# Cost overruns in Swedish infrastructure projects

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## Abstract

This paper explores the accuracy of cost estimates at different planning stages for Swedish transport infrastructure projects 2004-2022. Changes in project costs are tracked between the national investment plans established in 2010, 2014, 2018 and 2022. Cost estimates tend to increase considerably during the planning stages on average, while cost estimates at start of construction do not deviate systematically from final costs. The distributions of cost escalations between subsequent investment plans are highly skewed, with modes close to zero, but means in the order of 20-30 percent for projects in the planning stages. Average cost escalations are larger for rail projects than for road projects. The paper also briefly describes the Swedish infrastructure planning and decision process, summarizes previous Swedish studies, and discusses possible causes and remedies of cost overruns.

Keywords: cost overruns, transport infrastructure, project management, decision processes, transport policy.

# 1 Introduction

Cost overruns of transport infrastructure projects is a common problem all over the world, and Sweden is no exception. The Swedish Transport Administration is currently running a program to reduce the magnitude and consequences of cost overruns. The present paper is a contribution to this, presenting new evidence on how project costs evolve between subsequent national investment plans 2010-2022, comparing final costs to late-stage cost estimates for projects finalized 2004-2022, and discussing possible causes and remedies for unintentional cost escalation. To provide background for an international audience, the paper also gives a brief overview of the Swedish infrastructure planning process, and a summary of some previous Swedish studies on cost escalation in the transport sector.

As a background, section 2 gives a brief overview of the Swedish infrastructure planning process, focusing on how, when and by whom decisions are made. Swedish infrastructure investments are planned and decided using a twelve-year investment plan, which is revised once per election cycle (i.e. every four years). Section 3 summarizes conclusions from a number of previous studies of cost overruns in the Swedish infrastructure sector.

Section 4 presents new analyses of how projects' costs evolve between subsequent updates of the rolling 12-year national investment plan. The analyses follow projects through subsequent national investment plans to the finished stage, comparing cost estimates at different points in time. On average, estimated project costs tend to increase considerably during the planning stages, while cost estimates at the start of construction do not deviate systematically from final costs. The distribution of the cost escalations is highly skewed with a long tail to the right. For many projects, costs stay close to initial estimates through planning and construction. In fact, the mode (peak) of the distribution is close to zero. For a relatively small subset of projects, however, costs increase radically, and this is what causes the substantial increase of the total cost of the project portfolio.

Section 5 concludes by discussing possible causes and remedies for cost overruns.

When comparing cost estimates to final costs, there are several caveats to keep in mind. First, it clearly matters between what stages costs are compared, since early cost estimates tend to be substantially lower than later estimates. Which comparison is most relevant depends (primarily) on when the real go-ahead decision is made. In principle, the final go-ahead decision is not made until the start-of-construction decision. In practice, however, it is unusual that projects in the investment plan are cancelled, even if their estimated costs escalate, which makes comparing initial cost estimates to final costs highly relevant.

A second complication when following project costs over time is that the content and design of the project often changes. This applies in particular to the planning stage, but to some extent to the construction stage as well. This makes cost comparisons fraught with difficulties, especially since the changes in content and the resulting consequences for project costs are often poorly documented. This must be kept in mind when the evolution of cost estimates during projects' lifetimes are explored.

It is important (although often difficult) to distinguish between cases where the content of a project is intentionally increased (with an increased cost as a consequence), and cases where project content remains the same but initial cost estimates turn out to be too low. The latter is clearly a problem, since the investment decision might have been different if the true cost had been known. The former case is not as clear-cut. This so-called "scope creep" does not really constitute a problem *if* – and this is a big "if" - the decision to increase the size of a project is made taking the *opportunity cost* of the additional spending into account, since expanding a project budget means that some other (usually unknown) project somewhere else cannot be carried out. The problem is that the benefits of a specific, proposed project expansion is often much more salient than the opportunity cost (the benefits of some unspecified other project).

## 2 The Swedish infrastructure planning process

National transport infrastructure in Sweden is planned in a twelve-year plan, which is revised every four years (i.e. once per election cycle). The focus in the present paper is on the larger infrastructure investments specified in the plan, but the plan also specifies budgets for road and railway maintenance, funds for smaller[1] non-specified investments, research funding and various other items.

When it is time to revise the investment plan, the government issues a directive to the Transport Administration to draw up a proposal for a revised plan for the next twelve-year period. The directive specifies the government's general and specific priorities, e.g. general policy goals and specific investments that should be included in the plan proposal. The Transport Administration then constructs a proposal for a revised investment plan, updating benefits and costs of the investments already in the plan, suggesting which new investments to include, and (occasionally) which investments to exclude from the previous plan. In principle, there is no guarantee that investments in the current plan are included in the next plan proposal. Investments where costs have turned out to be higher or benefits lower, compared to estimates in the last plan, can be excluded in the new proposal. This rarely happens, however; usually, less than a handful of investments (and often none) are excluded from the current plan in the new plan proposal. On the other hand, it is fairly common that projects' content and design change between plans, often due to increased information about investments costs of alternative designs.

The Transport Administration presents its plan proposal to the government, and the government then decides a new plan, which usually contains some changes compared to the Transport Administration's proposal.

Investments in the plan are categorized in three planning stages, corresponding to the plan's year 1-3, year 4-6 and year 7-12. Year 7-12 are investments which are still in the planning stage; year 4-6 are investments which are being prepared for start of construction; year 1-3 are investments which have been approved for start of construction. In addition, the investment plan contains

[1] "Small" investments are not specified explicitly in the plan. The current definition of "small" investments is an investment cost below 100 MSEK (10 SEK ≈ 1€).

investments already under construction. A separate decision is necessary for each investment to move it from one planning stage to the next. These decisions are made yearly by the government, based on suggestions by the Transport Administration.

This means that there are three separate decision tollgates that investments must pass. First, an investment must be included in the national plan, where (as a rule) it is scheduled for year 7-12. Next, once its design, benefits and cost have been further investigated, it is moved from the year 7-12 to the year 4-6 group. After further investigation of costs and benefits, and often adjustments of its design and content, it is moved to the year 1-3 group, which means that construction is ready to start. Each of these steps are decided by the government, based on the Transport Administration's suggestions.

This process is not always followed to the letter, however. For example, an investment may sometimes enter the plan directly in a later planning stage (year 4-6 or even year 1-3). Occasionally, an investment is postponed and moved back to an earlier planning stage.

Proposals for new investments to include in the plan come from several different stakeholders, in particular cities, regions and the Transport Administration itself. New investment proposals are designed (usually) in a special process called *åtgärdsvalsstudie* in Swedish, which can roughly be translated to "solution design". The idea is that this process first specifies what "problem" needs to be solved, and then explores various "solutions" to this problem, starting with non-infrastructure policy measures (e.g. demand management measures), before considering adjusting existing infrastructure and only as a last resort building new infrastructure. The present paper focuses mainly on the evolution of cost estimates once an investment has been included in the plan, so the "solution design" process lies outside the scope.

Figure 1 summarizes how the infrastructure planning process is supposed to work (with some simplifications). Investments first enter the "planning" stage (the plan's year 7-12 and year 4-6 have been grouped together in the figure). When they are judged to be sufficiently analysed, they are moved to "ready for construction" stage, which means that construction is supposed to start within the next three years. Once contractors have been tendered and the final planning details have been decided, construction starts. Eventually, the project is finished. Figure 1 will be used in the following to compare changes in cost estimates throughout the planning and construction process.

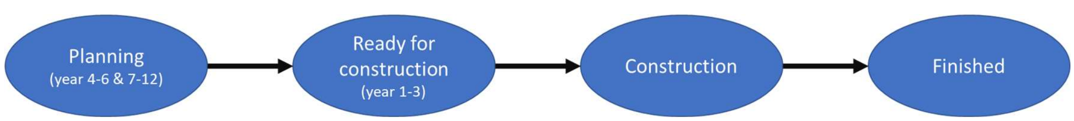


**Figure 1. Stages in the infrastructure planning and construction process.**

Sweden has had multi-modal infrastructure investment plans since it was decided to form the Transport Administration in 2010 (merging the Road Administration and the Rail Administration). The first multi-modal (road and railway) investment plan pertained to the period 2010-2021. The infrastructure planning process described above was formalized in 2013, and subsequently used in the national investment plans for the periods 2014-2025, 2018-2022 and 2022-2033. Before that, a similar planning process was used, but the categorization of investments into three planning stages was not formalized in the same way. Before 2010, the Road Administration and Rail Administration followed planning processes that were similar in many respects. In section 4, we will explore how project costs have evolved between subsequent plans from 2010 and onwards.

# 3 Previous studies of cost escalation in Swedish infrastructure projects

In a series of reports, the National Audit Office (Riksrevisionen, 2010, 2011b, 2011a) explored cost overruns in Sweden, concluding that it was a serious problem in the Swedish infrastructure sector. The reports documented a number of case studies, stressing that data was not documented in a way that enabled easy ex-post analyses of what happened during the process, or when and where cost overruns had occurred. Riksrevisionen (2010) followed up road investments, concluding that insufficient cost control had caused road investments to be too expensive, and that there was a risk that the wrong projects had been selected for construction. Riksrevisionen (2011b) tried to follow up rail investment in the same way, but concluded that the documentation of project content and costs was insufficient to enable detailed analyses or follow-ups. The report criticized the Rail Administration for comparing projects' final costs to their cost estimates in the last national plan, rather than to their cost estimates in plan when they were first introduced, and for adjusting costs over time with a construction cost index that increased faster than inflation, which hid part of the real-term cost increases. Following up projects finished 2005-2009, the report noted that the Rail Administration presented an average cost overrun of 25%, while a comparison between final costs and first cost estimates and adjusting costs only with general inflation yielded an average cost overrun of 55%. Riksrevisionen (2011a) analysed the mega-project Botniabanan, a railway along Sweden's northern coast, concluding that it became much more expensive than planned while still not generating the benefits that had been anticipated.

Lundberg et al. (2011) investigated cost overruns of Swedish road and rail projects completed 1997-2009. Comparing final costs with cost estimates in the last national investment plan and adjusting costs with the change in construction cost index, they found that final costs were on average 15% higher than the estimate in last plan. Rail projects had larger average cost overruns than road projects, with larger variability (rail: mean +21%, std.dev. 50%, N = 65; road: mean +11%, std.dev. 25%, N = 102). Relative cost overruns were larger for smaller projects, on average. The authors noted that there were many errors in the cost databases, making cost comparisons difficult and uncertain, and recommended that data for cost follow-ups needed to be improved. The authors also investigated the results from the transport administrations' so-called successive calculation process, which had then recently been introduced in the national plan as a way to estimate confidence intervals of the cost estimates. The authors found that the estimated confidence intervals tended to be much smaller than the variability of actual cost outcomes. Moreover, confidence intervals were roughly of the same size regardless of projects' planning stage, whereas one would expect that costs were more uncertain in early planning stages. Both findings questioned the validity of the results from the successive calculation process.

Lind and Brunes (2015) administered a survey to experienced project managers at the Transport Administration and the largest contractors, asking them about their view about the most important reasons for cost overruns. According to the respondents, the most important reasons were changes in project scope and design, and unexpected technical problems (65% of project managers thought that these factors “definitely” or “probably” often caused cost overruns). Less important causes were optimism bias in early stages (44% thought that this often caused cost overruns), lack of competence among technical or budgetary staff (33%), changes in input prices (21%) and intentionally setting budgets too low (16%). The authors note that most cost overruns occur in the initiation and planning stages up to the final design.

Lind and Brunes (2014) propose a number of reforms to reduce the extent and consequences of cost overruns. The proposed reforms concern three areas: organisational macro-structure, e.g. using more PPP projects, and decentralizing budgets such that cost overruns in one project in a region lead to less alternative projects in the same region; organisational quality, improving the possibility to see when and where cost overruns occur and who was responsible, and fostering an organisation culture of openness with a focus on improvements; and organisational processes, e.g. a systematic use of external reviewers in different stages of a project.

The Transport Administration (Trafikverket, 2018) followed up 21 projects (of which three mega-projects) completed 2015-2017, from their first inclusion in the national plan to completion. The average cost increase from first inclusion in plan was +17% for the 18 smaller projects and 6-56% for the three mega-projects. Comparing costs in the last plan to final costs, the average cost change was -4% for the 18 smaller projects, and between -4% and +4% for the mega-projects. No major differences between road and rail projects were found. The most common documented causes for cost changes were ”Uncertain cost estimate in first plan”, “Major changes in content or design”, “Changes in input prices” and “Changes in laws and regulations”. In most projects, content and design underwent substantial changes, especially during the planning stage but also during the construction stage. This makes cost comparisons difficult to interpret, especially when comparing early cost estimates. For example, several projects kept their budget by reducing the content of the project, while some projects increased in size both in terms of content and cost. In general, it is difficult to follow (with available documentation) to what extent cost changes were explained by content changes.

Nilsson, Nyström and Salomonsson (2019) investigate cost outcomes of contracted maintenance and investment activities, comparing final costs to initial contracted cost. Almost all final costs exceeded initially contracted costs (94% of railway contracts and 86% percent of road contracts), with a mean cost increase of 32% for railway contracts and 20% for road contracts. Average cost increases were larger for contracts with large budgets and long durations, and larger for investment activities than for maintenance activities.

Nilsson (2022) and Jäderholm (2020) follow seven mega-projects from conception to finalization[2]. All projects experienced extreme cost overruns and delays. Their total cost increased almost threefold, and all were delayed at least six years. The reports discuss how and why this

[2] One project is still under construction.

happened, focusing both on technical factors and on the structural factors in the planning and decision processes. The latter tend to cause scope creep and cost escalations, and also make it difficult to abandon projects even when facing extreme increases in costs. One conclusion is that the administrative framework currently makes it impossible to compare costs in contracts with final costs, meaning that there is no institutionalized learning process in place.

The National Audit Office (Riksrevisionen, 2021) followed 86 projects completed since the formation of the Transport Administration in 2010. The report concluded that investment costs had been systematically underestimated. Table 1 summarizes some main results. Cost escalations occurred primarily in the planning stages, while there were no systematic cost differences between final costs and cost estimates at start-of-construction. The report noted that the government very rarely changed investment decisions once a project was included in the national plan, even when there were substantial increases in project costs. The Audit Office also criticized both the government and the Transport Administration for not providing adequate information about cost overruns. Moreover, they found a lack of systematic evaluation of the causes of cost overruns and how they can be prevented.

Table 1. Results from Riksrevisionen (2021): Changes in project costs between national plans (all projects finished 2010-2018).

| | Cost change, average | Cost change, median | Absolute value of cost change, median |
|---|---|---|---|
| Plan 2014 → Plan 2018 | 39% | 15% | 22% |
| Plan 2010 → Plan 2018 | 68% | 23% | 28% |
| Plan 2004 → Plan 2018 | 165% | 60% | 61% |
| Last plan → Finished | 9% | -4% | 18% |
| Start of construction → Finished | 2% | -3% | 14% |

Sjögren and Norgren (2023) expand the Audit Office's data set to include more recently finalized projects, and estimate correlations between cost overruns and project type, project size, and regional location. They find that cost overruns are more common in small projects, but found no systematic differences between project types. There were significant differences between projects located in different regions.

The Transport Administration's proposal for national plan 2022-2033 (Trafikverket, 2021) contained an analyses of changes in project costs since the previous plan (2018-2029). Adjusting costs only for inflation, average costs had increased by 16% for projects under construction, by 45% for projects ready to start construction and by 51% for projects in the planning stage. (Trafikverket, 2021, p. 196). Two thirds of projects in (early or late) planning stages had experienced cost increases above 30%, and one third of projects over 60%. There were no major differences between railway lines and roads, but cost increases for railway system upgrades (e.g. the new signal system ERTMS) were considerably larger than for other projects. The report concluded that it would not be sufficient only to improve the quality of cost estimates, or to increase cost control in the construction phase, even if both were also necessary. The report stressed that it must be possible to reconsider previous decisions to include projects in the plan, and that this must be done early enough in the planning process that it is still possible to cancel a project, or radically alter its design or content.

Eliasson (2022) investigated how costs had changed between the national investment plans 2010-2021, 2014-2025, 2018-2029 and 2022-2033, comparing projects which are present in two subsequent plans. (The present paper is to some extent an update and extension of these analyses.) Railway system upgrades (e.g. ERTMS) and the planned new high-speed railway lines were excluded from the analyses. Adjusting costs with the construction cost index, the report found that costs tended to increase mainly during the planning stage, but more recently there had also been a tendency that costs increased during the construction stage as well. Table 2 summarizes the main results.

Table 2. Results from Eliasson (2022): Changes in project costs between national plans.

| | Plan 2010 → plan 2014 | Plan 2014 → plan 2018 | Plan 2018 → plan 2022 |
|---|---|---|---|
| Under construction in previous plan | -9 % | +3 % | +9 % |
| Started since the previous plan | 0 % | +9 % | +17 % |
| Not yet started | +5 % | +37 % | +36 % |
| *Change in construction cost index, excl. general inflation* | *+9 %* | *+4 %* | *+6 %* |

## 4 A comparison of cost estimates in subsequent investment plans

The Transport Administration (and its predecessors) have constructed four proposals for multi-modal national infrastructure plans, covering the time periods 2010-2021, 2014-2025, 2018-2022 and 2022-2033. Since planning and construction of infrastructure projects usually takes more than four years, most projects occur in two or more subsequent plans. This allows us to follow estimated project costs from start to finish for a relatively large number of projects.

In each plan, each project is classified to belong to one of four stages: in planning (year 4-6 and year 7-12 of the plan), ready for construction (year 1-3 of the plan), under construction, or finished. Most projects go through all these four stages in subsequent plans, but there are also investments which, for example, are classified as “in planning” in one plan and then go directly to “under construction” or even (rarely) to “finished” in the subsequent plan. The analysis presented here is built on all investments which are present in at least two subsequent plans. In total, the data set comprises 292 investments, with 334 corresponding cost changes between plans. Figure 2 summarizes the number of cost changes between plans, both in terms of number of projects and their total cost (billion SEK, in bracketed italics).

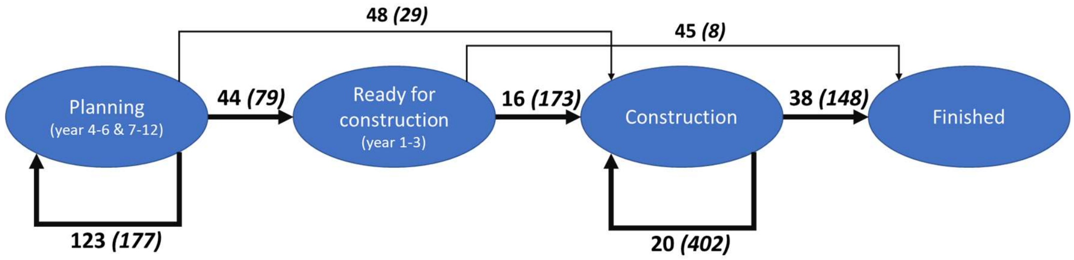


Figure 2. Overview of the data set: cost changes of projects between subsequent plans, grouped by type of status change. First number is number of projects, second number is total cost in billion SEK.

For brevity in the following, the national investment plans will be called "plan 2010" for the plan for the period 2010-2021, "plan 2014" for the 2014-2025 plan and so on.

## 4.1 Investment construction cost indices

The Transport Administration continuously calculates a so-called construction cost index, which measures how construction costs evolve over time. Construction costs have increased faster than inflation for several decades. Figure 3 shows the development of the construction cost indices in real terms (i.e. adjusting for general inflation) for road and railway investments for the period 2009-2023. In the following analyses, costs from different years are adjusted with these construction cost indices. Since the indices have increased faster than general inflation, this means that the following cost comparisons understate the cost increases in real terms.

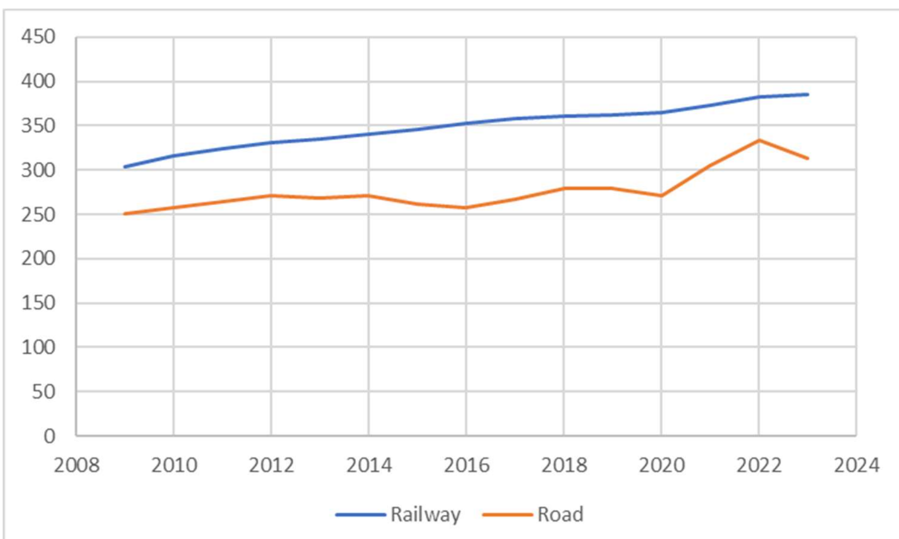


Figure 3. Construction cost indices for railways and roads, net of general inflation.

Table 3. Change in construction cost indices between plans (average of railways and roads).

| | Index increase | General inflation | Index increase excl. inflation |
|---|---|---|---|
| Plan 2010 → Plan 2014 | 14% | 5% | 9% |
| Plan 2014 → Plan 2018 | 6% | 3% | 4% |
| Plan 2018 → Plan 2022 | 15% | 7% | 8% |

## 4.2 Average cost changes between plans

Figure 4 shows how cost estimates evolve between plans, on average, depending on how projects change status from one plan to the next. Projects which go from the "planning" stage in one plan to "ready for construction" in the next increase their cost by 30%, on average. Projects which stay in the "planning" stage between two plans increase their cost by 34%, on average. Projects which go from "ready for construction" to "under construction" increase their cost by 21%, on average. Projects which stay in the "under construction" stage in two subsequent plans increase their cost by 7%, on average, while projects which go from "under construction" to "finished" increase their cost by 1%, on average.

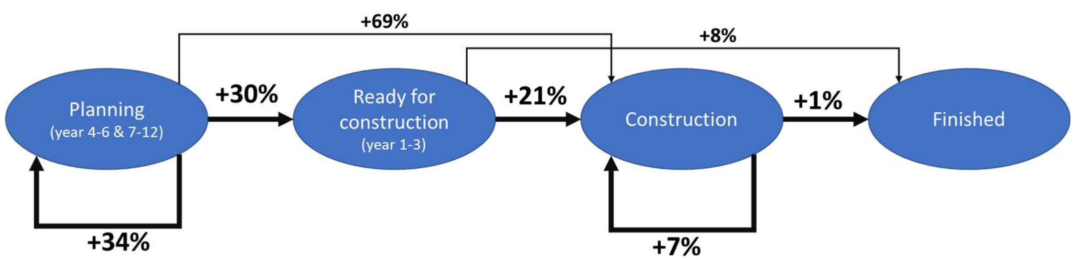


Figure 4. Changes in estimated costs between subsequent investment plans, depending on change in project status. (Percent changes are with respect to total project cost, i.e. large projects have a correspondingly higher weight.)

The conclusion is clear: during the planning stage, estimated costs increase substantially, on average, and more so for investments that remain in the planning stage for a longer time. On the other hand, costs do not increase much (on average) during the construction phase, although there is some cost escalation for projects with long construction times spanning several plans.

Note that these are *average* changes, however, and that projects exhibit large variability. The distribution of cost changes is highly skewed. A relatively small share of projects experience large cost increases between plans, while the majority of projects do not. In other words, the increase in average costs during the planning stages are mostly driven by a minority of projects, which (on the other hand) are subject to considerable cost increases.

Figure 5 shows the distribution[3] of how costs change from the first "planning" stage to the "under construction" stage, for road and rail projects respectively. The figure shows that for most projects, costs actually do not change much during the planning stage – but for some projects they change considerably. Moreover, the distributions are clearly skewed, with a long tail to the right.

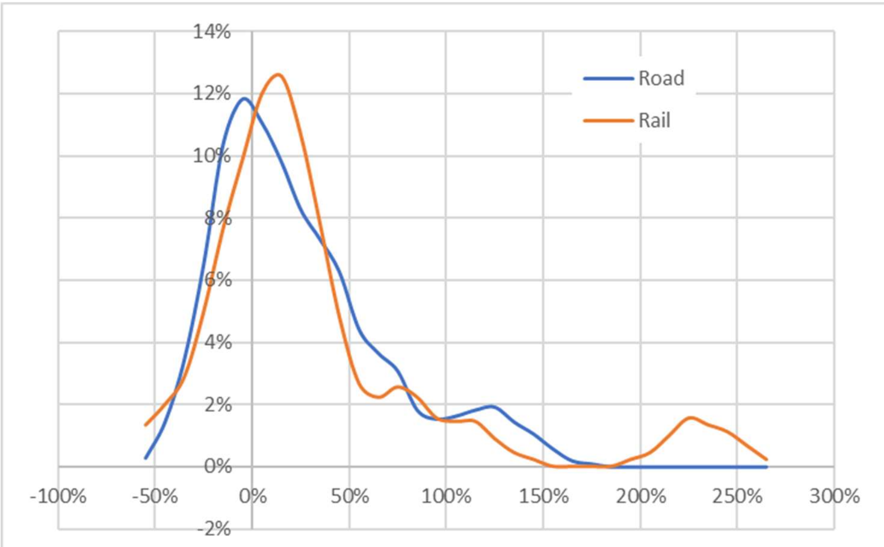


Figure 5. Distribution of cost changes from first inclusion in national plan to "under construction" stage. Road distribution: average +25%, median +15%, standard deviation 43%. Rail distribution: average +40%, median +17%, standard deviation 82%. (Cost estimates from different years are adjusted for the change in construction cost index.)

It is interesting to note that the modes of the distribution (the most likely values, i.e. the peaks of the distributions) are close to zero. This suggests that cost estimates reflect the *most likely* cost, rather than the *average* cost of a project. For symmetric distributions, i.e. when cost overruns are as large as cost underruns, the mode and average coincide – but this is not the case for skewed distributions.

Figure 6 shows similar distributions of how costs change from the "under construction" stage to finished project. Again, a majority of projects have final costs close to estimates in the "under construction" stage, but the distributions are less skewed than above. For road projects, the average cost change is close to zero (-2%), while it is larger for railway projects (+10%). The medians and modes of both distributions are close to zero.

[3] The distributions are smoothed using a kernel estimator (a generalization of moving averages).

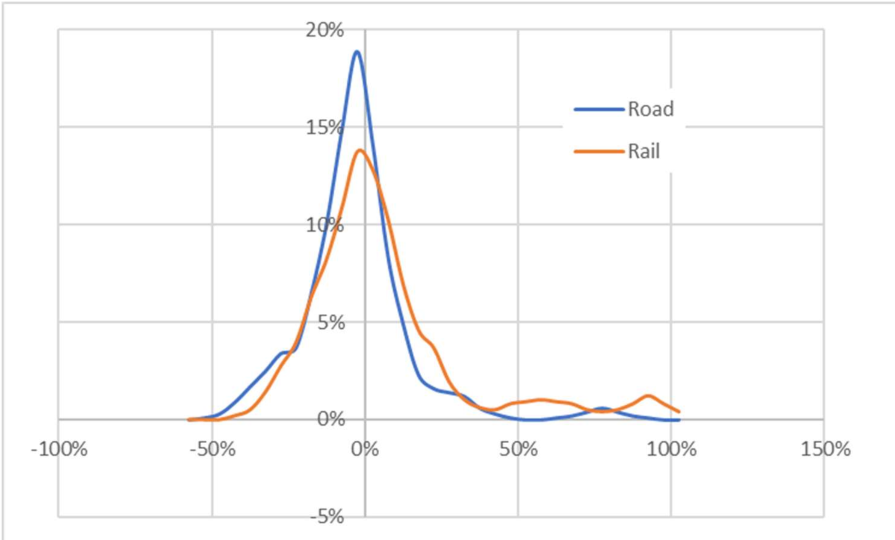


Figure 6. Distribution[4] of cost changes from "under construction" stage to final cost. Road distribution: average -2%, median 0%, standard deviation 17%. Rail distribution: average +10%, median 0%, standard deviation 36%.

There is some evidence that cost escalation has increased over time. Figure 7 is similar to figure 4, but cost changes are shown for each plan revision (i.e. from plan 2010 to plan 2014, from plan 2014 to plan 2018, and from plan 2018 to plan 2022).

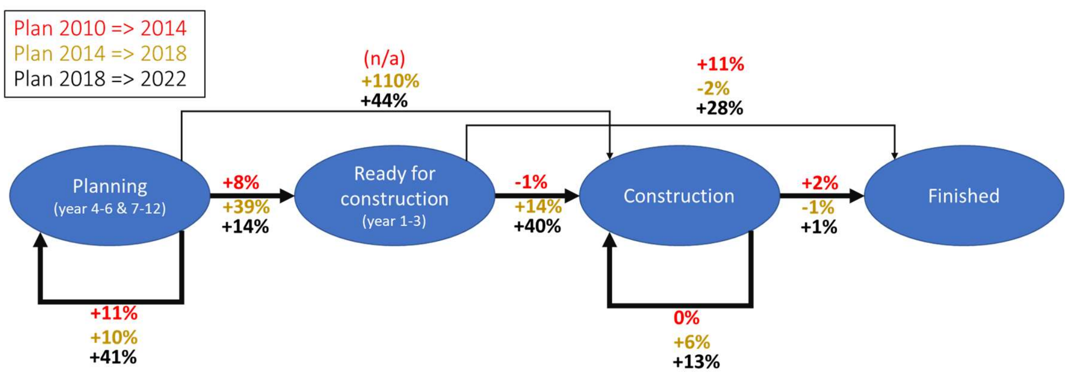


Figure 7. Cost changes between plans, grouped by type of status change.

With a few exceptions, it is clear that cost changes are larger for the recent plan revision (from plan 2018 to plan 2022).

## 4.3 Analysing final cost reports

In the Transport Administration's yearly report, final costs of all finished projects are published, and compared with cost estimates from the start of the construction phase and from the last national plan before start of the construction. A data set collected by Ulf Magnusson summarizes

[4] Distributions are smoothed using a kernel estimator.

all 276 finished projects during the period 2004-2022, allowing for structured comparisons between cost estimates in the last plan, at start of construction, and final costs.

Figure 8 shows average relative differences between final costs and last plan costs and start-of-construction costs, respectively, for each year. The small numbers in the diagram indicate the number of projects reported each year.

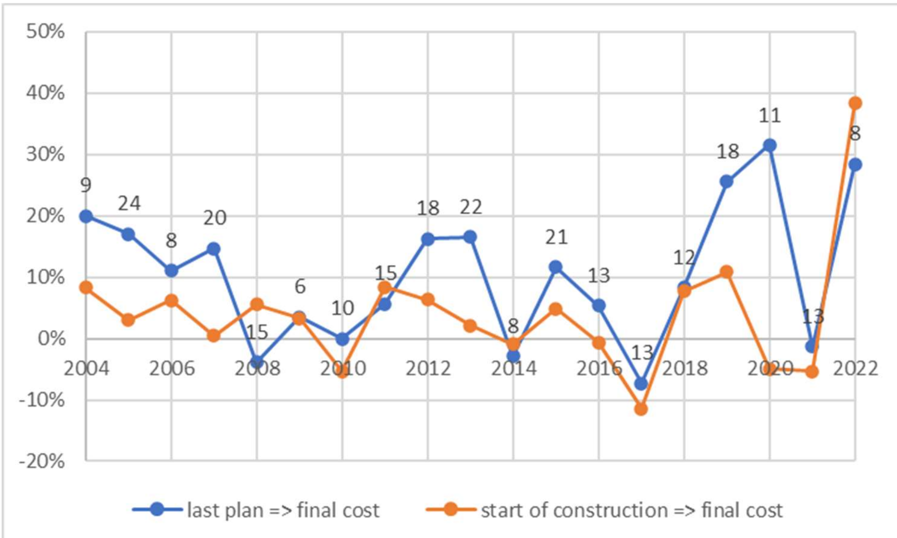


**Figure 8. Average cost escalation between final costs and last-plan cost and start-of-construction costs, respectively, by finishing year. (Small numbers show the number of projects finished per year.)**

On average, final costs exceed the earlier cost estimate, and there is some evidence that this problem has increased somewhat over time. Cost estimates in the earlier stage (in the last national plan) underestimate final costs more than the cost estimates in the later stage (at start of construction).

Figure 9 shows the distribution of cost deviations. Just as in the previous analyses, the distributions are skewed, with most projects having final costs close to estimates, but a minority of projects have substantial cost increases. Average cost increases are higher for rail projects than for road projects, and the standard deviation is also higher for rail projects.

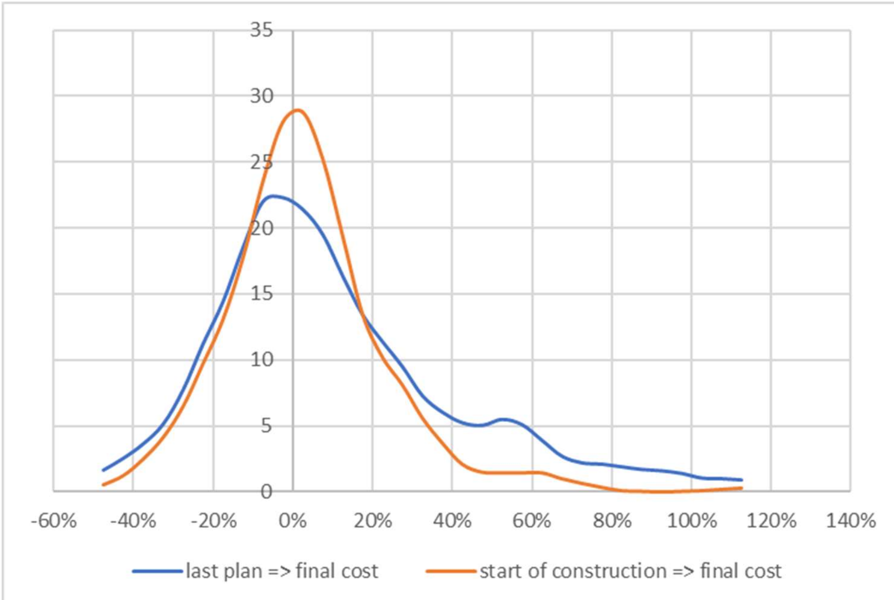


Figure 9. Average cost escalation between final costs and last-plan cost and start-of-construction costs, by finishing year.

Table 4 summarizes the distributions.

Table 4. Summary of cost deviations from final cost reports.

| Cost deviation | last plan → final cost | start of construction → final cost |
|---|---|---|
| Average | +11% | +4% |
| Median | +4% | +1% |
| Std.deviation | 36% | 22% |
| Average, road projects | +9% | +4% |
| Median, road projects | +4% | +1% |
| Std. deviation, road projects | 31% | 20% |
| Average, rail projects | +15% | +4% |
| Median, rail projects | +4% | 0% |
| Std. deviation, rail projects | 43% | 26% |

# 5 Possible causes and remedies

Several mechanisms causing cost escalations have been suggested in the literature. One group of explanations focus on engineering aspects such as inadequate methods for cost calculations, insufficient investigations of project conditions (e.g. soil conditions), increasingly stringent building regulations and standards, and lack of support for adequate risk assessment (e.g. basing calculations on most-likely outcomes rather than average outcomes). Such problems are often aggravated if decisions are made too early in the process, before detailed cost calculations have been made, or even before project data has been gathered or determined. Adding to this is a common lack of detailed follow-ups of construction costs, meaning that cost estimation methods are not updated or improved.

Another group of explanations focus on structures and incentives in the decision-making process. Such mechanisms include scope creep, selection bias, optimism bias, that early decisions are rarely reconsidered in later stages, and strategic behaviour of stakeholders and decision makers, including intentional misrepresentation of facts.

The mechanisms are not mutually exclusive, and it appears likely that they may all contribute. This means that there is no single solution. It is necessary to work both on engineering aspects (such as more accurate cost calculations) and procedural aspects (such as reducing the tendency to make irrevocable decisions early in the planning process). The following section sets out some general advice based on research literature and empirical experience.

At the time of writing (2023), work is ongoing at the Transport Administration to reduce cost escalations. This includes updating methods for cost calculations, revising the planning and decision-making process to ensure that reliable cost estimates are available at key decision points, setting up processes to learn from experiences of finalized projects, and gathering data for constructing so-called reference class forecasts (see below). The discussion in this section is a contribution to this; some of the suggestions presented here are already being considered or prepared.

### Project selection must be reconsidered if costs increase

Many projects compete to enter the national investment plan. The ones that are judged to generate the most benefits (in a wide sense) relative their cost are selected. The fundamental problem caused by cost escalation is that it distorts the selection of projects: if projects' true costs and benefits had been known, other projects (or project designs) might have been chosen. The only way to solve this problem is to require that project selection is reconsidered whenever costs increase, comparing the currently selected projects to alternative projects (which they have crowded out of the plan) based on updated cost estimates.

Failure to reconsider project selection when costs increase also also risk inducing strategic behaviour by stakeholders. It gives proponents of a project incentives to understate costs and overstate benefits early in the planning process. Stakeholders can also demand additions or increased standards, safe in the knowledge that the project will be carried out anyway once it has been included in the plan.

Flyvbjerg et al. (2002; 2004; 2009) argue that intentional "strategic misrepresentation" is the most important reason for cost escalation. Proving that misrepresentation is intentional is of course difficult, although there is quite a lot of anecdotal evidence that it does indeed occur. But even if misrepresentation of facts happens unconsciously rather than intentionally, the result is similar: projects whose costs are underestimated (or whose benefits are overestimated) have an unfairly large likelihood to be included in the investment plan. The only way to change this is to require reconsideration of project decisions when costs increase, re-comparing them against other candidate projects (or project designs).

### Beware of scope creep

That projects' content and design change during the planning stage is not a bad thing; indeed, that is the purpose of the planning stage. But the fact that average project costs increase so much during the planning stage suggest that there are structural problems. Clearly, there is a possibility that other projects had been selected, had true costs (and benefits) been known at the time of decision. Since projects are rarely cancelled once they enter the national plan, there is a risk that the pressure to be cost-efficient decreases as soon as a project enters the plan, and decreases more and more the further in the planning process a project gets. This is for several reasons: the political, institutional and psychological resistance to cancelling a project (or reducing it in scope) increases the longer the planning process has been going on.

*Scope creep* refers to the tendency for projects to increase in size once they are decided, for example by adding more content, or increasing design standards and specifications. One reason for this tendency is that here-and-now benefits are more salient than abstract opportunity costs in some unspecified project somewhere else. This makes it psychologically and politically difficult to say no to suggested additions to a project. Another reason is that if the most important goal is to carry out a project, rather than to stick to a budget, stakeholders whose cooperation is necessary for the completion of the projects (e.g. local authorities) can easier force through additions to a project.

Scope creep is a real problem which needs to be guarded against. Naturally, there may be additions to a project which are well motivated and worth their additional cost. But every addition to a project (in terms of content or design) needs to be judged on its marginal benefit and its marginal cost, compared to the alternative use of funds. As mentioned above, the problem with scope creep is that the benefits of additions to a specific project are often more salient, and have much stronger stakeholder backing, than abstract use of the budget somewhere else.

### Constantly improve basis and methods for cost calculations

Lind and Brunes (2015), interviewing experienced project managers, conclude that a common reason for cost overruns is that cost calculations often have too low quality. This may be because project decisions are made too early, before detailed cost calculations are made or even before project-specific data is available, or because the cost calculation methods themselves are insufficient.

Cost calculation methods need to be continuously evaluated and improved by validating them against observations in structured ways. This needs to be done at different levels of aggregation; both at a detailed level (e.g. observed costs of specific project elements or construction steps) and at an aggregated level (e.g. observed building cost of a kilometre of railway line or road tunnel). Such follow-ups and validations are carried out to some extent, but far less than warranted, largely because comparable data is too seldom gathered and made available.

Comparable and structured data about costs at micro and macro levels are also a prerequisite for benchmarking costs across countries and contractors.

Problems with low-quality cost calculations are aggravated by optimism bias and confirmation bias. Optimism bias is the well-documented psychological tendency to overestimate the probability of success, and the difficulty of imagining all possible reasons why things might go worse than anticipated. Optimism bias can be reinforced by confirmation bias, our tendency to easier observe and believe statements which support beliefs we already have. These biases occur in all contexts, but when it comes to planning, they are presumably further strengthened by a selection effect that makes particularly optimistic people more likely to become project managers, idea generators and lobbyists.

Since there are so many factors that can conceivably make a project more expensive, listing and evaluating all such factors is almost impossible. A way to remedy this conundrum is to take a more aggregate view of the project, abstracting away from project specifics and asking "how much do this kind of projects generally cost?". This kind of abstract benchmarking is often called *reference class forecasts* (RCF). The RCF approach has been suggested by Flyvbjerg and coauthors in a series of papers (Flyvbjerg, 2009), and applied in the UK and other countries. RCF:s can also provide probability distributions of costs, giving a way to estimate the risk for cost overruns.

As stressed above, the most serious consequence of erroneous cost estimates is that it distorts project selection. For RCF:s to help solve this, they need to be different for different types of projects. Simply adding a general risk premium to cost estimates makes overall budget planning more accurate – but it does not solve the problem of distorted project selection.

### Improve project documentation to enable follow-ups of costs

One of the conclusions from the cost comparisons presented in this paper is that it is very difficult to track *why* projects' estimated costs change from first estimates to final costs. During the planning stage, projects can have the same name but significantly change content. At best, planning documentation notes (in broad terms) what is added to or removed from the project, but very rarely an assessment is documented regarding the consequences for the project cost of such changes in project content. Projects' final reports may state that final costs have increased or decreased for various reasons (e.g. unforeseen circumstance or content changes), but very rarely do they assess quantitatively how much more expensive (or cheaper) this made the project.

Structured and easily available documentation, possible to compare and aggregate, is necessary to enable systematic follow-ups of cost estimates, systematic improvement of cost calculations, and assessment of risks of cost increases. This applies both to detailed cost estimates (costs of specific elements or steps) and aggregate estimates (benchmarking entire projects).

### Keep a portfolio contingency

Even with high-quality cost estimates, uncertainties cannot be entirely avoided; it is impossible to foresee everything that can potentially increase project costs. Cost uncertainty distributions are generally highly skewed; even if most projects keep their budgets reasonably well, there is generally some probability that a subset of projects face much higher costs than anticipated. The skewness of the uncertainty distribution is increased by the project selection process. As shown by Eliasson and Fosgerau (2013), as soon as costs influence project selection, the final costs of the selected projects will exceed the initial cost estimates on average, and their distribution will be skewed, *even if* initial cost estimates are correct on average and unskewed. The reason is simply that when one selects projects which appear to have high benefits-to-cost ratios (based on initial estimates), the resulting project selection will tend to be precisely those where costs were underestimated (or benefits overestimated). It is therefore expected that average total costs will exceed initial estimates.

In addition to this, it appears that cost estimates often refer to "typical" costs, i.e. the most likely outcomes. But when uncertainty is skewed to the right, average cost outcomes are larger than the most likely outcome. In addition to the analyses presented in this paper, the analyses in Welde and Odeck (2017) and Eliasson (2022) show that cost overruns are roughly as likely as cost underruns, but since the overruns are larger than underruns, average costs are still larger than estimates.

This means that a project portfolio should have a contingency to cover these expected, average cost overruns. Having a portfolio contingency reduces the risk for aggregate overspending, which in turn risks to upset budget planning and time plans. Note that the contingency should be at the portfolio level, not added to individual project budgets. The reason for this is that when contingencies are allocated directly to projects, they are likely to be used in any case, due to the tendency for scope creep (above).

# 6 Conclusions

When following projects between subsequent national investment plans, there is a strong tendency for costs to escalate, especially in the early planning stages. To some extent, it is natural and intentional that projects' content and design change during the planning process; but the fact that costs are much more likely to increase than to decrease suggests that there is a systematic problem. The fundamental problem is that this tends to distort project selection and design, resulting in less aggregate social benefits for a given budget than would have been possible if project selection and design had been based on true costs.

In the paper, some possible remedies for this are suggested. First of all, project selection must be reconsidered whenever costs increase. Secondly, scope creep need be guarded against, since it may be unintentional and biased towards existing projects. Methods and data for cost estimates need to be improved; part of this is better documentation of project costs and contents. Finally, project portfolios need contingencies, since some extent of aggregate cost overruns will still be likely due to skewed uncertainty distributions.

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