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Systematic construction risk, cost estimation mechanism and unit price movements ☆

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ABSTRACT

Researchers have already proven significant systematic cost over-runs measured from the decision to build estimate even in the most developed countries of the world. The reference class forecasting was introduced to counter this bias. However, the precise workings or cost over-run determinants are however still under-researched. We selected the case of the National Highway Construction Program in Slovenia and projects, completed between 1995 and 2007. The purpose was to determine the precise cost performance through time and analyze the cost estimating mechanism to see whether and how it influences the cost performance. The details of the cost estimating practice have been studied and compared with the existing practice in the USA and elsewhere. A representative sample of 36 projects could be constructed, valued at USD 2.7 billion (2006 prices) with a total length of some 235 km. Almost half of the cost performance variance could be explained by the cost estimation mechanism (cost-based estimation with historic bid database). In different variants, this approach appears to be dominant in the most developed countries of the World due to its relative simplicity. We find, that due to the behavior of bidders in the tendering process, the same mechanism also implies that some systematic cost over-run will likely occur, even if no other causes were present. This adds a new perspective to the suggestions of Flyvbjerg and others, who suggested that the dominant (but not exclusive) cause for the persistence of systematic cost is strategic misinterpretation. The findings suggest that project sponsors should perform a supporting analysis on how price changes on the construction market feed in to the cost performance to further support the reference class forecasting approach. The findings also suggests, that in case of strong cost performance shifts, longer periods need to be included in the analysis, before one can conclude, that the improvement or worsening is not temporary and is not the inherent result of the cost estimating mechanism.

1. Introduction

Cost over-runs in publicly financed projects usually receive a substantial attention of the public, even more so when considerable amounts are involved. Although it might be argued that cost over-runs receive much more media attention than cost under-runs, it was only in this century that sufficient data was gathered to allow statistical inference on the question of cost estimation accuracy. Estimated cost at the decision to build (and estimated benefits) are instrumental in the investment selection process.

Due to difficulties in obtaining data, researchers focused mainly on the area of transport infrastructure projects, where a sufficient number of observations (projects) were most likely to be gathered and where the financial impact of possible systematic mistakes in cost estimation is relevant to public policy decisions,[2] More recent studies in the transport sector (e.g. Booz Allen Hamilton Inc, 2005;

Abbreviations: C, project construction cost; CP, construction cost performance, expressed as a relation between the sum of actual and estimated construction cost; DARS, Motorway Company of the Republic of Slovenia ("Družba za avtoceste Republike Slovenije"); DDC, DDC Engineering and Consulting Ltd—state owned engineering and consulting company; HICP, harmonized index of consummer prices; IP, investment program document ("Investicijski program"); L, land acquisition and damages cost; LP, land and damages cost performance expressed as a relation between actual and estimated land acquisition and damages cost; NPIA, National Highway Construction Program ("Nacionalni program izgradnje avtocest"); O, other project cost; P, project Design cost; PP, design cost performance, expressed as a relation between actual and estimated design cost; RoS, Republic of Slovenia; SD, standard deviation; VAT, Value Added Tax; ZGIGM, Chamber of Construction and Building Materials Industry of Slovenia ("Zbornica gradbeništva in industrije gradbenega materiala")

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[2] The availability of data, required to perform a cost over-run analysis is limited. There are two reasons for this situation, firstly, when data is available their owners are not necessarily willing to share it, and secondly, many times the owners did not properly collect or store the data. During a study of cost overruns in the public sector projects Mott Macdonald (2002) reported, that it could only recover sufficient data for 50 projects out of 80 initially selected. GAO (2003) in the USA at the time reported that it was not possible to analyze cost over-runs in the federal aid supported road infrastructure because the data collection practice was

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Flyvbjerg et al., 2002, Flyvbjerg et al., 2003; Odeck, 2004; Berechman and Wu, 2006; Makovšek et al., 2012; Cantarelli et al., 2012a; Cantarelli et al., 2012b) focused on railways, roads, and fixed links (bridges and tunnels), and compared actual cost with estimated cost at the (formal) decision to build. The studies discovered statistically significant systematic cost over-runs of different magnitudes for different types of infrastructure and different types of financing arrangements.

Flyvbjerg et al. (2002) proposed a classification of possible cost over-run root causes into three groups, technical, psychological and politically-economical reasons (deliberate underestimation of expected cost). They proposed, that the politically-economical reason is the primary explanation for the systematic cost over-runs (and benefit shortfalls) (ibidem 290). As a very important element in favor of this conclusion, was a quantitative argument, when they detected a lack of cost performance improvement over the period of several decades, as measured in their sample of 258 projects (167 of the related to road infrastructure), which covered 20 countries from different parts of the world. The authors also assumed that the cost estimation methods had improved over time and an improvement in cost performance should have been recorded in such a long period, which makes it even more difficult to explain why no learning has taken place. Apart from measures, which would increase transparency in disincentivise deliberate underestimation, Flyvbjerg et al. (2002) also proposed the reference class forecasting to counter the discovered systematic bias, which uses the measured systematic error of past projects to correct the estimates of current investment decisions.

Despite a growing body of research on the subject of systematic cost over-runs, measured against the decision to build estimate, the precise workings of this problem are still not fully understood and normally, more recent studies do not explore further the relevance of various root causes.

This article challenges Flyvbjerg's view of political–economic causes as the reason directly responsible and the dominant cause for systematic cost over-runs at least in the sense, that it is so all the time and for all infrastructure types. We do so by directing our attention on a technical cause in the context of road infrastructure projects.

We focus on the mechanics of the cost estimation process and examine its influence on the accuracy of cost estimation at the decision to build. The analysis builds on the sample, presented in Makovšek et al. (2012), which studied the National Highway Construction Program (NPIA) in Slovenia in the period 1995–2007. The general mechanics of the cost estimation approach in the sample involve the use of historical data from recently awarded contracts to guide the cost estimates of new projects, an approach, that is in various variants dominant in the developed world. To the best of our knowledge, there are no similar studies available.

In the following chapters, we present a literature review, the NPIA background and a brief description of the estimating practice in Slovenia, a summary of the methodological approach, the results of the statistical analysis, and followed by a discussion and conclusion.

2. Past studies on cost over-runs

The problem of cost over-runs at the decision to build has been treated by several studies in the past century (e.g. Merewitz, 1973; Pickrell, 1990, 1992; Nijkamp and Ubbels, 1999). These studies built their analysis on small samples and some were limited by methodological issues (e.g. not taking account of nominal and real prices), as set out in Flyvbjerg et al. (2003). It was the seminal work of Flyvbjerg et al. (2002, 2003), which showed on a sample of large infrastructure projects, with statistically significant results, that cost over-runs:

- are common in the developed world;
- are systematic—the mean cost over-run is not zero but is positive by a substantial margin, which was different for different infrastructure types;
- appear not to have decreased over the 70 years of data, analyzed in the study.

The same study (2002) also suggested a classification of potential root causes of cost over-runs:

- the technical causes refer forecasting errors, which may be the result of honest mistakes, inadequate input data, limited accuracy of the forecasting approach used, inherent difficulty in forecasting the future and other similar explanations;
- psychological causes, whereby the forecaster is overly optimistic due to optimism bias (i.e. self-deception);
- economically-political reasons involve situations, in which the project cost is deliberately underestimated, either because the forecasters think this will create an (benevolent but inadequate) incentive to execute the project for less money or mainly because a project with lower cost will have a higher chance of approval in the evaluation process.

The technical explanation was deemed less fitting because the forecasting errors are not equally distributed around a zero cost over-run—honest mistakes would have been randomly positive or negative, it is unlikely because no improvement in forecasting performance is evident through the 70 years, despite the fact that forecasting tools and methods must have improved over time. The psychological explanation was also not accepted as a primary root cause, because the forecasters are not expected to be inexperienced and it is unlikely, that they would not learn from their experience (in which case an improvement in forecasting performance would have been evident over time). The authors proposed the third cause as a primary explanation, which had the best fit with the quantitative result of their study. In addition, earlier work by Wachs (1986, 1989, 1990) who conducted interviews public officials consultants and planners already pointed to the problem of deliberate cost underestimation. Flyvbjerg (2008) later appeared to give a greater weight also to optimism bias, as a good explanation in situations where political and organizational pressures are absent or low.

Other studies, which followed (Flyvbjerg et al., 2004, Odeck, 2004; Lundberg et al., 2011; Makovsek et al. 2012; Cantarelli et al., (2012); Cantarelli et al., 2012a; Cantarelli et al., 2012b) tried to examine the magnitude of cost over-runs, the characteristics of cost over-runs in transport infrastructure, whether it is influenced by project size, length of implementation phase, delays, geography, and ownership/procurement mode. These studies are also methodologically comparable, they:

- use the same estimate reference point (formal decision to build),
- consider cost in fixed prices, and normally exclude the cost of financing and taxes, and
- deal predominantly with larger, traditionally procured projects (as opposed to project structures, which involve the bundling of several project life-cycle phases (as is common in project finance—for example Design Build Maintain Operate, whereby the construction phase has a fixed price contract).

(*footnote continued*)
inadequate. The main criterion for project selection in various studies was therefore data availability.