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How Reliable are Estimates of Infrastructure Costs? A Comparative Analysis

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HOW RELIABLE ARE ESTIMATES OF INFRASTRUCTURE COSTS?

A COMPARATIVE ANALYSIS

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Abstract

Although the economic importance of adequate infrastructure is generally recognised, in practice decision-makers -faced with the judgement of new large infrastructure projects - are hesitant to approve such new projects because of the uncertainty in the related cost estimates. It is often argued by them that expost the actual costs of new infrastructure appear to be usually underestimated. Sometimes even the term 'strategic underestimation ' is used. This paper investigates the causes of misjudgement of infrastructure costs by distinguishing systematically various classes of miscalculations and misrepresentations of costs. Based on a comparative analysis of cost estimates of infrastructure projects in the Netherlands and Finland, the interesting conclusion is found that in general cost estimates tend to be rather reliable. Underestimations are - in addition to inflationary backgrounds caused by the delay ofprojects over a long time span - mainly the result of additional political wishes in the form of adjustments or extensions imposed during the preparation and implementation stage of projects and which lead to excessive cost rises.

1. Introduction

Transportation lies at the heart of the spatial-economic evolution of our economies (Nijkamp and Rienstra, 1995). A well-functioning transport network is one of the most important conditions for a competitive position of regions and cities. Seen from this perspective, infrastructure plays a fundamental role in the development of such areas. Investments in infrastructure are for many (local) governments a critical element of their policy. For example, the Dutch government planned to invest 7125 million guilders in infrastructure and transport in 1997 (MIT, 1997). This amount will significantly rise over the next three years. Within a European context, investments in transport infrastructure are usually regarded as a major incentive for economic development, especially when one looks at the Trans European Network (TEN) plans for connecting Central and Eastern Europe with Western Europe. Recently, much attention has also been given to the question whether these TEN plans and other new infrastructural projects should be financed as private or public goods (see Nijkamp and Rienstra, 1997).

Our paper will focus on cost estimations for these infrastructural projects, as this is a neglected area of study, especially in terms of before and after studies of costs in large transport infrastructure projects. This need for better insight into cost estimations may seem strange, because cost estimations play a major role in the decision-making process of the government; cost estimates at the beginning of an infrastructural project are aimed to give reliable information about the expected costs for the entire project. It is important for policy

makers to know as precisely as possible the expected total costs, because they must keep an eye on their budget (see also Bruzelius et al., forthcoming; Flyvbjerg et al., 1995 and Skamris and Flyvbjerg, 1996). But the few studies undertaken thus far all show the tendency of planners to underestimate the infrastructure costs. For example, in case of the Channel Tunnel case, there is an apparent cost overrun of 80 percent (Vickerman, 1996). When the Channel Tunnel Treaty was ratified by the French and British parliaments in July 1987, the total construction costs for this privately financed project were estimated at £ 2.60 billion (in 1985 prices). In May 1994 total actual construction costs had increased to £ 4.65 billion in real terms.

In the Netherlands the discussion on the reliability of cost estimations for infrastructure projects dates back to 1989, when the costs for the accessibility plan of the Randstad suddenly rose within 10 months by one billion guilders (D. G. Rijkswaterstaat, 1991). This remarkable fact prompted critical questions in the parliament to the responsible Minister. Enormous cost rises are unacceptable in the view of the parliament. The public organisation in the Netherlands which is responsible for the cost estimations, Rijkswaterstaat, admitted the problem and promised to do something about it. But nothing was said about other infrastructural projects built and estimated in the past; perhaps there has always been a cost overrun.

These two examples justify more in depth research into the problems surrounding the cost estimates for infrastructural projects. We will therefore examine some projects in the Netherlands and analyse how the actual estimations were made. It is even more enlightening to compare the whole cost estimation issue with experiences from another country; preferably of a similar size and with a similar planning tradition. Here we have chosen to investigate Finnish projects, as these are usually well documented. In this paper we will analyse (i) whether there is a systematic cost over- or underestimation in the projects examined and if so what the causes are for these misestimations, (ii) how the cost estimation process is integrated in the road (infrastructure) building process and (iii) whether there are differences between the Dutch and Finnish projects under consideration. Clearly, one has to distinguish the differences between infrastructural (road) investments and other investments (such as capital goods) in the first place. The infrastructural projects discussed in this paper are primarily road projects; only one railway project was suitable for investigation (mainly due to a lack of useful information on other infrastructural projects such as railways and waterways).

The paper is organized as follows. Section 2 deals with the differences between infrastructural and other investments. In Section 3 the road building and cost estimation process in the Netherlands will be outlined. Then in Section 4 a set of case studies on four road projects and one rail project in Holland is presented. Section 5 describes the Finnish road planning and design system, while three Finnish road projects will be evaluated in Section 6. In Section 7 the results from both countries will be compared, followed by an evaluation of the different causes for a systematic underestimation in Section 8. The final section concludes then with policy and planning recommendations.

2. The Nature of Investments in Infrastructure

There are three reasons why transportation infrastructure (such as waterways, railways and road infrastructure, and other kinds of infrastructure such as seaports, airports and telecommunication) are regarded as a major responsibility of governments. These reasons are: the infant industry (and 'infant region') argument, the market imperfection argument, and the ethics and justice argument (see Nijkamp and Rienstra, 1997). One may plausibly argue that

infrastructure is a quasi-collective good. All these arguments lead to a high budget claim on public resources for infrastructure provisions. In recent years however, it has become understood that mainly due to government failures automatic financing of all types of infrastructure by governments is no longer acceptable, and certainly not in a situation of high public sector deficits. These failures of government agencies refer also to the often problematic cost estimates. Clearly, it is overly optimistic to think that these failures will vanish with private financing of infrastructure investments. In addition, the private sector is generally not highly interested in financing and operating transport infrastructure. This is caused by the characteristics and risks involved in infrastructural investments. These features influence in several ways the cost estimations for infrastructural projects when compared with competing investments such as real estate and capital goods.

2.1 Characteristics of investments in infrastructure

Investments in infrastructure differ from competing investments. Broadly speaking one can identify seven characteristics of investments in infrastructure (ECMT, 1990 and Nijkamp and Rienstra, 1997).

Firstly, the expectation of the economic life of infrastructure is very long. This may range from 20 years to more than a century. The pay-back period of infrastructure investments is also long; concessions are often granted by the government for a period of 15 to 30 years. The pay-back period for normal capital goods is usually much shorter; the average is 8 to 9 years.

A second characteristic in many cases is the relatively low level of the operational (variable) costs, especially on longer distance infrastructure. There are some overhead, maintenance and labour costs, but compared to the construction costs of infrastructure or the exploitation costs of other investments, these costs are relatively low.

Thirdly, during the construction time, a large amount of capital is required. Often high loans have to be acquired, which makes the interest costs relatively high. The costs are also influenced by the project financier; the government is usually able to attract loans which are cheaper (i.e., lower interest rates) than the private sector.

Another feature of infrastructure investments is that the waiting period prior to actual infrastructure construction can be very long. This has to do with the many legal decision-making procedures, resistance by society and interest groups, and other time consuming formalities. These formalities often lead to project changes which have a major influence on the costs of projects. During this planning process different unforeseen facts may thus happen which are of critical influence on the whole project and may even lead to planning disasters (see Hall, 1990). In fact, this situation makes it very difficult to make a reliable and good cost estimation at the beginning of a project. Ideally, everything should be clear when the construction of the project starts, so that then a good estimation should be possible.

A fifth characteristic is the irreversibility of the investment once the project has started. If the construction is discontinued, this would lead to a significant capital loss, because it is not possible to use the investment in another way. In fact, once started, the project will be built if it is within the budget of the government. It is clear that the agency responsible for the project wants to finance it as soon as possible. One may safely assume that the costs of the project at that stage are as low as possible to ensure that the project will be executed. This suggests that the costs may be somewhat underestimated at the beginning of a project.

The next feature of infrastructural investments is the long construction period. This period may take two to seven years depending on the scale of the project. During this period there are no revenues, but there are of course already interest and other costs. This long construction

period also makes it more difficult to offer a good cost estimate, as several external factors may influence the project during this period, one example being the rise in the price level.
The final characteristic is the uniqueness of each infrastructure project. Each infrastructure project is different from another. This fact will likely have an influence on the cost estimations, because of missing experience, low learning possibilities and lack of comparability.
The above mentioned characteristics show that at the outset of a project high financial capital outlays are needed. This makes private investors more reluctant, because their flexibility tends to decline. The high costs at the beginning of a project are not immediately compensated for by high cash-flows. There are apparently many risks involved in infrastructure projects; these will be discussed in the next section.

2.2 Risks in infi-astructure investments

In infrastructure investments the rise in profits and revenues often begins many years after the initial investment; this increases uncertainty and risk compared to alternative investment options. Investments in infrastructure incorporate various risks; the following classes may be distinguished (Nijkamp and Rienstra, 1995):

- political risks; for example, changes in transport policy or regulations by the government;
- financial risks; for example, fluctuations in interest rates and exchange rates, and false expectations about inflation;
- construction risks; for example, delays, unexpected and higher or lower costs;
- operational risks; for example, damage by accidents and vandalism;
- commercial risks; for example, wrong cost estimates or wrong estimates of the traffic volume.

All these risks make it difficult to give a good cost estimation, because each risk has its distinct influence on the costs; for example, a new law supporting environmental protection. A policy shift may lead to the construction of a road tunnel to protect a natural area, whereas at the outset of the project, the road was scheduled to cross the area. This leads, of course, to higher costs which could never have been estimated at the start of the project.
The construction costs (including interest costs) of infrastructure are, up to a certain level of demand, fixed; the other costs are partly fixed and partly variable. The fixed costs are very high for an investor when compared with competing investments, while variable and marginal costs are normally relatively low.
From the aforementioned risks, the political risks are the most volatile with respect to other investments. The government has many reasons to interfere in the transport market. As mentioned earlier, there is always a danger of changes in laws or regulations, or there may even be a change of government and thus a change of transport policy.
In conclusion, because of the high risks of investments in infrastructure compared to other investment opportunities, these investments are often unattractive for private investors. There must be a high risk compensation for these private investors if they are to jump into these types of investments. This compensation may stem from high profit expectations, as is shown by recent road tunnel projects in the Netherlands. Another option is that governments make these investments more attractive, if they do not want to finance these projects directly. They could do so by means of joint-risk constructions (guaranteeing a public subsidy if the use of infrastructure is below the expectations), or by guaranteeing a minimum profit ratio.

It is clear that these risks and characteristics increase the difficulty of making a good cost estimation. Compared to normal investments, the long construction period and the political risks are the major uncertain influences to the cost estimation process of infrastructure.

3. The Dutch Cost Estimation Process; the Project Phases

3.1 Introduction

Every infrastructure construction project undergoes a variety of developmental phases. In each phase different kinds of cost estimations are made; this is logical because a more detailed plan leads to a more detailed cost estimation. In this chapter the seven different road project phases in the Netherlands will be described in the same way as used by the state road authority Rijkswaterstaat (see D.G. Rijkswaterstaat 1991). These phases are also used for infrastructural projects in general. Rijkswaterstaat is the state institute responsible for construction and maintenance of national road infrastructure in the Netherlands. This description deals with the estimation problems surrounding the design and construction of state roads.

3.2 Description of the seven project phases

During the first phase, the preliminary study phase, a rough sketch is made of the road to be constructed. In this stage very rough estimations are also made of the total costs in light of the absence of detailed plans. The aim of this phase is mainly to include a road project in the multi-year programme of infrastructure and transport (in Dutch: Meerjarenprogramma Infrastructuur en Transport (MIT)) (D.G. Rijkswaterstaat 1991).
The next phase is the studv phase, during this phase a project study is designed. This leads to the so-called "project memorandum". This project study includes an extensive examination in which a judgement must be given about the necessity for the road-connection between various cities, alternative trajectories, the tentative design of a road, etc.
The study phase is followed by the elaboration of the plan chase. During this phase the plan is elaborated into a preliminary draft, also called a "general plan". The aim of this phase is to develop the project, so that all necessary preparations (for example, the purchase of land) can take place. This is the basis for the subsequent preliminary design. When there is a long waiting period between the decision of the Minister and the elaboration of the plan it is possible that new technologies become available which may lead to plan changes. The method of estimation is more detailed and accurate than during the study phase (D.G. Rijkswaterstaat, 1991).
This phase leads to the specification phase. The definite designs and the detailed specifications are worked out. Nowadays this happens with the aid of a fully computerized and standardized specification system. The aim is to reach a detailed plan ready for the tender process. The method of estimation is as detailed as possible, because this is the last estimation prior to the tender and execution of the project. The projects are still mentioned in the MIT, but the amounts estimated are adjusted to actualized estimations and recent price index rates.
Next is the tender phase which incorporates the tender process, an analysis of the tender registrations, a mutual comparison between them, the negotiations, and finally a selection of the most suitable building contractor. The actualized estimation of the costs is very important, especially during the negotiations.

This all leads to the execution/construction phase. During this phase the quantitative estimates which are contractually determined in the tender phase can change for some reasons:

- in the contracts several clauses are mentioned in which risks are allocated to the instructor (Rijkswaterstaat). The increase in the price level is one of these risks.
- during the construction, several adjustments or changes may appear to be necessary or desirable. The extra costs of these adjustments lead then to new negotiations with the building contractor.

After the construction a new assessment of the final costs can be made, because by then the actual expenses are known.
Finally, this results in the transfer phase; the infrastructure works are then transferred from the building contractors to Rijkswaterstaat. After the definitive transfer, the final (real) costs of the project can be established.

3.3 Concluding remarks

The above description of the seven project phases aims to clarify the planning process of a road (or other infrastructural project) as used by Rijkswaterstaat in the Netherlands. The entire process takes much time, sometimes more than twenty years, but this depends on the scale of the project. During this process of seven phases, project plans become increasingly detailed; this applies to the method of cost estimation as well. As a consequence, the cost estimates will change over time.
Now that we have some knowledge on the preparations necessary for constructing an infrastructure project, it is possible to evaluate cost estimations of actually implemented projects in the Netherlands. The next section gives an overview of the estimated costs and the final costs of four road projects and one rail project. This will shed light upon the causes of over- and underestimation in case of miscalculations.

4. Case Studies on Dutch Infrastructural Projects

4.1 Introduction

Before the year 1989, hardly or no attention was given to the cost estimation problems of infrastructure in the Netherlands. But after an investigation of the parliament there has been an increasing attention for the subject of cost estimations for infrastructural projects. It was also clear that the responsible organisation (Rijkswaterstaat) was not very happy about these questions.
As a consequence, it is difficult to obtain useful and recent data for a comparison of estimated costs with final costs. Another reason is the scarcity of empirical data material.
Rijkswaterstaat has no archive of cost statistics for infrastructural projects from the past. For some projects, Rijkswaterstaat has no exact final costs and sometimes the reasons for an enormous cost increase are unknown.
The projects for the comparison in this section are chosen on the basis of recent and complete data. Complete means here all causes of changes in the estimations and a list of changes in estimations over the course of a project. For our study, large projects (in terms of money) were preferred.
The data used for all projects discussed here comes from Rijkswaterstaat. Three internal reports (Een Raamwerk voor Ramingen (1991), Meezitten en Tegenlopen (1994) and 200 Jaar

Ramingen bij Rij kswaterstaat, een Verkenning (1994)) illuminate the problems surrounding cost estimations. Aside from this source of information, several discussions with project leaders played an important role in gathering the necessary data. We will concisely describe here the various projects investigated.

4.2 The motorway between Den Bosch and Eindhoven (A2).

This project concerns the rebuilding of the state Road 264 to the Motorway A2. This was necessary because of the expanding traffic volume between Den Bosch and Eindhoven (see Table 1). The costs did not change much in 20 years, although there were considerable fluctuations in parts of the estimations. But if one examines the changes in the price-index rate level (108,5 percent increase from 1976 to 1996) one would have expected a much higher increase in costs (on this topic see also section 7.2). The influence of cost lowering measures and the agreement between the management team and the project leader to keep the costs within the project's budget is obvious. This does not change the fact that changes in the price-index rate are the most important causes of underestimation. After this there were some small changes in the plans which sometimes led to a cost decrease, in the end there was a slight cost increase.

Table 1: Cost estimations of Motorway A2, Den Bosch - Eindhoven (in million guilders).

year	estimated costs	description
August 1976	342	project memorandum
December 1980	400	first elaborated estimation
October 1988	420	specification estimation
April 1996	467	actual costs

Source: D.G. Rijkswaterstaat (199 1) and Rijkswaterstaat Directie Noord-Brabant (1996).

4.3 The motorway between Boxmeer and Venlo (A73)

This project concerns a section of the road connection between Nijmegen and Maastricht in the south-eastern part of the Netherlands. In the preliminary study phase in 1977 a first estimation of the costs was made (see Table 2). Then followed the study phase, which led to the project memorandum of 1979. The method of estimation which used here was very global. As with the first cost calculation in 1977, Rijkswaterstaat used global numbers based on cost data of the cost-price Department of the Regional Board. These numbers did not consider unforeseen expenses. The Motorway A73 was finally opened on the 29th of August 1996 by the Minister of Traffic and Public Works, six months beyond the deadline. The total costs at the end of this project are as yet unknown, as Rijkswaterstaat is still calculating the real costs. However, it is informally known that the amount does not differ significantly from the 1993 calculation.
Evaluating these results, one could say that the first estimations were too high, if corrected for inflation. Although the latter estimations were calculated with more accurate methods, these assessment methods can not necessarily claim to have a predictive value. The final underestimation (1979-l 993) is 195 million guilders (about 109 %), one half was due to price

rises in the index rate for road construction; the other half was the result of the incompleteness of the estimations and expensive adjustments (i.e., extensions) of the project.

Table 2: Cost estimations of the A73, Section Boxmeer-Venlo, 1977-l 993 (in million guilders).

Year	costs	Description
1977	178	preliminary study
1987	252	included in the MPP
1988189	287	specification phase
1990	290	tender phase
1991	325	included in the MIT
1993	373	estimation in MIT '94-'98

Source: D.G. Rijkswaterstaat (1991) and Van Heezik (1994).

4.4 The Wijkertunnel (A22)

This is the tunnel project under the North Sea Canal near Amsterdam. Although there has only been little research into the cost estimations of this project, it is included in our study. The reason is that the Wijkertunnel is one of the few privately financed projects in the Netherlands. It may be interesting to see what influence, if any, this fact has on the cost estimation process.
The Wijkertunnel is a project in which the private sector financed the infrastructure, but where the public sector (Rijkswaterstaat) was charged for the operating costs. This is a somewhat short-term budget solution, because there was no money for the tunnel at the beginning of the project. The construction period lasted three years, from 1993 to 1996.
The first estimation of costs was made in 1988. In October 1988 the total costs of the project in the project memorandum were estimated at 385 million guilders (see Table 3). It is remarkable that only two months later, in December 1988, a revised estimation was published which appeared to be 152 million guilders more expensive. This rise can not be explained from the inflation rate because of the short period of time. Reasons for cost increase given by the Regional Board of Rijkswaterstaat were: the solitary construction instead of a tunnelstream, a different way of construction, the higher cost for the road section, and extensions such as traffic signalling and new technical equipment. This was a huge rise in only two months. The first estimation in the project memorandum was thus very global and not based on these changes.

Table 3: Cost estimations of the Wijkertunnel (A22), 1988-1996 (in million guilders).

year	costs	description
October 1988	385	project memorandum
December 1988	537	extensions of the project
1992	581,4	estimates by accountant
1996	558,1	Wijkertunnel ready

Source: D.G. Rijkswaterstaat (1991) and Meijaard (1997).

In retrospect, one may say that the first estimation was not reliable at all. The subsequent estimations came very close to the final and real costs at the end of the project. The private financing appears to contribute to the good estimation but it is difficult to assess the extent to which this fact was responsible. But based on personal communications with project managers one may conclude that this fact prevented further cost increases. The cost estimation of the cost accountancy firm would probably never have been made had there not been a private financer behind the project. So there was apparently some influence on the cost estimation process by the means of financing. But this fact could not entirely prevent an underestimation of the costs.

4.5 The Hemspoortunnel

This project concerns a railway tunnel near Amsterdam and Zaandam. In 1975 the responsible Minister decided that the construction of the tunnel should begin. At that time, the total costs of the project were estimated at 350 million guilders. On 19 May 1983, the Hemspoortunnel was opened. There was an enormous rise in the estimated costs between the first plans and the final realisation (see Table 4).

Table 4: Cost estimations of the Hemspoortunnel, 1964-l 984 (in million guilders).

Year	costs	year	costs
1964	110	April 1975	350
May 1967	195	1978	580,3
1969	225	1980	562,7
1973	255	1984	599,4

Source: Van Heezik (1994)

The following extensions were mainly responsible for the increase in costs: doubling of the railway track, a change in tunnel design, a new railway station and a changed connection. These changes increased the total costs considerably . Between 1973 and 1976 these extensions were already responsible for one third of the extra costs. But the 54 million rise of 1977 can also be attributed to later changes.
It may be concluded that the amount of time (over 20 years) between the first and last cost estimation excused a major influence on the cost overrun. In the course of 20 years time, there were many cases of price changes and project adjustments. These adjustments (or extensions) were apparently the important reason for the cost increases and are mainly the result of societal changes during the 1970's. In particular, the greater environmental concern resulted in more emphasis on railway works, which consequently influenced this project via extensions. Nevertheless, the estimations were incomplete, for example, the absence of GAV (gross added value) in the estimations before 1975.

4.6 The Van Brienenoord Bridge

Compared to the four previous projects this bridge project was constructed first, namely in 1960. It is intriguing to see how time influences cost estimations. One might expect that over time, Rijkswaterstaat would become more experienced in making cost estimations for large

infrastructural projects. With this assumption, we would therefore expect more precise cost estimations nowadays and inaccurate estimations in earlier days. In 1958 it was decided to build the bridge which would play an important role in the ring road around Rotterdam. The bow bridge would become the biggest free spanned bridge in the Netherlands. In August 1960 the construction began; in February 1965, the bridge was officially opened.

Table 5: Cost estimations of the Van Brienenoord bridge, 1957- 1965 (in million guilders).

Year	costs
September 1957	45
1958	47
1964	46.5
1965	52

Source: Van Heezik (1994)

If one looks at the cost estimates in Table 5, one can say that this project was built with fairly reliable cost estimations. There is no spectacular cost overrun. An important reason for this is the relatively short period between the first cost estimation and the final completion of the project. Aside from this, cost control played a role here; costs were important to the decision-making at the very start of the project. This significance led to an accurate final estimation. Furthermore, there were no huge price rises during these years which could have affected costs. The statement that cost estimations in the past were inaccurate because of under-experience does apparently not hold in light of this project.

4.7 Concluding remarks

The discussion of the five above mentioned infrastructural projects constructed in the Netherlands shows some interesting facts. The preparation time prior to the actual construction is rather lenghty when compared with the actual construction time. The total time necessary for the planning process is indeed large and sometimes more than twenty years. We see that the costs of the various projects change drastically over time. For all the projects there appears to be an underestimation of costs. Broadly speaking there are three reasons for underestimation which have consistently emerged in each project; they are: price rises, incompleteness of estimations, and adjustments of the project. These causes will be discussed in more detail in Section 8. In the next section the Finnish road planning and design system will be described.

5. The Finnish Cost Estimation Process; the Road Planning and Design Sys tern

5.1 Introduction

Every road construction project in the Netherlands as well as in Finland, goes through different phases of development. In Finland, the Ministry of Transport and Communications is responsible for all traffic and transport affairs (just as the Ministry of Traffic and Public

Works is in the Netherlands). Under this Ministry, there are several departments, one of which is the Finnra. Finnra stands for Finnish National Road Administration and is responsible for the roads in Finland. This organisation also co-operates with the other departments in the transport sector in maintaining, improving and planning the overall transport system. The organisation and administration of the Finnra is subdivided into two parts. At the end of 1997, Finnra has been split up into an administrative client organisation for the planning of road and transport conditions, public services and purchasing in design, construction and maintenance of the public road network, and a state-owned business enterprise for design, construction and maintenance of public roads (Finnra, 1996). Finnra has nine regional offices, which will also adjust their activities and organizations in a dual way. These regional offices are foremost responsible for road maintenance, especially in winter.

The design and construction of state roads is a very difficult and diverse process. Finnra uses the road project and planning system to build new roads; this planning system was renewed in 1996. The road project planning process proceeds in phases. In the process planning, the phases and precision are co-ordinated with land use and other schemes (such as regional and financial planning).

In Finland, four sequential phases can be recognised in the planning process (Finnra, 1996):

- feasibility study
- preliminary engineering
- road and right-of-way plan
- final engineering.

However, location studies or co-ordinating the planning with, for example, land use planning may require additional stages. In small projects with limited impact, the phases can be combined. In the planning process the following activities may be undertaken:

- alternatives may be ruled out based on general studies
- planning concentrates on the issues important for decision-making and planning
- citizens and other parties have opportunities to participate in the planning process
- the process may be cancelled at any stage if there are insufficient grounds to continue planning.

The most important decisions of a road project are made during the planning stages although the immediate effect of planning on the resources is relatively small (Finnra, 1996). This holds not only for the Finnish situation but also in general. The cost share of planning is about 8-12% of the construction costs in Finland. The possibilities of influencing the project are the highest at the beginning of the planning. The four phases of the road planning system will now briefly be discussed.

The first phase in the Finnish planning process is the feasibility study. The basis for this study is the road network, land use plans or traffic and environmental problems discovered in other studies. The development needs for a road are outlined and based on current traffic information and objectives. This study can encompass a whole project or a large section of a road. As a result of the feasibility study, a road project is outlined; in the subsequent planning stages, it is made more specific and tangible.

The feasibility study, and land use plans, and additional studies are the ground work for the next phase: the preliminary engineering phase. This phase includes the global trajectory, principles for technical and functional solutions, and principles for environmental impact reduction. The degree of planning is so precise that the implementation of the solutions can be verified. The planning is most accurate in areas having a town plan and environmentally sensitive areas. The environmental impact assessment is included in this stage. The environment is obviously very important in Finland. The preliminary engineering can be

subdivided into several stages when there are important intermediate decisions to be made, such as decisions on precise trajectories. The dialogue with the public is intensive and the involved parties are the municipalities, regional councils, environmental authorities, other planners, land owners, local inhabitants, and citizens organisations.
The preliminary engineering phase results in functional solutions crucial for this phase, the road and right-of-way plan phase. Land use plans are also very important in this stage. The road and right-of-way plan includes the final location and level of the road, areas needed for the road, road arrangements, private road access, reduction of environmental impact, solutions for preventing harmful effects, and other detailed solutions. This plan includes accurate cost estimations.
Finally, there is the final engineering phase. This phase has as its basis the previous three phases. Construction can now start, if the previous phases are passed. The tender process also begins in this phase.
Now that we have discussed the phases of the Finnish road planning and design system, we will continue with the description of the costs of three road projects in Finland.

6. Case Studies on the Finnish Road Projects

6.1 Introduction

As mentioned in the general introduction of this paper, little research has been conducted on cost estimations, particularly the before- and after-studies of the costs of large transport infrastructure projects. This also holds for the Finnish situation. Only recently the attention has been focused on these issues. Currently Finnra is involved in an internal investigation about the cost estimation process in Finland. The results of this study are due to be published in 1998. This made it very difficult at this stage to get the needed information. The data presented here is based on several personal communications with responsible people and the archives of Finnra.

6.2 The motorway between Vuorela and Siilinjarvi (Mainroad 5)

The first plan of this part of Mainroad 5 had been drafted in 1968. The road was planned at the north of Kuopio in the Savo-Karjala district. Although at that time the road plan was rather vague, a tentative cost estimate has been made. The costs were estimated at 28,1 million FIM (Finnish marks). These plans were resumed in 1982; traffic congestion problems created a need for a new road. In 1986, the road and right-of-way plan was completed and accepted, so that the final engineering phase could begin.
One may conclude from Table 6 that there was an underestimation from 1982 to 1992 of 120 million FIM. This was mainly due to the price level rises and project extensions before the construction of the project started in 1986. But after this, costs were influenced only by the increase in the price level. This is mainly due to the strict Finnish planning system which does not allow for big project changes. This offers a good basis for a cost estimation, and thus seems to be the case for this project concerned.

Table 6: Cost estimations of the motorway between Vuorela and Siilinjarvi (Mainroad 5), 1968-1992, (in million FIM).

Year	costs	description
1968	28,1	first plan
1982	128	feasibility study
1986	202	road and right-of-way plan
January 1991	285	under construction
December 1991	272	under construction
1992	241,68	completion of the project

Source: Archives of Finnra (1968- 1992)

In the end, the costs even decreased. There are three reasons for this remarkable fact: the illumination used turned out to be cheaper, the tender process led to lower costs, and the foundation was made with re-used material. It is also remarkable to see that the estimation of 1968 was not really bad, if one looks at the price rises during this period. The price-index rate was then 17,2 and in 1992 130; this leads to the final costs of 2 12 million FIM. The difference between the real and inflated costs is only 30 million FIM.

6.3 The motorway between Hittulanlahti and Jynkkä (Mainroad 5)

This road project consists of two different parts of Mainroad 5. The first part is the road between Pitkalahti and Jynkkä; the other part is between Hittulanlahti and Pitkalahti. This road is situated at the south of Kuopio in the Savo-Karjala region. The first section was constructed from 1989 to 1992, and the second part started in 1992 and ended in 1996; so the whole building process lasted seven years.

Table 7: Cost estimations of the motorway between Hittulanlahti and Jynkkä (Mainroad 5), 1988-l 996 (in million FIM).

Year	costs	price-index rate of road construction (1985=100)
1988	144,3	119
January 199 1	199,4	130
December 199 l	221,9	134
1992	211,9	130
1993	171,0	127
1995	171,0	134
1996	171,723	135

Source: Archives of Finnra (1988- 1996)

It can easily be seen from Table 7 that there was an underestimation of 19%. This would have been far more, if the junction between the two roads had been built; this was of major importance for the project. In fact, the costs were not estimated well (a rise in the costs of 53% in only three years); this was mainly due to the short planning time of the second part of

the road, which led to unforeseen problems with the soil. Finally, the price-index rate increased by 13% over eight years, which is one of the other reasons for this underestimation.

6.4 The motorway between Mattilanniemi and Lohikoskentie (Mainroad 4)

This road was planned through the middle of Jyväskylä which is in the region of Keski-Suomen in central Finland. The general plan was made in 1980; at that time, the costs were estimated at 100,3 million FIM. When the road and right-of-way plan was finished in 1983, the final costs were 164,7 million FIM. The construction of the project (final engineering) started in 1986 and the road was ready to use in 1990, the final costs were 23 1,2 million FIM (see Table 8).
We may thus conclude that there was an underestimation of 130% which was mainly caused by the price level (113%). Another reason stems from project adjustments. The estimations were rather accurate, especially at the start of the project; besides there was a relatively short construction period which made it easier to make a precise estimate.

Table 8: Cost estimations of the motorway between Mattilanniemi and Lohikoskentie, 1980-1990 (in million FIM).

year	costs	price-index rate of road construction (1985=100)	description
1980	100,3	60	general plan
1983	164,7	92,3	road and right-of-way plan
1986	181,479	103,5	final engineering
1990	231,2	128	project ready

Source: Archives of Finnra (1980-l 990)

6.5 Concluding remarks

It is noteworthy that for two of the three Finnish projects the planning process takes longer than the construction period. Only Mainroad 5 between Hittulanlahti and Jynkkä was an exception. All projects showed an underestimation of the costs. The causes for this underestimation were: price rises, project adjustments and poor estimations. It is interesting that the Finnish projects showed little changes in the cost estimations after the project was under construction.
In the next chapter a comparison and short overview will be made of the Dutch and Finnish projects in order to draw some important lessons.

7. Comparison of the Various Projects

In our study five Dutch projects and three Finnish projects have been investigated, with a particular view on common elements in the cost estimation processes for Finland and the Netherlands. In a survey table we have highlighted the most important causes in both countries for the cost underestimation in all projects (see Table 9).
When we look at our findings some notable points can be mentioned. First of all, for almost each project the planning process takes more time than the construction period. Apparently, it is not so easy to build a new infrastructural project without time consuming procedures beforehand. This holds both for projects in Finland and in the Netherlands and confirms our remarks in Section 2.
Second, we observe that all the projects show a cost underestimation. This underestimation relates to the total project period between the first estimation and the final completion of the project. Clearly the longer the project period, the larger is the underestimation. This conclusion holds for both the Finnish cases and the Dutch cases. This phenomenon of underestimation relates in particular to the price rises, because the longer the course of time for the project, the higher the chance is that price rises will influence cost estimations. But on the other hand it should be noticed that there may be a significant rise in productivity in the infrastructure building sector which may exert a decreasing influence to the final costs.

Table 9: Overview of the various projects discussed, the rise in costs and price-index rates,

Project	Total cost rise (in %, until opening)	Total rise of price-index rate used for that project during the project period (in %)	The two most important causes for the cost underestimation
1. A2, Den Bosch-Eindhoven	36,5	108,2	price rises and project changes
2. A73, Boxmeer-Venlo	109,5	78	price rises and changes in project plans
3. A22, Wij kertunnel	44,9	30,8	project adjustments and price rises
4. Hemspoortunnel	437	300	price rises and project adjustments
5. Van Brienenoord Bridge	15,5	33,1	price rises and project extensions
6. Mainroad 5, Vuorela-Siilinjarvi	760	655	price rises and project extensions
7. Mainroad 5, Hittulanlahti-Jynnkä	19	13	poor estimations and price rises
8. Mainroad 4, Mattilanniemi-Lohikoskentie	130	113	price rises and project adjustments

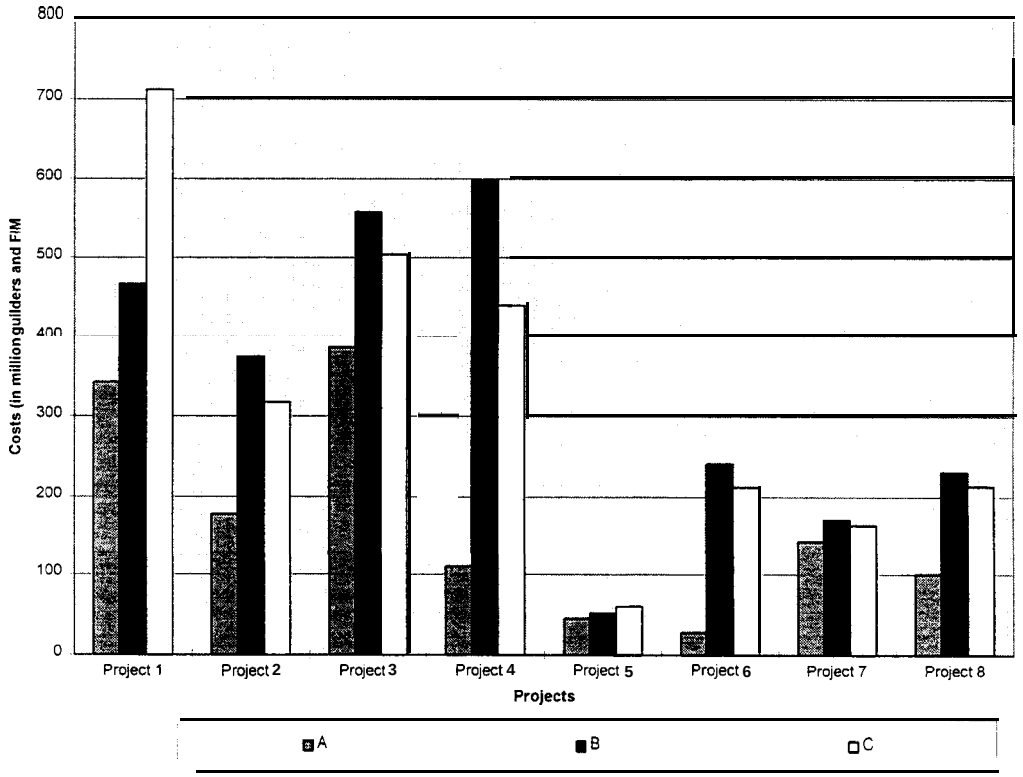
The causes of underestimation for the Dutch examples show a great similarity to the causes for the Finnish projects. The same causes return in each project. It is remarkable that the price

rises have such a great influence on the cost estimations. In order to examine the influence of price rises, in Table 9 the rise in the price-index rate during the project plans and construction period is presented. This table shows us the possible influence of the price rises, in particular the variation across different projects.

The three Finnish projects also show an underestimation of the actual real costs. The Vuorela-Siilinjarvi road revealed an underestimation of even 760%, but this number is so huge due to an estimation which was made far back in 1968. Otherwise, if we would have taken the estimation of 1982 as a starting point, the underestimation would only have been an 88%. The change in the price-index rate for 1982 to 1992 was 52%. A major difference with the Dutch projects (which is not apparent from the tables) are the few changes in the Finnish projects in cost estimations after the project is under construction (in two cases there is even a decrease in costs). One explanation could be the strict planning system used in Finland. After the road and right-of-way plan, there are not such large changes in the final road plan and the final engineering possible compared to the Dutch projects. When a plan is correct (clear and complete) and does not change over time, this has a clear effect on the reliability of the cost estimations. Then it becomes more easier to make a good estimate.

Finally, it is difficult to conclude that in Finland the costs are estimated in a more proper way than in the Netherlands. Our paper only includes three relatively small Finnish projects, and therefor it is impossible to draw a general conclusion. The fact that the Finnish projects are smaller than the Dutch projects could also be of influence on the cost estimation process. But it is clear that the cost estimation problems do not only exist in the Netherlands.

Figure 1: Comparison of the project costs



A= initial cost estimate, B= final costs, C= inflated initial cost estimate

Figure 1 shows all the previous facts in a structured way. There is one new element included. Bars A represent the initial cost estimates of the various projects at the start of the projects. Bars B indicate the final nominal costs, while Bars C (the new element) show the real costs of the project inflated only by the price-index rate level during the time from the first plan to the final completion. If we take project 1 (A2 Den Bosch-Eindhoven), for example, the first estimated costs were 342 million guilders. The total construction and planning time was twenty years (table 9), while during this period the total rise in price-index rate used for this project was 108,2 %. The costs of the first plan at the end of the project only influenced by the price level would then be around 712 million guilders. For only two projects (1 and 5) these costs are higher than the final costs. It also becomes very clear from this diagram that all projects show an underestimation of the final nominal costs, especially the Hemspoortunnel project.

8. Causes of Differences in Cost Estimations and Realizations

8.1 Introduction

In Section 7 the three primary causes of underestimation for each infrastructure project were discussed. These are: general price rises, incompleteness of estimations, and project changes or adjustments. These causes deserve more attention in order to come up with concrete recommendations.

8.2 Incompleteness of the cost estimations

One may conclude from our research that in some cases cost estimations were very comprehensive and in other cases incomplete (the best example is the A73 Boxmeer-Venlo). This holds particularly for the preliminary study phase of the Dutch projects, when the estimations in the project memorandum are often incomplete. Sometimes several cost elements omitted or had just vanished. This also makes it difficult to know the different causes of the cost changes. The project memorandum should be the basis for the project administration and management, and therefore, it is necessary to make an after-calculation of the costs; this happens only with very few projects, but it can help with critical questions concerning policy decisions.
In this study the incompleteness of various estimations became evident due to the absence of:

- general costs
- gross added value
- costs of different construction works
- unforeseen elements (contingencies)
- costs of land acquisition

This happened mainly in the preliminary study phase, the study phase, and the execution of the plan phase in the Netherlands, and in the feasibility study and preliminary engineering phase in Finland. But this was more a problem in the Netherlands than in Finland. In the early planning phases, certain cost elements are apparently missing, but these elements exert a major influence upon the level of the final costs of a project (D.G. Rijkswaterstaat, 1991). It is also true that with the change from one planning phase to another, the estimations are not fully adjusted or complete.

8.3 Project changes or extensions

It is clear that infrastructural projects are very often subject to modifications over time in the different planning phases. A good example of such a case is the Hemspoortunnel project. In most of the cases the modifications in the plans were responsible for several cost increases. This also holds for the Finnish side of this study.
The causes for such adjustments are divergent. Municipalities mainly play a major intervening role during the elaboration of the plan phase. In this phase they can negotiate with the State government about another connection in road infrastructure or other provisions. Clearly, such final changes could qualify as improvements of the project, but are most costly. Other possible causes for these changes, which we have seen during the discussion of the projects were changing social opinions and interventions of interest groups (Hemspoortunnel, in favour of environmental quality); the availability of new technologies (Wijkertunnel), and the state of the economy (growing traffic volumes lead to a two-lane road instead of a one-lane, for Mainroad 5 Vuorela-Siilinjarvi).
Finally another fact which may also have an influence during the planning process is the way of tendering. Clearly, different tender processes will have different impacts on the final costs.

8.4 Price rises

By far the most recurrent (and thus main) cause of underestimation of project costs are the price rises during the project time. The price-index rate used for recent road infrastructural projects in the Netherlands is the price-index rate for road construction. This index rate is based on budgets made by the building contractors for the specifications in six areas of the Netherlands. Within Rijkswaterstaat a new agency is established which has to take care of the index rate problem; there are indeed certain disadvantages with the use of general price-index rates for all road projects. It might be better to use a specific price-index rate for each project based on after-calculation data. Clearly, it is important to make a clear distinction between various index rates used (such as a general price-index rate, a specific road construction price-index rate or a price-index rate for a specific project) for different projects.
It should be added that the total price rise over the period 1980- 1990 in the Netherlands was not very high (20%); this contrasts with the Finnish situation. Their rise over the same ten years was over 90%. One can thus conclude that the price rise was more influential in this period for the Finnish projects' underestimation than it was for the Dutch projects. The price rises did influence the Dutch projects, but, not dramatically. In this period the price rises do not explain all the reasons for the underestimation. There are clearly other causes responsible for the underestimation of infrastructure costs.

8.5 Other causes for cost deviations

The elements mentioned in this section do not follow directly from the projects discussed in this paper, but they do play a role in the cost estimation process of large infrastructural projects.
First of all, one has to remember that all the estimations are made by two public bodies (Rijkwaterstaat and Finnra); they are firstly technical organisations. These organisations have as a main goal the delivery of qualitative high standard technical products. Inherent in these organisations with a technical orientation is the underrepresentation of financial,

administrative and procedural affairs. In general, there is little regulation in the area of cost estimations, especially in comparison with the high costs of these projects. These organisations are well capable of making good estimations, but the problems are situated in the underevaluation of financial, procedural and administrative processes, and this ultimately will have an effect on the cost estimation process.

There are two other mechanisms in the procedures surrounding the construction of infrastructural projects that influence the accuracy of cost estimations in a negative way. Firstly, relatively low cost projects have greater chances of being included in the various plan studies (in the Netherlands, for example, the MIT) than the more expensive projects (D.G. Rijkswaterstaat, 1991). A high estimation may reduce this possibility or lead to postponement of the project for years. This perpetuates the problem of underestimation of the costs during the study phase or the feasibility phase.

Secondly, other governmental institutions (municipalities) tend to have many demands on the construction phase of infrastructural projects. For example, they want more connections of a road or a railway station in their city. A relatively low estimate will give the Regional Board some advantage and thus a favourable position in the negotiations for extra provisions. The same holds for purchasing land. This also leads to the continuous underestimation of the costs, mainly in the first planning phases (D.G. Rijkswaterstaat, 1991).

9. Concluding Remarks

In this section some final conclusions will be drawn from the foregoing sections. In the first part of this paper the differences between infrastructural (road) investments and other investments were outlined. Broadly speaking, there are two distinct features of investments in infrastructure which lead to important differences, viz. the characteristics and specific kinds of risks. Characteristics which differ from normal investments are: the long expectation of the economic life-time of infrastructure, the low level of operational costs, the large amount of capital required during the construction, the long period before the construction of a project can start, the irreversibility of the investment once the project is started, the long construction period of infrastructure and the uniqueness of each project. Infrastructural investments also include specific risks, such as political, financial, construction, operational and commercial risks. The most important risk in this context is the political risk, as there is always a possibility that the government will interfere in the transport market. Because of these high risks compared to other investments, infrastructural investments are normally unattractive for private investors.

These specificities of infrastructure have direct consequences for the integration of the cost estimation process in the road (infrastructure) building process. The road building process is different for both countries discussed in this paper, Finland and the Netherlands. The Dutch road (also used for other infrastructure) building process consists of seven different phases. The Finnish road building process consists of four phases. It is clear that for both countries in every phase a cost estimation is made which becomes more and more detailed. This is logical because the plans become more determined and concrete over time.

This paper has shown that in all eight cases an underestimation of the costs was normal. Table 9 of this paper shows that all projects discussed show a cost rise. The Finnish projects show very little cost changes once the project is under construction. When the construction of the project starts, the plans are determined and changes (which will influence the costs) will not occur. The environment is also more important in the Finnish planning process than in the

Dutch one. Another (relatively small) difference appears to be the influence of the national economy of Finland on the cost estimation process.
In the light of these observations we can now trace the causes of underestimation. In fact, one can distinguish two different kinds of causes, viz. those which follow directly from the above presentation of the projects, and those which are of indirect importance. The direct causes will be mentioned for all projects (both countries), followed by the indirect causes.
The main cause of underestimation is formed by the price rises. Because of the length of planning and construction (sometimes more than twenty years) the influence of inflation was clearly large. Until recently, these rises were not included in the estimations (for the Finnish situation these are still not yet included). A second cause is the incompleteness of the estimations. This became clear in the discussion of the projects due to the absence of, for example, gross added value and costs of different construction works. The third - and also important - cause is formed by the adjustments to the projects (or project changes); the extensions of the project also belong to this class. Infrastructural projects are very often subject to modifications over time. It sometimes happens that projects in comparison with the preliminary study phase change in such a way that one can actually speak of a new project (see, for example, the Hemspoortunnel project). Another reason may originate from a poor estimating procedure for specific cases. The soil condition, for example, may be different than expected and extra work may have to be done. In conclusion, there are different direct causes which relate to the various projects. Table 10 gives a concise overview of these main causes. From this table it becomes clear that price-index rate rises and project extensions are the predominant causes which have the largest influence on the underestimation.

Table 10: Overview of the different causes of underestimation of infrastructure costs and their influence

Projects Causes	price-index rate rises	project extensions	changes in the uroiect	incompleteness of estimations	poor estimation
A 2	++		+		
A73	+++	+	++	+	
A22 Wiikertunnel	+	++	+		
Hemspoortunnel	++	++	+	+	
Van Brienenoord Bridge	+	+			
Mainroad 5, Vuorela -Siilinjarvi	++	+			
Mainroad 5, Hittul • Jynnkä	+				+
Mainroad 4	+++	+		+	

+++ very large influence on the final underestimation
++ large influence on the final underestimation
+ moderate influence

Some other causal elements which do not follow unambiguously from the projects investigated will only briefly be mentioned here. These causes are less important than the direct causes, but may undoubtedly play a role in the underestimation of the costs. First, all

estimations are made by technical organisations (Rijkswaterstaat and Finnra). The financial, administrative and procedural processes may be underevaluated and may hence lead to poor estimations or an incompleteness of estimations. Secondly, inexpensive projects have a greater chance of being included in the different plan studies. Thirdly, estimators tend to take the demands of governmental institutions into account; this gives some space for negotiations. Now that the causes are clear it is possible to draw strategic policy lessons to improve the cost estimation process. Firstly, it is necessary to increase the importance of the first planning phases in order to prevent the project plans from undergoing large changes. Secondly, the price rise has to be monitored more preciseley. In this context, an adjusted measure to tackle the price rise problem, viz. indexing the estimations every year, is possibly very effective, mainly because it has become the preponderant cause of underestimation. Next, the after-calculation is also important for improving information for future projects as part of a learning procedure. And finally, one might consider a system of penalties for under- or overestimating the costs by the government. Clearly all such measures will take time, but they will lead to an improved cost estimation process (see e.g. the Wijkertunnel).

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