative. In this box we focus on negative external effects of roads, distinguishing externalities caused by the traffic and by the infrastructure itself.

Road transport in general causes several types of negative external effects. The most important are environmental externalities (such as noise, pollution and barrier formation) and congestion and accident externalities that the users impose on each other. While it is generally clear what is meant under environmental externalities, we need to discuss congestion in more detail.

Congestion is a special type of a negative externality. On an individual level, congestion is external, since a driver does not take into account the delay that his presence may impose on others if the road is near its capacity. However, if we look at the system level, congestion is fully internalized. Road users impose delays on *each other* rather than on people outside the group of road users. At the system level, congestion is therefore not an externality, but rather an inefficient way of rationing excess demand. There is a broad literature on congestion issues, including Meiburg (1963), Newbery (1989), Verhoef (2002), etc. Environmental and congestion effects of heavy trucks are analysed in Parry (2006).

The findings with respect to accident externality are parallel with those on congestion externalities in that a larger external accident cost arises at high traffic flows. Dickerson et al. (2000) finds that while there is a nearly proportional relationship between the accidents and traffic flow for low and medium flows, the marginal accident rate raises above the average at higher traffic flows.

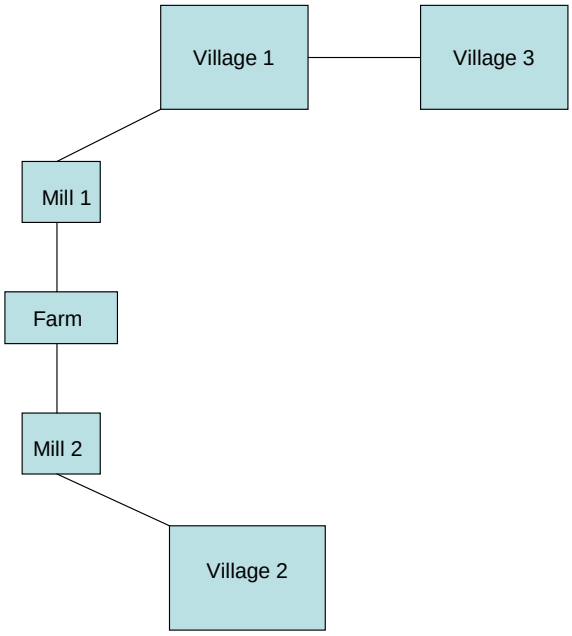
Apart from the externalities associated with transport, road infrastructure itself causes little externalities (exceptions are barrier formation and visual pollution). However, it may be efficient to adjust the infrastructure in the construction phase in order to mitigate external effects of the use of roads. Noise nuisance for instance could be mitigated by building acoustic screens. The benefits of reducing the damage to the environment have to be traded off against the extra construction costs which this would require. See for example a cost-benefit analyse for the Zuidas Amsterdam by Eijgenraam and Ossokina (2006). Since private parties will not internalise social costs and benefits, the market will not yield the optimal outcome.

[6] This definition is taken from the Glossary of Political Economy terms on http://www.adburn.edu.

3.5 External Benefits

Let us now return to our green field example and suppose that the villagers have found some way around these problems. Now, we add a third village, and suppose that trade opportunities between villages 1 and 3 are large enough to facilitate the construction of a new road. This changes the situation as follows.

Figure 3.2 Network including a third village



The new road has a positive value for the inhabitants of village 2, as their travel possibilities are now extended; they can now also travel to village 3. Moreover, the value of the road between villages 1 and 2 has increased as well, since it now also facilitates travel to village 3. This phenomenon is referred to in economic literature as network externalities, meaning that the expansion of a network increases the value of existing links in the network.

One may wonder why network externalities are considered a market failure. On first sight it simply looks like the users of the network receive a free bonus. The problem with network externalities is that prices get distorted, and this influences economic decisions. What if the road to village 3 in our previous example were marginally unviable, but would increase total welfare because of the network externalities? Then the road would not be built and the market outcome would not be optimal. In some cases, the existence of network externalities therefore requires some form of coordination.

The second reason that network externalities are considered a market failure is that they constitute a serious barrier to entry. If the value of a network increases with the number of

connections, any existing network is worth more than a start-up, and a customer is more likely to choose the existing network over the start-up. This barrier to entry hinders the competition between networks, which in turn may lead to market power.

Now that the three villages are connected, their economies are thriving. The roads between them facilitate welfare-enhancing trade and economic activity is booming. Soon, road capacity becomes insufficient, and road users start demanding for more capacity. They claim that the government should take care of more capacity, as the thriving economy is a positive external effect of these roads.

This is a common misunderstanding about roads. It is obviously correct that roads facilitate trade and hence can boost economic growth. These effects are however not external, as they accrue to the road users themselves, either directly (in the case of a trader) or through prices. A notable exception to this rule is the case where markets function better merely because of the ability to transport goods or people. Labour force mobility, in particular, leads to more flexibility at the labour market. Less transportation constraints mean more competition between producers located in different regions, the benefits of which may accrue to other people than the ones using the road. This is an external benefit of roads, also labelled spillovers.

Note that the external benefits discussed in this section are all related to the mere availability of road connections, whereas the external costs discussed in the previous section are strongly linked to the actual use of the road.

More on external benefits

Katz and Shapiro (1985) define network externalities, stating that for some products the utility for the user increases with the number of consumers of the good. The obvious example of network externalities is that of telecommunications, where an increase of the number of connections increase the value of an individual connection. Many networks have some type of network externalities present. The paper by Katz and Shapiro also discuss the implications of these externalities for competition between networks and for the compatibility of competing networks.

Numerous empirical papers find a positive effect of road infrastructure on growth and other economic indicators. In particular, Pareira (2006) finds a significant effect of investment in the road infrastructure on investment, employment and growth in Portugal. For Germany, Stefan (1997) reports a positive effect of the road infrastructure on the German manufacturing industry. However, there are also some studies finding no important productivity spillovers. For example, Holtz-Eakin et al. (1995), who analyse the effects on productivity in the US, find no important effects.

3.6 Conclusions

Based on our analysis of market failure in road infrastructure provision, we identify those that require government intervention. In particular, government intervention may be needed to overcome the public good problem that sometimes arises in the road provision. However, there are also situations in which private financing is also a viable option. A private owner is generally well equipped to solve congestion and other network externality problems. Given non-contestability for many roads, private ownership may be associated with market power. Therefore, government has a role in curbing this market power of a private owner. Finally, the government may also play a role in internalising external effects for the economy arising due to the road presence and use. In the next chapter we discuss instruments that the government can use to prevent market failure and possible problems that may arise when the government intervene. Since government intervention may be not failure free, optimal policy have to find a balance between the two extremes: fully public and fully private provision.

4 Instruments and government failure

4.1 Introduction

In the previous chapter we have identified several sources of market failure. Market failure may give rise to government intervention. When considering government intervention, one should keep in mind that governments, like markets, are subject to failure. Government intervention comes in different types. Several ways exist to distinguish between types of government intervention. We use the following, fairly crude, distinction, which is not uncommon in Public Finance and Public Economics:

- Regulation (price, quality, environmental)
- Financial instruments (taxes, subsidies)
- Public provision

The table below confronts the types of market failures distinguished in the previous chapter with this crude distinction between government instruments.

Table 4.1 Market failures versus government instruments

	Regulation	Financial instruments	Public provision
Public goods	Universal service obligation	Subsidies	Public production PPP[7] Procurement
Market power	Price regulation Quality regulation	-	Tendering
External costs	(tradeable) Permits Environmental regulation	Pigouvian taxes	
External benefits	Universal service obligation	Subsidies	Public production PPP Procurement

From the cells in the table above, we cluster the instruments in 4 groups, and use this clustering to discuss instruments and the associated government failure in the following sections. Most types of government failure apply to more than one type of instrument and are not necessarily limited to the section where they are discussed. The next section covers the use of subsidies and (universal) service obligations to ensure optimal outcomes, followed by a discussion on price and quality regulation aimed at mitigating the effects of market power. Section 4.4 discusses government instruments to handle external costs. Government instruments involving public

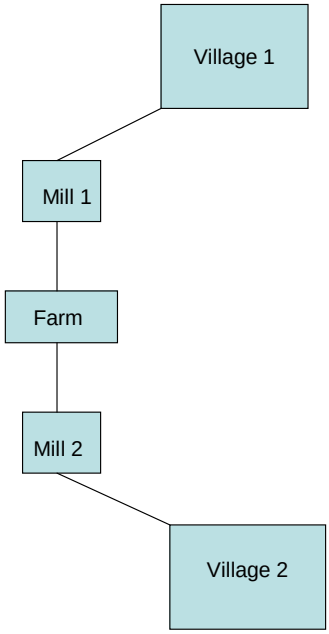
[7] PPP stands for Pubic-Private Partnership. See chapter 5 for more detail.

provision are discussed in chapter 5. Like in the previous chapter, each section ends with a text box containing theoretical highlights and references.

4.2 Subsidies and the universal service obligation

Let us return to the base network (repeated below for convenience) and suppose the network is in place but needs expansion. Let us assume that the costs of expansion are lower than the total benefits to society. However, due to several types of market failure (public good and positive externalities, as described in the previous chapter), the total willingness to pay of all villagers is lower than the costs of expansion and hence expansion is not economically viable if looked at from the perspective of individual road owners. Given that the road is socially desirable, the government may subsidize capacity expansion, to persuade the road owners to expand the road. The amount of subsidy should exactly equal the value lost because of market failures to ensure optimal investment. Since it is difficult to assess the loss caused by market failure, it is difficult to determine the optimal amount of subsidy in practice.

Figure 4.1 Base network



Instead of persuading road owners to expand their capacity, government may also oblige them to do so. Such a (universal) service obligation may seem costless at first glance, but it is not. A firm forced to engage in unprofitable activities may evade the obligation by going out of business, either voluntarily or because the firm becomes unprofitable altogether. In practice, governments often provide a reward to companies that they enforce a universal service obligation on. The governments in our villages may for instance guarantee to toll road owners that no parallel roads will be build for a number of years. They may also soften price constraints

if any were in place. On a toll free road, a USO will probably be accompanied by a subsidy. Note that travellers, who have only one road to choose from, will eventually pay the price for the universal service obligation, meanwhile loosing welfare in the way we described in section 3.3.

More on financial instruments

Subsidies are a fairly straightforward way to encourage producers to increase production or investment. Subsidies can lower the costs of an investment, resulting in a shift of the supply curve. It is a straightforward textbook case (e.g. Gruber, 2005, p. 130) to show that a subsidy exactly equal to a positive externality will render a socially optimal outcome.

The universal service obligation (USO) is well known and studied extensively in many network sectors, such as postal service, electricity, public transport and telecommunications (see Cremer et al., 2001 for a recent overview). The European Commission defines universal service as "the minimum set of services of specified quality to which all users and consumers have access in the light of specific national conditions, at an affordable price"[8]. A universal service has, therefore, four main characteristics. First, from a societal perspective, these services are viewed as so essential that they must be made available to everyone. Second, the service must conform to certain quality standards. Third, it must be available to all users irrespective of location and financial means. Fourth, it must be affordable for everyone. (See De Bijl et al., 2003 and 2006, for some examples of designing a USO.)

USO, or any other form of enforcement of production or investment, is very similar to subsidies in economic terms. At first sight, the costs are laid in the hand of the provider. In general however, this cost is compensated by granting the provider rights that enable the provider to engage in cross-subsidization (see e.g. Crandall and Waverman, 2000). This leads to suboptimal pricing elsewhere and therefore comes at a cost as well.

4.3 Price and quality regulation

In section 3.3, we discussed the possibility that market power may prevent the market from delivering the optimal outcome. Let us suppose the road is tolled and in order to prevent the abuse of market power, the government of the villages decides to regulate the price of road use. The government officials are also aware that the road owners use prices as a mechanism to manage demand peaks and spread traffic over the day. If the government were to enforce a fixed price, this mechanism would be lost, leading to underpricing and congestion in the peak and overpricing in off-peak periods.

Instead, government officials choose to regulate the average price, so as to prevent overpricing because of market power, while leaving the road owner the opportunity to manipulate demand by time of day. The next choice they will have to make is whether they base the maximum price on current costs or on some historical level of prices or costs. The first type of price controls clearly gives an incentive to road owners to allow costs to increase, as this allows them to increase their prices as well. Using a historical level has the disadvantage that suboptimal

[8] Commission Communication on Services of General Interest in Europe, 2001, OJ C 17/4.

pricing in the past is not corrected. To overcome these disadvantages, the government of the villages may look at (the lowest) prices charged for roads elsewhere and use it as a cost estimate. These may also be biased upwards of course, but if the number of other roads in the comparison is sufficiently large, this bias will not be very large. The type of price controls in which the price charged by each company depends on the performance of other companies is often referred to as 'yardstick competition', since it makes regulated companies virtually compete on price with each other. This mechanism creates incentives to match the lowest price observed elsewhere.[9]

If a monopoly is unregulated, it will have the incentive to choose the price-to-quality ratio that maximises its profit in the long run. With price controls in place however, the road owner will still want to make a profit and starts cutting operational expenses. Government officials may be aware of that, but they may not feel the need to act because of their short time horizon. At the next election, they will be judged on their recent achievements, not on the future effect of their actions.

Let us for now suppose that the government officials in the villages are very concerned with long run issues despite the risk that they may be voted out of office. Then they may want to impose quality regulation on road owners, to prevent them from cutting back on maintenance. They can either set standards or incorporate some kind of reward for quality levels in the price regulation system.

The problem with both costs and quality is that they are hard to measure. In order to solve the measurement problem, the government of the villages hires specialists to gather the necessary information. These specialists maintain – by the nature of their activities – close contact with the regulated road owner. They may work for the road owner as well, or they may be former employees. This increases the (already large) risk that the road owner manipulates the information that the government uses for regulatory purposes. The road owner may even directly influence the specialists or the decisions of government officials through bribes or other favours. This may also take other forms. With the increase of industry knowledge, a specialist may become a bit too familiar with possible problems in the industry, allowing the road owner to exaggerate costs. This type of government failure is commonly known as regulatory capture.

[9] Obviously, one should take good care of unavoidable cost differences, such as differences caused by geography or climate. Otherwise, roads will be priced below cost price, which is also harmful for welfare.

Regulation and possible government failure

Price regulation such as restrictions on tolls would be a way to prevent excessive pricing by private owners. However, the task of the regulator is complicated by information asymmetry between the regulator and the firm. The problem of the regulator can be described as a Principal-Agent Problem, in which the Principal (regulator) has to induce a certain action of the Agent (regulated firm) under information constraints. The economic literature distinguishes two types of information asymmetry: moral hazard (the effort is not observable) and adverse selection (the firm's type is not observable). The informational advantage of the firm implies that the regulator cannot achieve both: induce the highest effort and to extract all rents, but has to balance between these two objectives. See e.g. Chapter 1 in Laffont and Tirole (1993) for more detail. Regulation schemes that put more weight on effort inducement are called 'high powered incentive schemes', while the others are called 'low powered'.

In their 'pure' form, theoretical price regulation models can be divided into several classes: (i) cost-based regulation, which links the allowed revenues to the incurred costs in the same period, (ii) price- or revenue-cap regulation, under which prices are fixed en-ante, based on previous information on costs and forecasts about the future cost development (iii) yardstick competition, under which the regulator sets prices based on costs of other companies operating in similar conditions. Here the first class of models has low incentive power, and the other two classes feature high incentive power. In practice, however, price regulation often takes a hybrid form.

A price-regulated monopoly can undersupply quality, which affects transportation speed and safety. (CPB/OCFEB, 2004.) Quality standards, e.g. with respect to safety and design, can also be used to guarantee certain standard quality level of the roads. They can be complemented by economic incentives, which can be created by integration of price and quality regulation. The latter regulation forms were used recently by some regulators in other network industries (e.g. electricity). By setting the compensations for quality change at the social value of this change, the regulator internalises the trade-off between cost and quality of the service provision. This is possible as long as quality is contractible. However, the situation is more complex if quality is non-contractible. Laffont and Tirole (1991) analyse a regulation model with non-contractible quality. They distinguish between the case of a 'search good', in which quality can be observable to consumers so that their demand for a good to quality changes, and the case of an 'experience good', which quality can be observed only after buying the good. It appears that the search-good case is close to the situation with contractible quality. There high powered incentive schemes can be designed in such a way that prevents a detrimental effect on quality, while this is not the case for an experience good.

In addition to information asymmetry between the firm and the regulator, there are other factors that can limit the effectiveness of regulation. Short time horizons constitute a source for government failure. Some economists claim that politicians have a time horizon as short as the next elections (e.g. Wolf, 1978). Although this extreme stance is debated by other economists, some agreement and empirical evidence on the existence of political business cycles exists (e.g. Reid, 1998; Price, 1997). Another problem with government officials regulating industries is that of regulatory capture. These officials may be influenced (ranging from bribed to misinformed) by the industry in order to have them make decisions that are favourable to the industry. See Chapter 11 in Laffont and Tirole (1993) for an extensive overview of the literature, as well as a formal game theoretic model.

4.4 Internalization of external costs

The government in our villages has several options to combat external effects. Pricing, the obvious solution in the eyes of an economist, is treated further on. Let us first return to the example of the farmer experiencing inconvenience from the road passing his farm (see section 0).[10] Government may force road owners to build noise walls and a pedestrian bridge near his farm, or it may restrict capacity expansion near the farm, more or less forcing them to create a bypass when capacity expansion is required.

Instruments to internalise external costs

Environmental and safety norms can affect the design and location of the roads. For example, norms on noise, how far the road should be from the residential houses, safety norms and so on. Such norms may are likely to lower the private efficiency of the road owner and increase costs. This is likely because the road owner would have chosen the private optimum if left unrestricted. Any change imposed by rules is therefore a deviation from this optimum, but can improve total welfare, as long as the decrease in external costs outweighs the decrease in the road owner's benefits (Lijesen et al., 2006)

Since the geography of the regions changes with time (new construction objects being built, other ones being abandoned/moved, etc.) the road infrastructure shape changes over time. As it would be too costly to predict all possible contingencies that may be relevant for the development of the road infrastructure in the future, the government needs to be able to intervene to secure that all social costs and benefits are taken into account.

For instance, it may be necessary to protect certain areas (such as natural areas, etc.) or to direct the development of the infrastructure in the newly built area. This mainly concerns the stages when the road is conceived and designed. First, such an intervention can prevent building roads that bring more social welfare damage than benefits. Second, in case it is still optimal to have the road, intervention may be needed to prevent private parties from choosing a suboptimal route or a cheaper construction model not taking into account the damage to the nature, or other social costs. These types of intervention bring about the risks that pressure groups will influence decision making, serving their own interest rather than that of the general public.

There are already several experiences with variable tolls on the French toll roads in the 1990s. One of the rules applied is "no revenue increase": e.g. higher tolls in peak hours have to be compensated with lower tolls in the off-peak. The first time-variable toll was introduced in 1992 on A1 to the North of Paris, implementing a toll increase in weekend rush hours, as well as a 25%-toll increase in certain (peak) hours of the day and 25%-decrease in the other hours. This variance in toll has succeeded to shift 10% of traffic to the off-peak. There are also environmental tolls (e.g. on the Alpine tunnel) and itinerary-variable tolls (on alternative routes from Paris to the Alps).

[10] In that specific case the road owner is the farmer himself, so let us suppose from now on that, at some point in time, he sold the road.

More in general, the government of each of the villages may prohibit road construction or expansion near areas that are considered valuable by the public, whether it is residential, ecological or otherwise. This introduces the risk that pressure groups try to exaggerate the value of any area *they* find important, implying the risk that the protection of these areas will be overvalued in public decision making.

An alternative option would be that the government of the villages imposes an environmental tax on the use of the road. Villagers will travel less, as the costs of travel have increased. At the same time, tax revenues may be used to compensate the farmer for the nuisance or to construct the measure that would otherwise have to be imposed upon road owners.

Congestion pricing

The primary reason for tolling is reducing congestions. The two important 'products' provided by the road are traffic volume (requiring capacity) and standard loading (requiring durability, or in the other words, 'pavement thickness'), as formalised in Winston (1991). When the road infrastructure is free, road users disregard their contribution to congestion and damage of the infrastructure pavement (environmental impact being ignored for the time-being). Efficient pricing internalises these negative external costs that users impose on each other.

Mohring and Harwitz (1962) showed that under certain assumptions the revenues from optimal congestion tolling can be covering the cost of optimal road capacity. These assumptions include constant returns to scale (CRS) for both road construction and road congestion. Newbery (1989) showed that if there are CRS in the road construction of roads with a given strength and CRS to road use then, even under increasing returns to scale (IRS) in strengthening the road, the optimal user will recover the total cost.

In the Netherlands, the problem of road-pricing got attention in recent years. Verhoef et al. (2004) stress the generally low acceptance of the need for road pricing policy among Dutch drivers and policy makers. They investigate effects of switching to more efficient pricing policy, highlighting the important implementation issues. The question whether congestion pricing will be cost-covering in the Netherlands has been left open. According to OC&C (2002), it is unlikely that toll-financing would be sufficient to cover the complete cost of most roads in the Netherlands, since the toll amount necessary would be typically at least tens percents of the integral cost of a car.[11]

Besides these main effects of congestion pricing there are also secondary effects, such as effect on labour supply. Parry et al. (1999) stresses that the way of recycling the tax revenue from congestion taxes for work-related traffic has an important welfare effect. If congestion tax revenues are used to reduce labour taxes the net impact on labour supply is positive, and the efficiency gain in the labour market can raise the overall welfare gains of the congestion tax by as much as 100 percent. Recycling congestion tax revenues in public transit subsidies produces a positive, but smaller, impact on labour supply.

[11] The complete quote in Dutch reads: "Gegeven typische verkeersdichtheden is het echter zeldzaam dat uit tolopbrengsten een weg geheel kan worden gefinancierd (ten indicatie: noodzakelijk tarief minstens tientallen procenten van de integrale kosten van een auto!)" (OC&C, 2002, p.23).

As we have seen earlier, congestion is a special case. Road users impose external costs on each other rather than on others. Looked at the perspective of all road users, this cost is therefore not external. This opens the possibility to let the road owner solve congestion through the price mechanism. It is optimal for the road owner to reduce congestion as much as possible, as the villagers will be willing to pay more for road use if the road is uncongested.

5 Public roads versus private roads

5.1 Introduction

This chapter takes the involvement of the government of the villages in road infrastructure yet another step further. In chapter 4 we limited the role of government to interventions in private decisions, in this chapter we expand the role of government to ownership and production, either by itself or in conjunction with private parties. Section 5.2 discusses public production of roads, followed by a discussion of procurement. In the final section, the focus lies on public-private partnerships (PPPs). This section also focuses on the production chain.

5.2 Public production

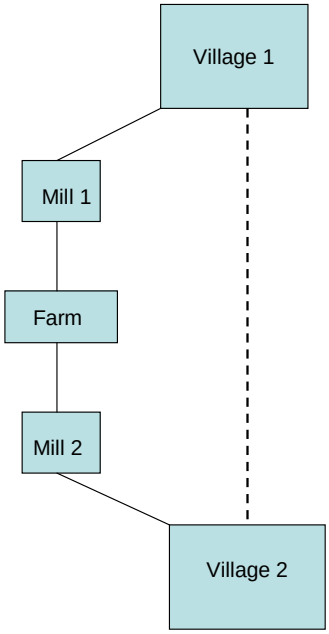
Let us now return to the example used earlier. Suppose that the villagers have decided that market failures are so severe that government should step in, and suppose they choose the option of public provision. In our example a road already exists, so government buys the road from its owners and is from now on responsible for capacity decisions, as well as for the entire DBFO-chain. Let us assume that roads are financed through taxes that are not directly related to road use. Does this solve the problems associated with the public good market failure we mentioned in section 3.2? Provided that the government in our example has sufficient information on road users' preferences, it will provide the optimal level of roads. In this sense, both the public good problem and the network externalities problems are solved. A well-informed government will take the spillovers into account as well. Note however that this only solves a part of the problem, as the villagers will still be able to use the road for free and will therefore generate more trips than would be socially optimal.[12]

However, public production is associated with government failure (see the box at the end of this section). A road authority is installed to plan and manage the roads between the villages. The chief of this organisation is likely to expand his organisation, as this increases his power and prestige, and probably also his salary. Once several inefficient mechanisms come in place in his organisation, he is bound to leave them as is, since the reward for removing them is zero, whereas removing the inefficiency may cause him quite some trouble. In a well-functioning market, this type of inefficiency – labelled X-inefficiencies – are punished by customers switching to less expensive suppliers, eventually leading to bankruptcy of the inefficient supplier. In the case of government-provide roads, there is no such thing as customers switching, clearly reducing the incentive to raise efficiency.

[12] Remember from section 3.2 that transaction costs of road pricing are assumed to be prohibitively high. If this assumption is relaxed, the public good argument disappears altogether.

The money needed for infrastructure investment is collected through taxes. These taxes affect prices elsewhere in the economy of the villages, and therefore distort market outcomes. These distortions are the costs of public funds, discussed in section 4.2 before.

Figure 5.1 Alternative routes for capacity expansion



Suppose that the government has owned the road for some time now, and all goes reasonably well. The villages have grown over time, as have traffic volumes and road capacity is becoming tight. At this point, politicians will have to decide whether and how to expand road capacity. The Local Motorists Association starts a frantic lobby to convince politicians to build a new, direct road (dashed line in figure 5.1) rather than expanding the old one. The lobby may convince the politicians, even if it is not in the general interest to build the new road. This is similar to the influence of environmental pressure groups, discussed in section 4.4.

More on public production and potential government failure

Public production solves a great deal of the problems caused by market failure. Provided that the government is benevolent and omniscient, it can produce public goods in optimal quantities, it will not abuse (but still have) market power and it will take into account positive and negative externalities when taking decisions. Furthermore, but beyond the scope of this study, governments will take into account distributional effects of their decisions. These appealing characteristics may explain why economists in the 1930s and 1940s were fairly optimistic about government ownership and public production.

From the economic theory perspective, as long as quality is contractible, both private parties and government organisations should be equally able to deliver public good. However, the outcome may be different when quality or some aspects of it are not contractible. Hart et al. (1997) address the problem if the government should provide service itself or outsource it to private parties in such a case. They consider two types of incentives: those to reduce cost and to improve (not-contractible) quality. When assets are publicly-owned, the public manager has relatively weak incentives to make either of these investments. In contrast, these incentives are strong under private ownership, which is why, "private ownership should generally be preferred to government ownership when incentives to innovate and contain cost must be strong" (as stressed by Shleifer, 1998).

Since a private party has a stronger incentive to save cost, while cost reductions may affect non-contractible quality, there are also situations when government ownership is likely to be superior. In particular, Shleifer (1998) points the following situations: (i) significant opportunities for cost reductions lead to non-contractible deterioration of quality; (ii) innovations are relatively unimportant; (iii) competition is weak and consumer choice is ineffective; (iv) reputational mechanisms are also weak. In other situations, the case for private provision is strong. The possibility of provision by private non-profit firms and the inclusion of political considerations, such as political patronage and corruption, make the case of private provision even stronger.

Empirical literature on the effect of ownership on companies' performance generally supports the latter claim. For example, this conclusion can be drawn based on the review by Megginson and Netter (2001) of the findings of 22 empirical studies that analyse the effect of privatisation in different countries and industries. In this studies efficiency improved after privatisation, or in some cases, even anticipation of privatisation has had a positive effect on efficiency. They found only one study (concerning British companies), where this was not the case.

5.3 Procurement

Now that the villagers have found out that public production is quite an expensive way to build roads, they start searching for ways to cut on spending. Since the villagers want to retain the advantage of public production, to cure almost any market failure, they do not want to abolish public influence altogether, but begin evaluating outsourcing possibilities along the DBFO-chain for the best place to decrease X-inefficiency. Actual construction (Build in de DBFO-chain), where the bulk of the expenditures are located, is the most obvious candidate.

By handing out the construction activity to the private sector, the villagers got rid of a large part of the X-inefficiency that accompanied public production. The villagers, experienced as they had become with market power issues, decided to procure the building stage through tendering. This way, firms will have to compete to get the assignment, thus reducing market power.

Enthusiastic as they have became by the large gains in efficiency through procurement, the villagers start thinking about and experimenting with the procurement of other links in the DBFO-chain. They find that any part of the chain may be outsourced, but some parts are more vulnerable to the return of market failure than others. This is mainly driven by the contractibility of activities, as defined in the box below.

After some time of relative quietness, the local newspaper reveals that a civil servant was caught red-handed receiving bribes from one of the companies bidding for a tender. This is a clear example of another possible government failure, corruption. Although the likeliness of corruption differs greatly between cultures and regions, it is generally the case that an increase in the stakes increases the risk of foul play.

More on procurement issues

The government can limit market power by a proper design of a procurement auction or tendering procedure (see Klemperer (2002) for an overview). Nowadays, especially in developing countries, many governments auction highway franchises to the private sector. In these auctions the regulator usually fixes the length of franchise (usually 20-30 years) and firms bid on the toll. The lowest bidder gets the project. However, experiences of different countries show that there are problems with using this mechanism, such as the frequent use of government guarantees reducing incentives to control construction costs and government bailouts for franchises that face financial trouble. Engel et al. (1997) argue that many of the problems stem from the fact that franchises are typically awarded for a fixed period, the length of which does not depend on demand realisations. They propose a new auction mechanism, where the regulator sets the toll schedule and the firm that bids the *least present value of toll revenue* wins the franchise. Assuming that the regulator is not allowed to make transfers to the franchise holder, and that firms are unable to diversify risk completely, they show that optimal contracts are achieved by using *least-present-value-of-revenue* auctions.

Ades and Di Tella (1997) develop a model showing that active government intervention (in their case: industry policy) is likely to promote corruption. They test their model empirically and find a significant effect of corruption on investments. Ades and Di Tella (1999) find that corruption is higher in economies where competition is weak.

5.4 Public-private partnerships

Having gained the knowledge that not every activity in the DBFO-chain can easily be contracted, the villagers conclude that they somehow should find an optimal mix between public and private. They are aware that some of the activities in the chain are linked, or may achieve higher efficiency when linked. For instance, if construction and maintenance are in the same hands, optimal decisions will be made on investments that save on maintenance in the future. The downside of allocating both these activities to the same party would be that the road owner can increase the information asymmetry and thus earn information rents. This leads to the view that the public and the private sector should not divide the DBFO-chain, but that they may be better of operating (parts of) the chain together. This type of cooperation is known as public-private partnership (PPP). Appendix A lists the most important types of public-private partnerships.

Traditional procurement versus PPP

The paper by Hart et al. (1997) evaluates public and private ownership forms in general, but does not distinguish between different organisational forms that are feasible for multistage projects, such as road infrastructure provision. In the other words, it does not explain the existence of PPP constructions, under which the government lets a private party to build the asset, transfers it to public ownership and leases it back to the same private party to operate. Why it is sometimes important that the same agent both builds and operates the asset?

Hart (2003) develops a model that distinguishes conventional provision, in which the government contracts with a builder to build the facility, and then later on with another private party to run it, from a PPP organisation, in which both stages are bundled. In their model, the builder makes investment, which reduces costs and affects quality at the second stage positively (productive investment) or negatively (unproductive investment). Both types of investment are observable to the party that will run the facility, but they cannot be verified and, therefore, cannot be included in the contract with the builder. The outcome of the model is that under PPP, the builder does more of both productive as well as unproductive investment, than under unbundling. This implies that conventional provision is good if the quality of the building can be well specified, whereas the quality of the service can not be. In contrast, PPP is good if the quality of the service can be well specified in the initial contract, whereas the quality of the building can not be.

Bentz et al. (2005) suggest a complementary model to evaluate the relevance of PPPs. In their model, the investment of the builder, which is his private information, enhances the quality of the asset. At the operation stage, the operation cost can be high or low, and this is private information to the service provider. There is also one off set-up cost at the operating stage, which is initially private information to the government. Bentz et al. obtain that when the quality enhancing costs are small, the optimal investment in the case of a PPP comes without extra payments from the government to the operator to reveal operation costs. But if these costs are large, then the government can only trigger these investments by substantially increasing the payment in the 'revelation mechanism'. They conclude that PPPs are the optimal mode of service delivery when quality-enhancing investments at the build stage are relatively cheap and the set up costs at the service provision stage are low. In contrast, when these costs are high then conventional procurement is either optimal or at least as good as PPPs.

Bartelsman et al. (1998) define PPP as cooperation between the government and a private firm in which both parties have mutual financial interest in a project. They stress that PPP should be applied when it can increase the social return of the project by tacking between market and government failures. Canoy et al. (2001) underscore that risk sharing arrangements within PPP provide an instrument to reduce the moral hazard problem and create incentives for both parties to increase efficiency of the project. A recent contribution by Engel et al. (2006) analyses road ownership and financing options. They conclude that if private sector is more efficient, concessions for a self-financing road should be fully private, but for a limited term. However, if private sector is more efficient but the road does not pay its way, i.e. requires government subsidies, an indefinite (very long) PPP is optimal.

The role of the government has been rethought in recent years (see e.g. Shleifer, 1998), giving the private sector more room in the provision of goods and services that used to be delivered by the government. New forms of private participation relieve tight public budgets, reduce the costs of public funds and increase efficiency. However they are also not fully free from government failure. While most PPP-literature focuses on private party incentives, Maskin and Tirole (2006) analyse failure on the government side. When comparing a PPP with a simple (unbundled) situation, they show that unbundling can decrease welfare because it prevents early assessment of projects' costs, while PPPs increase transparency of public accounts. This benefit however comes together with costs: bundling may make intertemporal transfer possible. Therefore, officials may choose for a PPP, instead of simple unbundled contracts, in attempts to evade budget constraints, which they would face otherwise. A PPP contract allows contractors to mask the true cost of the project (in the beginning) to shift rents to later stages of the project (the so called 'rent backloading'). This can be done by strategically increasing incompleteness of contracts, which allows contractors to accept a lower payment initially, to have higher rents at the later stages. Such shifting does not occur in the case of unbundled contracts, because the party that builds the asset cannot appropriate rents arising at the service delivery stage. The authors stress the necessity of reviews of PPP contracts by independent authorities.

An important issue in establishing a public-private partnership is the distribution of risks over the partners. A wide variety of risk sharing may be found in existing PPPs, and the issue has an important impact on the outcomes of a PPP, as will become clear in the next chapter.

6 Case studies

6.1 Introduction

In order to illustrate the work of different instruments we include three case studies in our analysis. As said, many countries recently experienced a shift from more intensive forms of government intervention in road provision (such as fully-public provision and operation of road infrastructure) towards less intensive forms (such as PPPs and private provision). Therefore, we have chosen case studies corresponding to such new forms of provision. Two of these case studies, Road A59 (section 6.2) and Wijkertunnel (section 6.3), address recent experiences in the Netherlands. The third study (section 6.4), presents the case of a privately-provided road in the US.

The case studies aim to illustrate the work of different government instruments that can be used to solve one or another type of market failure in road infrastructure provision. An important feature of the selected projects that they cover several phases of the DBFM-chain, in particular the phases of building and operation, which make these cases especially interesting.

Table 6.1 Summary of differences between the case studies

	A-59	Wijkertunnel	SR-91
Type of infrastructure	Upgrading a short piece of the existing road	A new tunnel	New express lanes along a busy route
Type of project	PPP	PPP	Private concession initially, later replaced by public ownership
Type of payment mechanism	Zero toll for the users, availability payment by the public sector	Shadow toll per car	Free toll (set by the private owner)
Type of price regulation	Availability payment; it is reduced when less lanes are available	Tolls are fixed in the contract	No

We have selected cases that differ in the type of infrastructure, degree of government intervention, type of payment mechanism and type of price regulation (as summarized in Table 6.1), and some other contractual aspects, which we discuss in more details per case in the following three chapters.[13]

[13] There were some other potentially interesting cases, which we considered in the process of case selection for this report, including in particular Autopista Central in Chili (concessions and tolls in city areas), Westerscheldetunnel in the Netherlands (publicly owned toll concession), France motorways (toll concessions, privatization); tunnels and crossings in the UK (concessions with toll-financing) and Swedish low-volume roads (government subsidies and local ownership). We refer to relevant experiences on different occasions in this report. See boxes in chapters 4-5.

6.2 A59 in the Netherlands

This case study discusses one of the first Dutch experiences with the use of PPP forms in road provision. We start with giving some background information on this road in section 6.2.1, after which we discuss the contractual arrangements in section 6.2.2, followed by the analysis of the potential market failures for this case and their solutions in section 6.2.3.

6.2.1 Background

A59 is the road that replaces the old road N59 between Rosmalen and Geffen, which used to be a bottleneck of the connection between 's-Hertogenbosch and Nijmegen. It is a relatively short piece of 9,1 km (with the speed limit of 100-km/h). It is the first road in the Netherlands built under PPP.[14] The DBFM form has been chosen.

The discussion about the reconstruction of N59 started already in 1989, but no priority was given to this project, because of lack of financial means under the Ministry's budget constraint. After some delay, state financing for this project was finally reserved for 2007-2010. However, in 1999 the province Noord-Brabant suggested that this project could start before 2007 as a PPP. Hence, the use of a PPP relieved the temporary financing constraint.

The use of the tendering procedure in the contractor-selection process helped to curb potential market power. The selection process went as follows. There were in total 59 parties (organized in 7 consortia) that suggested themselves for selection, of which five were selected to participate in bidding. The Private-Public-Comparator test was performed, in which the total project cost was compared to the cost in the case of usual tendering of project parts to different parties (the latter is called a Public Sector Comparator). The government had also to increase the budgetary amounts to be paid for this road, as the initial budget appeared too small. Two consortia were selected to participate in negotiation, one of which later was dropped as unsatisfying to the requirements on the side of the province. The final remaining bid was 14% under the Public Sector Comparator (Deloitte, 2003).

6.2.2 Project organization and financing

This PPP-project is a DBFM between a private party, the consortium Poort van Den Bosch, and public parties, municipalities and the province Noord-Brabant. The consortium designs, builds, maintains and manages the road until 2020. The length of the contract is 18 years. The construction had to be completed in 2005, after which the province pays to the consortium each year the so-called 'availability-payment' for this road, while the consortium does the road maintenance and management.

[14] According to the project report on http://www.infrasite.nl.

The initial investment was done by the consortia 'Poort den Bosch', financed by bank loans, and later compensated by payments of the public parties participating in the PPP.

The total cost of the project is 218 mln euros[15], 195 mln of which are paid by the Dutch Transport Ministry, MVW. This is transferred during 18 years in annual amounts to the province, which is in charge for payments to the consortium. The rest is split between the province (the province paid these 11,5 mln) and the group of several municipalities (11,5 mln: 4,5 are paid in the construction phase, and the rest later). The payment to 'Poort van Den Bosch' is spread into quarterly amounts: larger compensations begin only upon the road completion.

The contract includes fines for not meeting certain quality requirements (e.g. some safety norms), as well as fines for unavailability of lanes (e.g. because of maintenance), varying depending on the severity of the hinder to the traffic (e.g. higher fines in peak-hours).
Since the payment is not per product delivered in each phase of the project but for the service that is offered, there are incentives for the private party to optimize the relations within the chain: between construction expenses and maintenance expenses, as well as between maintenance and operation expenses, etc.

In the contract, risks associated with the national-wide law and regulation changes are allocated to the Ministry. The risks associated with uncertainty in local situation (local regulations, delays because of local problems: protests, environmental protection, etc), rent fluctuation and large damage to the third parties are borne by the province, while the project risks (such as design, construction, maintenance and management risks) and risks of smaller damages to third parties are allocated to the consortium.

6.2.3 Discussion of market failures and solutions

This section links the situation observed in this case to the general theory on market failures in road provision and policy instruments offering solutions, which we discussed in the previous chapters. This project mainly illustrates solutions to market failures that relate to public good and market power.

In the case of A-59, we are not dealing with a new road construction, but with an upgrade of an existing road. Since it is simply a 10-km piece of an existing free-access road, not a tunnel or a crossing where the introduction of limited access is easier both politically and technically, non-excludability is an issue here. This public-good feature of this project is responsible for market failure, because of which the market itself would not deliver this road. Besides, market parties

[15] Source: http://www.infrasite.nl.

would not consider positive spillovers from the road infrastructure for the economy.[16] Therefore, government intervention was needed to initiate this project.

Market power could potentially have been a problem in this case (despite no real toll), as the government had to select one party as a contractor. However, as we know from theory, this problem could be solved by introducing 'competition for the market' at the selection stage and by a proper allocation of risks between the state and the private contractor. A necessary condition in order to introduce competition is that there should be several parties qualified to compete for this project, which was the case here (see section 6.2.1). The use of a PPP-form allowed for ascribing the risks in such a way that if one party was in a better position to carry a certain risk, then this risk was allocated to this party. For example, the government was carrying risks related to the local situation and legislation, while the private contractor, who had an informational advantage regarding construction and operation risks and trade-offs, was also the carrier of these risks. Letting the (same) private party to construct and to operate the facility internalizes the externality with respect to quality enhancing investment in the building stage. The theoretical literature (see Hart, 2003)[17] supports the use of a PPP if the quality of service is easier to specify than the quality of the asset, which seems to be the case here.

In this project, the private party does not collect tolls, but receives 'availability payment' from the state. This availability payment is unrelated to traffic volumes. In such a way, the private party does not face the potential insolvency risks because of price and volume fluctuations, and at the same time it is unable to exploit such fluctuations to make excessive rents. In addition, this payment scheme provides the private contractor with the incentive to perform the maintenance with minimal traffic disruptions.

The downside of having the availability payment instead of user fees is that the road operator does not have an incentive to internalize congestion externalities efficiently. As explained in the theoretical chapter, adding more capacity to the road solves congestion issues in the short run, but not in the long run. The increased free capacity of the road usually attracts more demand. Since road use has not been priced efficiently, demand growth is likely to outpace the capacity level, increasing future congestion externalities. However, since this A-59 road extension represents a regular piece of a road, not a special infrastructure item as for example a tunnel or a crossing, transaction costs (including technical, legal and political costs) of limiting access to this particular piece of infrastructure would be relatively high. Therefore, a separate tolling on this peace of road is unlikely to be a good option. Besides, introducing tolls on this short piece of road may distort the traffic allocation, diverting too much traffic to free roads. Therefore,

[16] Negative (environmental) external effects are of a less issue in this case, because here we deal with a road improvement, not with a completely new road.

[17] See the box 'Traditional procurement versus PPP' in section 0

more comprehensive measures (including tolling other roads) may need to be considered as a solution to potential congestion issues on this route.

6.3 Wijkertunnel in the Netherlands

This case study addresses the contractual arrangements for the Wijkertunnel and highlights market power issues in road provision. We first describe the Wijkertunnel facility and the project organization in section 6.3.1, followed by the discussion of both market and government failure issues and policy instruments to curb them in section 6.3.2.

6.3.1 Background and project organization

The Wijkertunnel is a tunnel under the North Sea Canal near Amsterdam. It has been build in order to reduce the traffic load on the Velsertunnel. The construction work took three years, after which the tunnel was opened in 1996. The construction cost was about 600 mln dfl (272 mln euro).

It is one of the first PPPs in the Netherlands. Three quarters of construction cost, 480 mln, were paid by the consortium of banks and insurers (including ING Bank, Nationale Nederlanden and the Commerzbank). This had to be compensated by the 'shadow toll', which will be paid by the Dutch Government over the period of 30 years, after which this tunnel will be transferred to the state at the symbolic amount of 1 dfl.[18]

The shadow toll amount is set per car, therefore the payment of the state for this tunnel is sensitive for traffic volumes. The resulting risk is somewhat reduced by including in the contract the provision of a lower shadow tolls when the traffic increases significantly. The National General Accounting Office (*Algemene Rekenkamer*) argued that the estimates of the cost of this project for the state were very sensitive to computational assumptions (e.g., volume development and inflation rate), and that it was very likely that the government would eventually overpay for this project. They estimated that the government might eventually spend more on this tunnel than if the tunnel would be provided by the state[19] (AR, 1993).

6.3.2 Market failure, government failure, solutions

In contrast to the previous case (section 6.2), market power represents the most important issue here, while public-good features did not play a role.

[18] See 'Toespraak van de minister van Verkeer en Waterstaat mevr. A. Jorritsma-Lebbink bij de opening van de Wijkertunnel op donderdag 11 juli (1996) te Velzen', http://www.verkeerenwaterstaat.nl.

[19] "De Rekenkamer heeft berekend dat – in nog veel sterkere mate dan bij de Noordtunnelovereenkomst – de prijs van private financiering op basis van de door haar gehanteerde uitgangspunten aanzienlijk hoger is dan het geval zou zijn geweest als het Rijk zelf zou financieren en exploiteren..." (AR, 1993). See also *NRC* (1998), http://www.nrc.nl/W2/Lab/Profiel/Infrastructuur/reveil.html.

Non-excludability is generally not an issue for tunnels, bridges and crossings, where limited access is relatively easy to arrange. As problems related to this public good feature are easy to curb, the market should be able to provide such a road as long as there is a sufficient number of users who want to use the facility. However, under restrictive land policy of the state, the acquisition of the land may cause an impediment for private parties to undertake such a project. As soon as the state lets a private provider use the land, the private sector would probably be willing to provide the road.

Letting a private party provide the road gives rise to concerns about market power. This case study illustrates that the market power problem in road provision can be very large. It began to manifest from the very beginning of the project. In contrast to the case of A-59 considered in section 6.2, where several parties competed to carry on the project, there was one party that had a special construction experience in this area. In particular, this party had earlier developed a similar tunnel. As a result, this party had a large advantage compared to competitors and also a large informational advantage compared to the public party in the PPP (van Bommel et al., 2003). This demonstrates the danger of introducing competition for the market when there are not enough competitors. Perhaps, a more competitive situation could have been achieved if competition for the market had began at the 'conceiving phase' of the project, i.e. in the phase in which it was decided what kind of infrastructure should be build to facilitate the connection. In such a case several different infrastructure projects could have potentially competed with each other, which would have decreased their individual market power.

From theory, we know that governments often take a somewhat short perspective in their decisions (see e.g. Wolf, 1978, and Grier et al., 2000). Also here, a 'short-term budget solution' was chosen, "because there was no money for the tunnel at the beginning of the project."[20] The project went on, despite the pessimistic evaluations of the net value of such a contract for the state by the National General Accounting Office. This case study illustrates the danger of 'back loading' under government budget caps (Maskin and Tirole, 2006).[21]

The contractual arrangements contributed to increasing private monopoly rents. In the construction phase, the state carried risks associated with the foregone interest as the result of the delay of the construction (AR, 1993), which increased the bargaining power of the private party even more. Furthermore, the government has set the price (shadow toll) per road user,

[20] Nijkamp and Ubbels, 1998, p.8. Additionally, Nijkamp and Ubbels argue that the initial estimates of the cost of this project were not reliable at all. These estimates were made in October 1988 and revised in just two months after that, with a substantial increase. This second estimate was 152 mln gulden higher than the initial estimate and relatively close to the actual cost. The reasons for the increase compared to the initial estimate that were given by the Regional Board of Rijkswaterstaat were: 'the solitary construction instead of a tunnel stream, a different way of construction, the higher cost for the road section and extensions such as traffic signaling and new technical equipment', which illustrates that the first estimation was very global.

[21] See the box 'Traditional procurement versus PPP' in section 5.

letting the payment to the private party depend on the traffic volume. As the actual volume outperformed the forecast, the government is paying too much to the private contractor[22] (even though this effect was dampened by making the 'shadow toll' dependent on significant increases of the traffic volume). The theoretical literature recognizes problems associated with fixing the franchise length irrespectively of demand realizations. In particular, Engel et al. (1997) argues for the use of the least present value auction as the most efficient mechanism for road-concession procurement (see the box 'More on ownership and procurement issues' in section 5).

Road financing in the UK[23]

In the UK, private finance initiatives launched in 1992. Unlikely many other countries, the UK mainly use shadow tolls: i.e. private contractors provide the road (parts of it) and receive a payment based on traffic flow and a notional toll. These contracts with private contractors are managed by Highways Agency. DBFO-contracting forms are used for many roads. Such forms transfer the responsibility for the road to private contractor, which allows the government to balance incentives for better construction quality in order to reduce the maintenance cost. On the positive side, public good and market power problems get solved. On the negative side, shadow tolls do not encourage efficient use of the infrastructure by the road-users.

For some principal crossings, toll-concessions are used. Instead of fixed period concessions, the UK mainly uses concessions that run until the capital cost of the new infrastructure is amortized up to maximum life, usually 20 years. The toll undertakings thus generally cannot raise tolls to make extra profit. Here again, the system is effective in deterring market power abuse.

Dartford crossings represent an example of a project with a clear monopoly situation, in which the private sector has been able to provide the infrastructure profitably. The Dartford crossings were provided under maximum 20 years franchises and the operator has been able to amortize the capital cost and transfer the infrastructure to the public sector in less than two-thirds of the expected time (in 2003). Hence, market failure associated with monopoly provision was mitigated by the concession rules not allowing making profits.

The UK experience with road provision, described in the box 'Road financing in the UK' included in this section, is useful in this respect. In the UK, the contracts are designed in such a way that the profits of the private provider are capped and cannot largely exceed the costs because of mistakes in traffic volume forecasts. Instead of fixed period concessions, the UK mainly uses concessions that run until the capital cost of the new infrastructure is amortized up to maximum life, usually 20 years. On the one hand, this ensures that the private party only undertakes the project if it expects the 'social value' of the project (expressed as the shadow toll amount multiplied by demand for this facility) to be above the private costs. On the other hand, this eliminates the possibility of excessive private rents.

[22] Bruinsma et al. (1999)

[23] Sources: http://www.dft.gov.uk/stellent/groups/dft_roads/documents/pdf/dft_roads_pdf_029710.pdf and Vickerman (2004a, b).

With respect to congestion issues, we notice that shadow tolls (as well as real tolls that do not reflect congestion externalities) do not solve these issues efficiently. Since the road users are not confronted with the true cost of this externality, they tend to 'over-consume', i.e. to use the tunnel not in the way that would be efficient, not counting for the congestion costs imposed on the other users.

6.4 SR-91 in the US, California

The California State Road 91 (SR-91) express way was one of the few private franchises in the US, which has been bought back by the public authority. The experience with this road highlights possible dangerous effects that arise because of contractual incompleteness. Another important issue raised in this example is the potential inefficiency of the coexistence of toll roads and free roads. As stressed by Vickerman (2004a), tolls tend to produce free traffic flow on the tolled route with congestion remaining on the parallel untolled route and thus an inefficient allocation of the road space. On the positive side, the experience from this road shows the innovative ability of the private party in solving congestions by using time-varying tolls. In this section, we first give some background information on SR-91 in section 6.4.1, and then proceed with the discussion of the main lessons from this case study in section 6.4.2.

6.4.1 Background and project organization

SR-91 connects Riverside and Orange County in California. It is a major limited-access (toll) express way, heavily used by commuters. The road was one of few privately built and operated roads in the US. It was one of the first candidates for franchising under the new US law allowing a limited number of highway franchises. The new legislation has set certain restrictions on private franchises: profits from franchises were limited by predetermined rates of return, and private highways had to obey standard environmental requirements and laws, but there were no other restrictions on tolls, project specification, design, financing and operation.

The Orange County Transportation Authority (OCTA) had planned to build high-occupancy lanes in the median of the existing highways, but public funds were insufficient. Therefore, the California Private Transportation Company, a limited partnership formed by subsidiaries of several corporations, proposed to introduce private lanes for the median of SR-91. In 1990 a 35-year franchise was awarded; and in 1995 private lanes were opened. The lanes were innovative in many respects, implementing electronically collected tolls and congestion pricing. Toll rates were not regulated except that limits were set on the rate of return. Toll revenues were high enough to recover costs.

The congestion pricing mechanism implemented on SR-91 discriminates between direction and day of week in one-hour time periods. This impressive innovation in toll pricing eliminated congestions on these lanes.

Although initially the road was seen as a pure net benefit (solving several market failures, such as public good and congestion, and having a positive spill-over effect), the public opinion changed by the end of the 90s, when the California Department of Transportation wanted to add more lanes (between the free lanes and the new private lanes).

The original franchise on SR-91 contained a 'non-compete' clause, which precluded the public authority to develop road capacity which could abstract the traffic on the private toll lanes. This clause was included, because it was considered to be essential to ensure that the private investment would not face unanticipated competition. Safety reasons could override this clause. However, despite the need of new lanes was partly motivated by safety concerns (the accident rate grew), the public authority did not manage to justify this safety needs indisputably (Boarnet et al., 2004).

The problem was solved only in 2003, when the Orange County Transportation Authority bought[24] the toll lanes from the private owners to remove this rule. The purchase of the road by the public authority cleared the way for enhancing the Riverside freeway corridor to increase the capacity of traffic flow. The efficient investment in the road expansion has been carried out. The congestion pricing scheme that was implemented on the tolled lanes initially is still in place.[25]

6.4.2 Discussion of market failures and solutions

This case illustrates on one hand, the danger of giving too much freedom to a private party under uncertainty, potentially leading to market power. On the other hand, the experience from this road shows the innovative ability of the private party in solving congestions by using time-varying tolls.

Market power

The road has been introduced as a limited access road along a very busy route. Public good problems did not play a role. The possibility to collect tolls to cover the investment was present; hence there was a private party who was ready to provide the road. But the danger of market power was underestimated when including a 'non-compete' clause in the contract with the private provider.

[24] For 207.5 mln dollars.

[25] Motorists who would like to use this road must set up a financial account and carry an electronic transponder to pay a toll, which varies hourly according to fixed schedule. Carpools of three or more get a 50% discount. The congestion pricing mechanism used on this road discriminates between directions and days of week in one-hour time periods.

As discussed in the theoretical chapter, governments tend to underestimate risks associated with uncertainties. This short-sighted behavior can be a reason for government failure in provision of long-lasting infrastructure such as roads. When granting the concession, the Californian authority was more concerned about the possibility of having the road in the near future than about the risk related to the capacity constraint until the end of the concession. This resulted that when the traffic volume increased, the authority (or better to say, the society represented by this authority) had to pay for this contractual flaw.

In this case the prices were unregulated. By the inclusion of a 'non-compete clause' in the contract, the Californian authority committed not to expand road capacity, hence, securing traffic volume for the private contractor. This gave the private party market power (toll discretion and the possibility of rationing the traffic to maximize profit). Time has shown that the monopoly provider exploited this flaw in the contractual design.

The experience from SR-91 highlights the problems of incomplete contracting between private and public parties, when unexpected circumstances arise. In particular, Boarnet et al. (2004) stresses the danger of letting too much discretion to private parties and argues for public-private partnership in highway provision.

Congestion externalities

While the congestion pricing mechanisms implemented on SR-91 eliminated the congestions on these express lanes, it did not solve congestion problems in the region efficiently. The economic literature on the effect of the pricing policies adopted on this road suggests that the coexistence of parallel free and toll lanes is inefficient. The literature offers pricing schemes that can improve the efficiency of traffic allocation.

Small and Yan (2001) show that the effect of the introduction of tolls depends on assumptions on the road user heterogeneity. In particular, the performance of such policies generally improves, if the assumption of user homogeneity is replaced by the assumption of heterogeneous users. However, for a reasonable range of heterogeneity, the profit-maximizing tolls are so high that overall welfare reduces compared to the baseline scenario of no-tolls. The empirical analysis by Small et al. (2005a), based on surveys among the users of SR-91, justified the relevance of the heterogeneity assumption.

Small et al. (2005b) address the issue of optimal pricing policy for parallel roads. The empirical analysis is based on information from data surveys among the users of SR-91 before it was purchased by the OCTA. In the model, the travelers can choose between a free but congested roadway and a toll roadway. The authors show that such policies are inferior compared to 'two-way-toll' as well as to 'no-toll' policies (for reasonable ranges of user heterogeneity). With

application to SR-91, Small et al., suggest a pricing scheme that uses two-way-toll pricing policy but differentiates the prices of express lanes and regular lanes. This scheme improves efficiency more than other policies, and has less distorting effects for welfare distribution.

This is in line with the theoretical paper by Palma et al. (2000). From the analysis by de Palma et al. (2000), who study competition in a duopoly setting under various ownership regimes, it appears that two private toll roads achieve higher allocative efficiency than free-access road infrastructure, and higher allocative efficiency than in the situation when they compete with public toll infrastructure. Efficiency increases if tolls are varied to eliminate queuing. The case of SR-91 supports the latter argument about the effectiveness of time-varying tolls to eliminate congestions and to improve the traffic flow on the road. It also highlights congestion issues that arise in the long run for free access roads of a given capacity.

6.5 Conclusions

The case studies highlight the importance of contractual design in road provision. Full private provision can work well under some circumstances (e.g. we did not observe large problems in the UK, where the concessions prevent excessive rents by private contractors), but can also lead to market power problems, as the last case study demonstrated. The lessons learned there: under contractual incompleteness, the private party should not be entrusted with market power, while the government has no instruments to curb the market power.

Road provision by public-private partnerships provides the government with a better grip on the situation than in the case of private provision. In this case, the government is better able to limit the opportunity of traffic rationing by the private party to extract monopoly profit. From economic theory we know that one of the main benefits of public-private partnerships consists in the possibility of internalizing the externality with respect to the investment of the builder in the asset quality. The downside, however, is that it may be difficult to contractually specify the costs or quality of future services in advance (Hart, 1997, Bentz et al., 2005). Besides, such projects have a higher risk of ‘back-loading’ (i.e. intertemporal transfer of private rents towards the end of the project, see Maskin and Tirole, 2006). Flaws in contractual design may lead to excessive rents for the private contractor. So in the case of the Wijkertunnel, the contractual design did not accommodate the uncertainty about the actual development in a proper way, fixing the contract length and shadow toll, hence making revenue of the private contractor dependent on demand realizations.

Flexible time-varying tolls work well in solving congestions on the tolled road, however, the coexistence of such a tolled road with a public freeway road is not optimal. Tolls divert the traffic from the tolled road to the free access road; as a result the free access road becomes even

more congested than in the case when both roads are either tolled or free. Pricing both roads, but differentiating between the usual lanes and express lanes, is the most efficient in solving congestion, according to the literature (Palma et al., 2000, Small et al., 2005b).

7 Conclusions

Starting with a 'greenfield' situation, we have shown that leaving road infrastructure provision fully to the market is typically not optimal from a welfare perspective. Market failures in road provision can relate to (a) public good features such as non-excludability and non-rivalry; (b) market power of the owner; (c) external benefits in terms of labour mobility and positive spillovers; as well as (d) external costs, including congestion, pollution, and other environmental damage.

If markets fail to deliver the optimal welfare outcome, government intervention can improve welfare. Government intervention comes in different forms, such as financial intervention (taxation, subsidies), regulation (price, quality, environmental), and public provision. The analysis of the literature regarding the government instruments allows us to establish a correspondence between the forms of market failures and instruments.

Subsidies (compensating the owner for the external benefits that a private road delivers to the society) are the least restrictive and straightforward form of government intervention to encourage optimal investment. While subsidies are used to internalise external benefits, taxes work in the opposite way, providing an instrument to internalise external costs. However, not all types of market failures can be dealt with by financial instruments, e.g. financial instruments cannot prevent market power of the private owner. Besides, it may be difficult to determine the optimal amount of subsidies and taxes.

Regulation is generally more intrusive than subsidies. However, one of its forms, called 'universal service obligation' (USO), appears to be similar to subsidies economically. At first sight, the costs of USO are laid in the hand of the service provider. In general however, this cost is compensated by granting the provider rights that enable the provider to engage in cross-subsidization.

Price regulation such as restrictions on tolls can prevent excessive pricing by private owners. Historically, cost-based and price-cap regulation models have been used to establish the toll amount. However the modern theory and practice (from other sectors of the economy) point towards the use of more market-oriented regulation models, such as 'yardstick competition' and competition for the market, for example, through procurement auctions.

Quality regulation can take a form of quality standards, e.g. with respect to safety and design. Such standards can be complemented by economic incentives, which can be created by integration of price and quality regulation. Environmental and safety norms can affect the

design and the location of roads. Examples include norms on noise, norms restricting the distance of roads from residential houses, safety norms and so on.

From the economic theory perspective, as long as quality is contracted, both private parties and government organisations should be equally able to deliver public goods and services. However, the outcome may be different in the case of non-contractible quality. In particular, private ownership is not optimal in the case of a large detrimental effect of cost reductions on non-contractible quality. The case for government provision is stronger if (i) significant opportunities for cost reductions lead to non-contractible deterioration of quality; (ii) innovations are relatively unimportant; (iii) competition is weak and consumer choice is ineffective; (iv) reputational mechanisms are also weak (Shleifer, 1998).

Uncertainty about future developments may be another reason for the presence of the government in the road sector. Since the geography of the regions changes over time, so does the road infrastructure. For instance, it may be necessary to protect certain areas (such as natural areas, etc.) or to stimulate the development of transport infrastructure in newly built area. As it would be too costly to predict all possible contingencies that may be relevant for the development of the road infrastructure in the future, contracts with private providers are inheritably incomplete. Therefore, contractual design should not neglect the uncertainty regarding future changes.

However, the economic literature also warns that government failure may arise when governments intervene. Government failure may be associated with information asymmetry, X-inefficiency (especially under full government provision), lobbying, a short-term horizon of government officials, regulatory capture and corruption. Therefore, when choosing the degree of intervention, the government should take the risk of government failure into account. The welfare loss due to government failure should be weighed against the welfare loss of market failure.

Given the chain-character of road infrastructure provision, finding the optimal allocation of tasks between the government and private contractors is challenging. Under a public-private partnership (PPP), the government bundles several stages of the production chain. For example, it lets the same private contractor to build and to operate the asset. This provides the private contractor with better incentives to do quality enhancing investment at the building stage. The downside, however, is that it may be difficult to contractually specify the costs or quality of future services in advance. Besides, such projects have a higher risk of ‘back-loading’ (i.e. intertemporal transfer of private rents towards the end of the project). Both costs and benefits should be taken into account when choosing for a PPP.

The case studies highlight that full private provision can work well under some circumstances, but can also lead to market power problems. Under contractual incompleteness, the government should not entrust a private party with market power, while leaving itself no instruments to curb this market power (as happened in the case of the State Route 91, in California). Road provision by public-private partnerships provides the government with a better grip on the situation than in the case of private provision. However, here again, flaws in contractual design may lead to excessive rents for the private contractor. So in the case of the Wijkertunnel, the rents of the private providers increase substantially with the increase of traffic volumes.

With respect to congestion issues, we observe (based on the theoretical and empirical literature) that flexible time-varying tolls work well solving congestion on a tolled road. However, the coexistence of such a tolled road with a public freeway road is not optimal: tolls divert the traffic from the tolled road to the free access road. As a result, the free access road becomes even more congested than in the case when both roads are either tolled or free. Therefore, pricing both roads, but differentiating between usual lanes and express lanes, is the most efficient option in solving congestion.

An important conclusion that we draw from both the economic literature and the case studies is that the optimal pattern of the road infrastructure provision is often very sensitive to particular circumstances: what works well in one situation, may not be suitable for another. For example, private provision (and ownership) of low-volume roads by local cooperatives works successfully in sparsely populated parts of Sweden, but almost unthinkable in many other countries, because of both geographic and political reasons. Moreover, even when the same government instrument is applied, the outcome in each situation is also sensitive to the particular contractual design used. Think of toll concessions, where the outcome is sensitive to the way of incorporation of traffic forecasts in the contractual framework.

There are however general principles essential for efficient road provision, such as the importance of the government presence in coordination of road provision (land policy), regulation of safety and other quality norms, creating a good investment climate for private parties by reducing legal and political risks. With the development of market economies, the role of the government has been transforming from the sole provider towards a market creator (creating competition for the market) and/or partner in a public-private project. The latter organizational form provides the possibility of attracting private capital as well as exploring the benefits of a more optimal risk sharing between the public and private sector. The theoretical literature on this subject is however rather limited and general. Few papers address this issue, focusing specifically on the road networks and the road production chain. There is a need for more theoretical and applied research on the effect of road provision policies to fill this gap, which in our view represents an important direction for future research on this topic.

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Appendix: types of PPPs

Public-private partnerships (PPP) refer to contractual agreements formed between a public agency and private sector entity that allow for greater private sector participation in the delivery of infrastructure projects. These projects combine both public and private characteristics. Traditionally, private sector participation in infrastructure development has been limited to separate contracts on planning, design or construction contracts, paying to the private contractors a fee for their service. However, the private sector role has been expanding in recent years.

PPPs' potential revenue is a better risk division between public and private parties and a higher ambition of the project, as they commit the parties to each other. However, there is a danger of non-cooperative behaviour in different stages of the project. (Canoy et al., 2001).

The IMF defines a typical PPP as a DBFO (design-build-finance-operate) structure, however, much more possibilities exist. In addition to the DBFO structure, other structures have been used, such as BOO (build-own-operate), BDO (build-develop-operate), DCMF (design-construct-manage-finance), BOOT (build-own-operate-transfer) and BLOT (build-lease-operate-transfer). (Bentz et al., 2005.)

For instance, a range of PPPs has been used in the road provision and operation in the US.[26] The table below summarises these options decomposed by stage in the road infrastructure provision chain.

[26] There are also some experiences with PPP projects for public roads in the Netherlands, such as the High Speed Line South and the A59 and N31 motorways. According to the Ministry of Transport, Public Works and Water Management, PPPs will be structurally applied to new infrastructure projects in the coming years. (Source: http://www.verkeerenwaterstaat.nl.)

Basic project delivery options for roads in the US

	Own	Conceive	Design	Build	O&M	Financial responsibility
Design-Bid-Build	Public	Public	Private by fee contract	Private by fee contract	Public	Public
Private Contract Fee Services	Public	Public or private by fee contract	Private by fee contract	Private by fee contract	Private by fee contract	Public
Design-Build	Public	Public	Private by fee contract		Public	Public
Build-Operate-Transfer (BOT)	Public	Public	Private by fee contract			Public
Design-Build-Finance-Operate (DBFO)	Public	Public or private	Private by fee contract			Public, public/private or private
Build-Own-Operate (BOO)	Private	Public or private	Private by contract (concessions)			

Source: http://www.fhwa.dot.gov/ppp/project_delivery_options.pdf