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# Relationship between costs and perceptions of infrastructure projects

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Subject review

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## Relationship between costs and perceptions of infrastructure projects

Large infrastructure projects are forerunners of economic trends, change the structure of society, affect economic growth, and at the same time are exposed to strong criticism and negative perception. Complex circumstances make it almost inevitable to exceed costs ranging from a few percent to huge values of 200 % or 300 %. The public does not recognize the complexity of the issue, which often makes the negative perception present unjustified and creates pressure on decision makers. By harmonizing the methods of calculating overdrafts, standardization of terms and records, public institutions are encouraged to systematically limit the unavailability, non-transparency and inconsistency of data on project implementation. This opens space for the possibility of comparing experiences and reducing the negative perception of infrastructure investments.

### Key words:

cost overruns, infrastructure projects, estimated costs, reasons for overruns, estimates

Pregledni rad

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## Povezanost troškova i percepcije infrastrukturnih projekata

Veliki infrastrukturni projekti su preteče gospodarskih kretanja, mijenjaju strukturu društva, utječu na ekonomski rast, a istovremeno su izloženi burnim kritikama i negativnoj percepciji. Složene okolnosti čine gotovo neizbježnim prekoračenja troškova koja se kreću od nekoliko postotaka pa do golemih vrijednosti 200 % ili 300 %. Javnost ne prepoznaje složenost problematike, što prisutnu negativnu percepciju često čini neopravdanom i stvara pritisak na donositelje odluka. Ujednačavanjem metoda izračunavanja prekoračenja, standardizacija pojmova i evidencija potiču se javne institucije na sustavno ograničavanje nedostupnosti, netransparentnosti i neujednačenosti podataka o realizaciji projekata. Time se otvara prostor za mogućnost uspoređivanja iskustava i umanjivanje negativne percepcije infrastrukturnih ulaganja.

### Ključne riječi:

prekoračenje troškova, infrastrukturni projekti, procijenjeni troškovi, razlozi prekoračenja, procjene

## 1. Introduction

As indicated by Siemiatycki [1] and Samset and Volden [2], negative perception tarnishes the image of many infrastructure projects, and is most often related to delays in construction time and cost overruns. Instances of cost overrun were registered on numerous projects that have marked our history [3]. In addition, cost overruns on large infrastructure projects have been reported in scientific and professional literature relating to all segments of economy. In the USA [4], large and sometimes enormous cost overruns are quite usual in transport infrastructure projects financed by the state. In Australia, four years after the planning and design of the greatest ever state-financed social infrastructure project – the Fiona Stanley Hospital – cost overruns exceeded in 2004 the initially planned sum by 320 %, even before the start of construction work on the project. Similarly, due to poor management of the Perth Arena Project, and significant changes in the scope of the project, it is expected that the total estimated costs will exceed US\$ 500 million on this project, which is an increase of more than 200 % [5]. Costs were exceeded by 48 % for the construction of the European Central Bank (ECB) headquarters in Frankfurt, with as many as three years of delay in construction time. The realisation of the Elbphilharmonie Concert Hall in Hamburg was delayed by seven years and the total cost was exceeded by 1025 %. The works are still unfinished at the Berlin-Brandenburg (BER) airport project, and also at the Stuttgart 21 railway project – the biggest railway project in more than 100 years. It is currently planned that the Stuttgart 21 will be completed in 2025 – six years behind the schedule, and the cost overrun on this project is currently estimated at approximately 228 % [6]. Construction costs were also exceeded on numerous projects in Asian countries [7] as well as in many other countries all over the world.

Although engineering procedures and skills aimed at achieving accurate prediction of costs and traffic volume have evolved over time, these improvements have sadly not resulted in greater prediction accuracy [8]. Cost overruns have not reduced over time and are present in all geographic regions [3]. Cost overruns on transport infrastructure projects transcend geographic boundaries, i.e., the overruns have proven to be a global phenomenon [9]. Because of their great significance and influence on the society, the general public is highly interested in the realisation and the effects of infrastructure projects, and the reactions are sometimes quite intense. Construction projects are regularly on top of the news headlines because of poor management and budget overruns [10]. In the late 1980s Norwegian media wrote about uncontrolled costs and instances of the fraud and abuse of public funds [11]. Cost overruns on infrastructure projects are often used as a means for settling scores between various stakeholders and political parties pursuing their diverging objectives, and, in such cases, explanations for cost overruns are given in a partial, unsubstantiated, and sensationalistic manner. It is indisputable that numerous examples exist in which the problem of cost overruns comes as a consequence of fraud and abuse [12]. Unfortunately, perceptions about public projects are more often than not being unjustly twisted. Samset and Volden [2] report that

the project involving construction of the Oslo University Hospital in Norway was completed, due to adoption of new technologies, a year behind of schedule with cost overruns that were significant in absolute terms, but insignificant from the real-life perspective. The project was tarnished with numerous highly critical newspaper reports and by a public inquiry, and it was only after several years of operation that it was generally concluded that the project was in fact highly successful. On the other hand, general public accepted with benevolence the project involving construction of an on-shore torpedo battery at the northern coast of Norway in 2004, which completely missed the strategic goal even though the costs were kept within the initially planned budget. This project was realised within the scheduled time and cost, but was closed down by a parliamentary decision only a week after its opening to service. Samset and Volden [2] report: The media tend to give unsuccessful projects more publicity than successful ones. However, their perspective is highly restricted. The number one criterion of failure in the media is cost overrun; number two is delay in time." They consider that the use of cost overrun as a dominant criterion constitutes a very narrow approach of the media to this issue [2]. Perception (lat. percipere – to adopt) is a process of creating a notion about a certain occurrence, event of object from human surroundings, by interpreting the data arriving from various senses to obtain a meaningful whole. In this paper, perception is considered to be an opinion about public projects, or an interpretation of the data transmitted to general public through various media. The objective is to provide appropriate data, through an overview of literature, so as to enable better understanding of the complexity of the cost overrun issue, and to thus contribute to greater objectivity of perceptions. Understanding this complexity can be a strong argument for reducing prejudice about an infrastructural investment.

## 2. Analysis of cost overrun structure presented in literature

The most frequent way of analysing the cost overrun and delay in construction work is based on the enumeration of various factors that cause these problems, which is often supported by a ranking system [13]. The complexity of the cost overrun issue is manifested through discrepancies in the ranking of overrun reasons between the studies analysed in the paper. Table 1 gives a comparative presentation of two studies in which the frequency of occurrence of overrun reasons, as reported in published scientific papers, is studied.

The left part of the table shows reasons for overruns as presented by Durdajev [14] following consultation of literature and analysis of 48 papers. Overrun reasons obtained by Adam et al. [13], based on 40 relevant papers, are presented in the right part of the table. A difference in the number and description of the cost-overrun reasons can be observed in this table. Durdajev gives ten reasons for overrun, while Adam et al. provide eight categories of basic reasons for overrun. It can be seen that only two categories, namely those relating to financing and communications, are similar by description, while others are completely different and can not

Table 1. Comparative presentation of cost overrun causes identified in literature [14]

Origin of overrun	Number of papers	Explanation of causes	Origin of causes	Trend of occurrence in papers by period; minimum occurrence – 5, dominant occurrence - 1		Explanation of causes
				Period	Number of papers	
Problems with design documentation and incomplete design documentation	23	Civil engineering design is prone to various changes or errors during delivery, and change orders become unavoidable	Design	1985 - 1990.	3	<ul style="list-style-type: none"> <li>▪ Complexity of the project.</li> <li>▪ Project duration</li> </ul>
				1991 - 1996.	5	
				1997 - 2002.	3,1	
				2003 - 2008.	2,8	
				2009 - 2014.	3	
Inaccurate estimates	23	Lack of experience, "inadequate bidding documentation, lack of practical knowledge of the cost estimator, and insufficient time given for estimating costs" are the main reasons for inaccurate estimation of costs.	Management	1985 - 1990.	3,4	<ul style="list-style-type: none"> <li>▪ Poor site management,</li> <li>▪ Supervision and control,</li> <li>▪ Inadequate management</li> <li>▪ Capabilities,</li> <li>▪ Slow decision making,</li> <li>▪ Changes by the client,</li> <li>▪ Inadequate design specifications,</li> <li>▪ Changes,</li> <li>▪ Poor planning of the work and materials,</li> <li>▪ Lack of equipment</li> </ul>
				1991 - 1996.	5	
				1997 - 2002.	1,8	
				2003 - 2008	1,9	
				2009 - 2014	2,3	
Poor planning	20	Planning assists in the management of actions needed for achieving goals of the project. It is extremely important to establish a plan that is strictly operational and that takes into account possible obstacles during project upheavals.	Organisational	1985 - 1990	2	<ul style="list-style-type: none"> <li>▪ Inadequate management structure.</li> <li>▪ Poor organisational structure.</li> <li>▪ Poor process-related procedures.</li> </ul>
				1991 - 1996	5	
				1997 - 2002	3,1	
				2003 - 2008	3	
				2009 - 2014	3	
Weather conditions	18	The author links the influence of weather conditions with cost-performance on the project. This influence depends on the type of the project and weather conditions in which the project is realised. Interruption of work due to adverse weather conditions causes significant losses in work rhythm, especially on those projects that mainly involve open-space activities.	Material	1985 - 1990	3	<ul style="list-style-type: none"> <li>▪ Lack of equipment.</li> <li>▪ Poor planning of materials.</li> </ul>
				1991 - 1996	4	
				1997 - 2002	3,8	
				2003 - 2008	3,85	
				2009 - 2014	3	
Poor communication	17	The construction project cycle is known for its dynamic structure, which involves various participants at various levels and resources that need to be managed, and a dynamic flow of information.	Komunikacija	1985 - 1990	5	<ul style="list-style-type: none"> <li>▪ Lack of communication between the contractor and the client.</li> <li>▪ Inefficient communication.</li> </ul>
				1991 - 1996	5	
				1997 - 2002	4,5	
				2003 - 2008	4,2	
				2009 - 2014	3,7	

Tablica 1. Usporedni prikaz razloga prekoračenja troškova identificiranih u literaturi, prilagođeno od [14] - nastavak

Origin of overrun	Number of papers	Explanation of causes	Origin of causes	Trend of occurrence in papers by period; minimum occurrence – 5, dominant occurrence - 1		Explanation of causes
				Period	Number of papers	
Capabilities, skills and competences of the participants	18	Despite advances in construction technology, capabilities, skills and competences of the employees are still highly significant for the success of the project. Most of the studies in which this factor is mentioned come from developing countries.	Psychological	1985 - 1990	5	<ul style="list-style-type: none"> <li>▪ Optimism bias</li> <li>▪ Delusion</li> </ul>
				1991 - 1996	5	
				1997 - 2002	3	
				2003 - 2008	4	
				2009 - 2014	5	
Financial problems / poor financial management	17	Poor cash flow management on projects, economic instability of the market, especially in developing countries, lack of funding, delay, price fluctuations	Financing	1985 - 1990	1	<ul style="list-style-type: none"> <li>▪ Delayed payment to contractors / consultants</li> <li>▪ Poor financial planning</li> <li>▪ Price increase</li> </ul>
				1991 - 1996	2	
				1997 - 2002	4	
				2003 - 2008	5	
				2009 - 2014	3,2	
Price change	16	Financial problems of countries faced with political problems and economic instability. Frequent price fluctuations, especially in politically unstable countries. Longer construction time requires deeper understanding, regular monitoring of price fluctuations, and influence on clients	Time	1985 - 1990	5	<ul style="list-style-type: none"> <li>▪ Adverse weather conditions.</li> <li>▪ Unforeseen soil conditions</li> </ul>
				1991 - 1996	3	
				1997 - 2002	1,2	
				2003 - 2008	3,5	
				2009 - 2014	3,7	
Contract management issue	15	Award of contract to the most favourable bidder who is not capable of realizing the project, neglect of previous contractor experience on similar projects, neglect of competences, financial capabilities, etc.				
Soil conditions / foundations	14	It is included among project characteristics as infrastructure projects often require underground operations throughout the life of the project; lack of accurate on-site inspection of the project.				

be compared. Furthermore, Durdayev [14] listed the instances of overrun by the number of papers in which the cited cause is mentioned. Adam et al. [13] present their results by the number of occurrences of overrun reasons in individual time periods, thus offering an information about historical trends. For instance, it is interesting to note from conclusions made by Adam et al. that all papers selected in the 1985-1990 period cite financial factors as the primary cause of overrun. In the 1997-2002 period, financial

factors were ranked as the fourth most significant cause of overrun. Also interesting is the ranking presented by Durdayev in which the leading reasons for overrun are "Problems with design documentation and incomplete design documentation" and "Inaccurate estimates". The fact is that an individual most often cited reason is related to the probability of its occurrence in future overruns, but not to the solution of the problem. It is obvious that research does not enable an unambiguous definition of a

universal reason for overrun, or its participation in the cost overrun on a future project. Adam et al. [13] obtained lower grades (lower influence on cost overruns and time delays) for factors related to categories Communication (Lack of communication between the contractor and the client. Inefficient communication) and Psychology (optimism bias, delusion). They however point out that this does not necessarily undermine the importance of these influences in causing time delay and cost increase. They leave the possibility that issues relating to communication or psychology are the main causes of factors such as improper coordination or poor estimation of costs, both of which are categorised differently in the analysed papers. In fact, during the research, it is very difficult to determine – when identifying causes for delay and cost increase – where does the real cause occur in the chain of events that took place prior to the occurrence of the time delay or cost increase. Leaning on the paper published by Bhargava et al. [15], they report that the causes determining cost overruns and time delays often intersect. For instance, it can be claimed that a rework is a subset of improper planning, and that delusion is an indicator of poor employment policies. On the other hand, Durdajev [14] does not cite these reasons even in the explanation of the category “Poor estimates”. Based on the above, Adam et al. [13] correctly point out that one should be cautious so as not to rely too much on such information as it may give the false sense of security. A factor identified as a common and usual factor causing cost overruns and time delays is not necessarily the factor that exerts the highest influence. The order of factors only points to their prevalence, and not to the severity of their implications.

Discrepancies in the description of reasons, magnitude of overruns, and suggestions for eliminating cost overruns, can easily be observed through comparison of numerous studies. For instance, the studies published by Vu et al. [16] for Vietnam motorways, Al Hazim et al. [7] for several countries in Asia, Narayanan et al. [17] for India, and Love et al. [18] for Hong Kong, present the reasons for such overruns in individual geographic areas that are difficult to compare to one another. The question can be put whether the diversity of presented reasons could be the consequence of personal opinions of the researchers. Siemiatycki [19] compared the studies of two groups having different mandates, objectives and data access possibilities, i.e., researchers and authors of papers on the one hand, and state-employed independent reviewers on the other. He concludes that explanations of overrun causes depend on the observer’s perspective. State reviewers consider that central reasons for cost escalations on projects are the changes in scope arising from technical errors and difficulties in the realisation of large and complex projects. Strategic misinterpretation and optimism are rarely or not at all mentioned in most reports issued by state reviewers. On the contrary, errors caused by technical challenges are present in many research papers, but are not sufficient for explaining the cost-overrun frequency on transport infrastructure projects. Instead of that, the economic, political, and psychological explanations are the most prominent [19]. However, we have shown through the review of literature that reasons for cost overrun differ even within the researchers group, which is probably related to the observer’s perspective.

### 3. Two approaches, two “truths”

Understanding the reasons behind overrun is a necessary precondition for an objective prediction of the realisation success and contribution of infrastructure projects. Cost overrun that is not the consequence of a targeted project change is in the origin an incorrect estimate based on the conscious or unconscious provision of incorrect data. Flyvbjerg [20] claims that cost overruns are mostly due to optimistic bias and incorrect strategic presentation. He considers that most cost estimators are either “fools” (i.e., prone to excessive optimism) or “liars” (i.e., offering strategically incorrect presentation). This standpoint is based on the approach presented by Daniel Kahneman, a psychologist from Princeton University, Nobel prize laureate in economic sciences for the application of psychological breakthroughs in economic theory. Lovallo and Kahneman [21] report: “When forecasting the outcomes of risky projects, executives all too easily fall victim to what psychologists call the planning fallacy. In its grip, managers make decisions based on delusional optimism rather than on a rational weighting of gains, losses, and probabilities. They overestimate benefits and underestimate costs. They spin scenarios of success while overlooking the potential for mistakes and miscalculations. As a result, managers pursue initiatives that are unlikely to come in on budget or on time-or to ever deliver the expected returns”.

Two approaches to cost overrun can generally be differentiated in literature. The first one is based on the sources of overrun that are exclusively related to project features, i.e., to the changes in the scope of the project, intricacy of complex decisions, and definition of key project milestones or of the moment(s) in relation to which the estimation is made [22, 23]. According to this approach, cost overrun is considered to be a project management problem, and the solution is expected through better cost estimation and project implementation methodologies. However, the fact that estimations are not improving over time – although that could be expected through continuous learning from experience and advancements – is the foundation of a different approach to the understanding of the reasons for overrun [8, 12, 24]. The behavioural science implies the change in perspective: The cost overrun problem is not an error, but rather a bias. Furthermore, the problem is even not the cost overrun: it is the underestimation of costs. The overrun is the consequence of the underestimation and is manifested before the overrun [25]. Flyvbjerg et al. [25] report: “Your biggest risk is you, according to behavioural science. The root cause of cost overrun is human bias, psychological and political. Scope changes, complexity, geology, archaeology, bad weather, business cycles, etc. are causes, but not root causes.” Flyvbjerg explains the cost overrun issue through three main groups [8, 26]:

- Technical explanations: Cost overruns are explained in the sense of inaccurate and unreliable data. Some technical complications can occur during the project and lead to higher costs.
- Psychological explanations: These explanations focus on the theories relating to the study of behaviour, optimism bias in particular.
- Political-economic explanations: Here the issue of cost overrun is explained through intentional strategic misrepresentation

so that it would be more likely that the projects of one party, rather than the projects proposed by the competition, will obtain approval and financing. Strategic cost estimate would be low, which would then result in cost overrun.

Flyvbjerg et al. [27] grouped fundamental reasons for all estimation errors into three categories: 1) delusions or honest mistakes; 2) deceptions or strategic manipulation of information or processes or 3) bad luck.

However, Love and Ahiaga-Dagbui [28] consider such statements as ignorance and neglect of the complexity and nuances of the process of development and estimation of transport infrastructure projects. Love et al. [23] consider that there is no universally accepted theory that could explain the causality of cost overrun. They accept that the political cause of overrun can not be excluded. Politicians often announce planned cost of infrastructure projects before detailed engineering drawings and costs, usually just to fulfil their pre-election obligations or to attract new voters [28], but they see real reasons for cost overrun in a completely different light. Eliassona & Fosgeraua [29] also consider that bias may arise simply as a selection bias, without there being any bias at all in predictions ex ante, and that such a bias is bound to arise whenever ex ante predictions are related to the decisions whether to implement projects. They claim that Flyvbjerg's arguments are incorrect and that they are completely unsubstantiated. It is perfectly possible that forecasts are actually unbiased, but that selection of the best projects, influenced by the same forecasts, leads to bias. It follows that it is not possible to conclude from the observation of ex post bias that that bias must be deliberate. All that is essentially required for selection bias to be present in project appraisal is that there is some kind of selection process in operation whereby selection is influenced by a "noisy" prediction. Criticism of the Flyvbjerg's approach strengthens in a way the overrun curbing approach based on project management methods.

The complexity of the issue can clearly be seen in the overview of literature on the reasons for the cost overrun, which is considered as one of major sources of negative perception about infrastructure projects. For an objective evaluation of a concrete infrastructure project, it would be indispensable to determine reasons behind the overrun. It is a demanding task as the reasons for cost overrun range from negative intentions to misconceptions (delusions), from reasons due to complexity of the project to superficiality or ignorance. However, the solution of this task is a precondition for criticizing and estimating the success of the project. Otherwise, we would have a superficial or intentional encouragement of negative perceptions about the effects of an infrastructure investment. Such actions may be different in their source, but their effect is equally negative and undesired.

#### 4. Discrepancies in cost overrun definitions used in literature

The cost overrun is generally defined as the difference between the initially planned budget and actual construction costs [30, 31]. The authors that use relative overrun values apply several approaches. The overrun is related to estimated costs, and it is considered that the costs are exceeded if they are by ten percent greater compared to initial estimates. The second approach is to calculate the cost overrun as the percentage ratio of the difference between the actual and estimated costs to estimated costs, and then every percentage that is greater than zero represents a cost overrun. The third group of authors calculates the cost overrun as the ratio of actual cost to estimated cost [31].

Invernizzi et al. [31] graphically show in Diagram 1 that the amount of cost overrun is a relative term as compared to a reference moment in which the estimation is made. If a construction project was estimated to cost £100 after the concept screening phase and £150 after the detailed design phase, but the contract was ultimately awarded after the tendering process at £180 and the final actual cost of the project was £178, are we confident to say that the project is affected by cost overruns? Or: if the project was approved to proceed after the concept screening for £200, the detailed design estimated costs for £230, but the contract was awarded after the tendering process for £180 (at the lowest bid), and the final actual cost was £230, are we confident to say that the project was affected by cost overruns? And, if so, how much was the cost overrun? [31] Table 2 shows more recent literature data as a follow-up on the data presented by Invernizzi et al. This table shows further discrepancy in the presentation of research results.

Based on the data presented by Invernizzi et al. [31] and according to Table 2, it can be concluded that the following

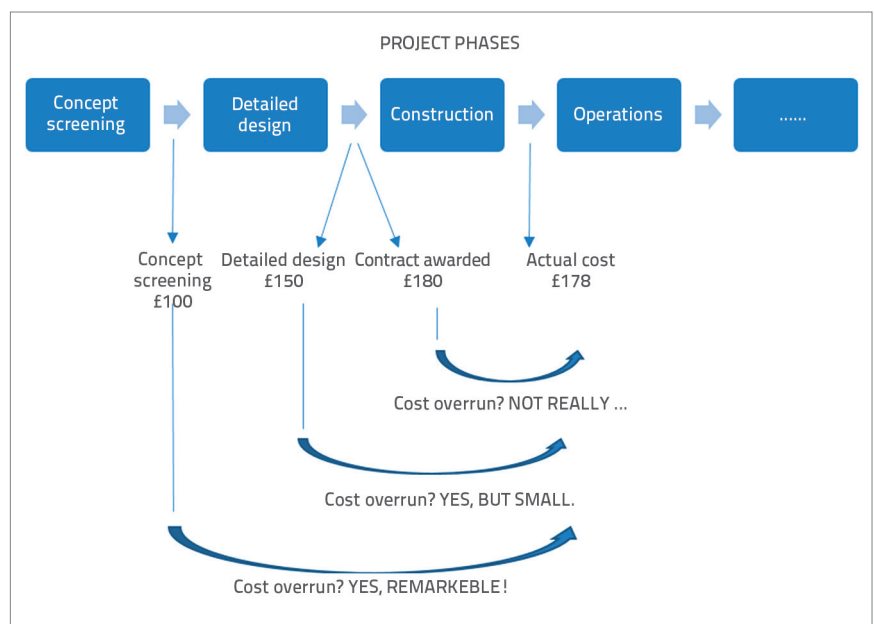


Figure 1. Estimation of cost overrun [31]

Table 2. Overview of cost overrun assessments presented in literature

Literatura	Definition of cost overrun	Absolute or relative?	Actual cost $C_{end}$	Initial cost $C_{initial}$
[37]	Cost overrun is calculated as actual outturn costs minus estimated costs as a percentage of estimated costs	Relative	accounted construction costs determined at the time of project completion	budgeted or forecasted construction costs determined at the time of the formal decision to build
[31]	Cost overrun is the escalation of project cost implying unforeseen over-budget costs due to underestimation of actual cost during budget calculation	Absolute	$C_{end}$ - actual costs	$C_{initial}$ refers to budgeted amounts
[10]	Cost overrun involves unexpected additional costs incurred due to underestimation of the expected budget	Relative	$C_{end}$ - final costs	$C_{initial}$ refers to planned costs
[32]	Cost overrun is the difference between estimated and actual construction costs	Relative	$C_{end}$ - accounted construction costs determined at the time of project completion	$C_{initial}$ - forecasted construction costs determined at the time of the decision to build
[33]	Cost overrun refers to unexpected costs that exceed budgeted costs	Relative	$C_{end}$ - accounted construction costs determined at the time of project completion	$C_{initial}$ - budgeted costs
[34]	Cost overrun refers to monetary deviation of price agreed with contractor during contract award from the final account (i.e., from the final price of the contract)	Relative	$C_{end}$ - final account costs	$C_{initial}$ - contract price
[35]	Cost overrun is defined as the difference between actual costs and the costs estimated at the time of contract award	Absolute	$C_{end}$ - actual project costs at the time of practical completion of the project	$C_{initial}$ - project costs estimated during contract award

terms are used for final costs: actual costs, costs determined at the time of project completion, costs at the end and during the development of the project, costs at the point at which the project entered operation, and costs at the moment of project completion. It is obvious that definitions of the end point of the interval defining overrun vary greatly, but the positive moment is that these costs can, as a rule, be identified quite easily. There is always a document or some kind of final account by which project participants wish to conclude their contract relations by summing up the costs. That is why the final cost definition is generally comparable between projects. However, project participants show a particular interest in the initial estimation of costs. Lovrenčić Butković [32] states that the initial cost estimation is the third most important factor among factors that are critical for the success of international construction projects. The definition of what exactly are the initial costs constitutes the main difference in the determination of cost overruns. It can be observed that initial reference costs can be defined as:

- budgeted amounts
- values as close as possible to "the first formal activity", i.e., "acquisition of any land right required for the project"
- estimated budget,
- estimate made at the full-funds authorization

- budgeted or forecasted construction costs determined at the time of the decision to build.

The reference year for "cost estimation" is therefore fundamental to understand if the project is over budget [33].

## 5. Discrepancies in cost overrun calculations presented in studies

In one of the most comprehensive and most-cited studies [28] in the field of mega-project management [1], Flyvbjerg et al. [12] indicate that cost overruns with respect to initial estimates, amounting to 28 % on an average, were registered on 86 % of projects (or in simple terms on 9 out of 10 projects). This study is characterized by a great number and variety of project types, by a long time period of analysis, and by an extensive geographic extent of the study. This makes it significant for the analysis of cost overrun frequency and reasons, but at the same time we have to bear in mind that this study does not identify all particularities that result in overrun. The study points to the link between the extent of overrun on the one hand, and the geographic area and project category on the other. The overrun has proven to be the greatest in railway projects, with the cost overrun amounting to 44.7 %, which

Table 3. Review of literature on cost overrun studies [11]

Study No.	Year of publication	Author(s)	Country in which study was conducted	Continent	Number of projects (roads)	Average overrun [%]
1	2009	RGL Foresenics, Frontier Economics, Faber Maunsell and Aecom	Some EU countries	Europa	21	9,4
2	2011	Lundberg et al.	Sweden	Europe	102	11,1
3	1997	Skamris and Flyvbjerg	Denmark	Europe	7	14
4	2004	Odeck	Norway	Europe	620	8
5	2006	Qing WU	Canada	North America	50	82
6	1973	Merewitz	USA	North America	49	26
7	2004	Bordat et al.	USA	North America	2668	5
8	2007	Ellis et al.	USA	North America	3130	9
9	2008	Lee	South Korea	Asia	138	11
10	2003	Flyvbjerg et al.	World	World	167	20
11	2012	Cantarelli et al.	Netherlands	Europe	37	18,6
12	2009	Kaliba et al.	Zambia	Africa	8	69
13	2010	Singh	India	Asia	157	15,84
14	1994	Riksrevisionsverket	Sweden	Europe	8	86
15	2004	INDOT	USA	North America	2668	4,5
16	1995	Odeck and Skjeseth	Norway	Europe	12	5
17	2007	UK National Audit Office National roads	England	Europe	36	6
18	2007	UK National Audit Office Local authorities	England	Europe	20	18
19	2007	Flyvbjerg		World	44	44,9
20	2008	Nicanor and Chalermpong	Filipini	Asia	85	5,4
21	2011	Makovšek et al.	Slovenia	Europe	36	19

is followed by bridge and tunnelling projects with 33.8 %, and by road projects with 20.4 %. An average cost increase for Europe in the category of "Roads" is 22.4 % which is much more compared to 8.4 % for the same category in North America. At the same time, for the same geographic area, the overrun is lower compared to the category "Railways". A very significant difference was noted for the category "Other geographic areas" (ten developing countries and Japan) where the overrun amounts to 64 %. Cantarelli et al. [30] confirm this fact while pointing out that the results of this study do not necessarily relate to individual countries [34]. They came to the conclusion that in the Netherlands as many as 55 % of projects result in cost overruns, with an average overrun amounting to 41.3 %. For construction costs of Vietnam motorway network, Vu et al. [16] indicate that these are by 1.5 to 2 times greater than those of the surrounding countries. As to Palestine, Al Hazim et al. [7] indicate that cost overruns occur on approximately 76 % of the projects, with an average overrun amounting to 15 percent. In Jordan [7], the difference between the estimated and final costs ranges from 101 % to 600 %, with an average of 214 %. Narayanan

et al. [17] analyse cost overruns on 15 road infrastructure projects in India and conclude that the overrun ranges from 0.4 to 249 % on these projects. Love et al. [18] analyse the difference between the allowed budget, bidder estimates, contract price, and final accounts for transport projects in Hong Kong. They reject the claim that 9 out of 10 transport projects are realised with cost overrun, and reveal that this percentage is 47 % (i.e., approximately 5 out of 10 projects). Odeck [11] investigates the influence of organisational framework on cost overrun, i.e., he presents the results showing the influence of management framework reforms in Norway on the reduction of cost overruns. Consequently, the review of literature shows that cost overruns are linked with several characteristics. The review also shows that there are great disparities in overrun values, even within the same category of structures. Table 3. shows cost overruns on road projects [11].

An average overrun percentage for the presented road studies is positive, and great variations can be noted in the magnitude of overrun. For instance, Flyvbjerg et al. [12] talk about an average cost overrun of 20 %, while Odeck [35] reports a more modest



average cost overrun of 8.0 %. It can be concluded that instances of cost overrun are dominant in road projects, and that the overrun magnitude depends on the costs the authors select as reference costs. An additional criterion for comparing overrun values, but also for estimating the level of success in project management, is the phase of the project selected for preparation of the budget. After having studied Swedish projects, Brunes and Lind [33] conclude that most cost overruns occur in the planning phases, i.e., until the final design phase, and that such overruns are linked to changes in the design and to an increase in the quantity of input data needed due to technical and administrative problems. Underestimation of costs at the initial phase (front-end phase) can be significant, and can have dramatic implications on the relevance of the selection, and on the long-term usefulness of the project, and it is probably a much greater problem compared to cost overrun at the realisation phase. This is the phase in which the project exists only as a concept, i.e., the phase before the project becomes operational. It encompasses all activities from the moment the first idea is conceived and until the final decision about project implementation (project financing) is made. The projects that survive this early phase are much more likely to obtain financing but, if their survival is based on false premises, with an unrealistically low price - which is a very tangible factor in this respect, this will certainly corrupt the decision-making process [36]. However, an unambiguous approach does not exist even in the selection of reference point for determining the overrun. Proposals range from the phase of detailed design and planning [35], to the notion of "the formal decision to build" [25], and, finally, to the moment when calculations are made during procurement (contract award) before the start of construction work [28].

## 6. Practical examples from the Republic of Croatia

Poor estimates, and the resulting cost overruns, also contribute to negative perception of infrastructure investments in the Republic of Croatia. It is oftentimes not easy to identify whether the source of overrun is a technical reason or whether technical deficiencies were imposed through external influences, while psychological reasons are the actual source of overrun. When trying to identify the causes of time delays and cost overruns, it is very difficult to determine at exactly which point in the chain of events preceding the time delay or cost overrun did the cause of such events occur. Leaning on the study made by Bhargava et al. [15], Adam et al. [13] report that causes that determine cost overruns and time delays often intersect. For instance, it can be claimed that the change is a subset of inadequate planning, and that the delusion is an indicator of poor employment policies. In other words, changes in the project that are caused by cost overrun can be the consequence of poor technical documentation. However, poor technical documentation can be the consequence of initiation of an unprepared project, which is the result of the fallacy or delusion, and the issue could be avoided if the poor decision is not made by decision makers. The contract price for the realisation of the Ravča – Ploče section of the Split – Dubrovnik motorway in Croatia was increased by as much as HRK 450 million [37]. It is a significant cost overrun

that can cause considerable disturbances from the standpoint of planning. On the other hand, if an appropriate value of the project is obtained from such increase in cost, it can be stated that the increase in contract price is justified. However, this can in no way justify the cost overrun as it is the generator of numerous negative effects. This example confirms that an estimation at an early stage of the project can result in significant cost overruns. The problem is additionally aggravated by the fact that contract negotiations were initiated based only on such poor estimate, which solely relied on an incomplete and undeveloped design documentation (conceptual design). Whether or not the decision to proceed with contract award was the consequence of delusion or fallacy [8], it did subsequently affect decisions of stakeholders that did not take part in the contract award process. The incomplete design documentation resulted in significant change in the scope of the basic contract involving the change of the entire route and the corresponding increase of contract price. In fact, it was highly significant to link the motorway network with the port of Ploča (being a significant transport hub), and with the international Vc corridor at the border with Bosnia and Herzegovina. The analysis revealed that the economic influence of the new route on the area it traverses is more significant, that the maintenance of the constructed motorway will be much less costly, and that the construction per unit of length will be lower. At that stage, the decision makers found themselves faced with a very complex decision. On the one hand, there was the threat of interruption of the project and that of financial costs of compensating the contractor due to breach of contract while, on other hand, the issue was the irregularity of changing the scope of the contract. The efficiency of the project was increased by signing an annex to the contract, but this nevertheless resulted several years later in criminal charges and negative perception of the project. It is therefore disputable whether the decision to sign an annex to the contract was in fact the right one. Nevertheless, it is indisputable that the decision to enter into contract based on conceptual design is quite wrong from the aspect of project management. The insufficiently mature project was brought to the point of no return after signature of the contract, and so various improvements had to be made during the progress of the project. The question of whether such a decision can be justified by political or economic aspects calling for urgent establishment of the motorway network will be left for some other analyses. What is important is to make a distinction between the causes and explanations. The causes consist of individual factors that bring about some effects (cost overruns and/or time delays), while explanations attempt to offer a wider and more general description of the events that resulted in overruns. An explanation could therefore consist of several causes. Two projects can have the same primary cause that determines the cost overrun or time delay, but they still have different explanations. Every explanation is unique and path dependent to the project being studied and can therefore not be directly transferable to a different project [13]. In addition to poor preparation of the project, cost overruns can also be due to changes during construction that can not be avoided in large-scale construction projects. At the Drava Bridge Project on the Beli Manastir – Osijek – Svilaj Motorway, these overruns

could be accepted if mutually agreed in the scope of negotiation procedure specified in the contract. The consortium of companies that carried out the works required payment of additional HRK 202 million as condition for continuation of works. It was finally agreed that HRK 94 million will be paid and an annex to the contract was signed for completion of the bridge [38].

On the other hand, in the case solutions to possible problems are not clearly defined, differences between contracting parties can result in long-lasting court proceedings, and can put the projects under negative public scrutiny. Additional costs claimed during construction of the Dugopolje – Šestanovac motorway sector were finally resolved - after a series of disputes, upheavals and court proceedings - through contract-based arbitration proceedings. In effect, a loosely defined surface excavation was at the origin of the dispute involving recognition of the cost item for preparation of terrain in karst area (colloquial term is "exposed karst"), which was finally resolved after a number of years through arbitration proceedings [39]. The arbitral panel determined that the need for additional work can normally occur during realisation of the rights and obligations in the scope of capital construction projects, and motorways certainly belong to such category of projects. The works under dispute were carried out under conditions that are harsher compared to conditions specified in the design documentation. At the same time, these works were indispensable for fulfilment of contractual obligations, and the invalidity can not be claimed as in this case the defendant would need to return what he received through realisation of the contract. As this is not possible due nature of services rendered (completed works), he would have to provide a monetary compensation according to prices applicable at the time the court decision was made (exceeding the price of additional works). Thus, it can generally be concluded that cost overruns are almost unavoidable on large infrastructure projects. These are technically complex undertakings, with intricate relationships between participants, and so additional works and disputes can hardly be avoided. The resolution of these disputes is in the public limelight, and public disapprovals are quite frequent, which then becomes a persistent source of negative perceptions.

## 7. Conclusion

The perseverance and pervasive nature of cost overruns on infrastructure projects leads to the conclusion that reasons for overrun should not be attributed only to the intention or negligence, but also to objective complexity of the project development and cost

estimation issues. The result of this can be seen in the literature through non-uniform definition of terms and greatly differing presentation of research results. The perception is directly related to external incentives where unclear circumstances open up the space for subjective criticism, as opposed to objective analysis of the efficiency of public projects. Lack of understanding of complex circumstances characterising the development and realisation of infrastructure projects encourages negative public perceptions, which are most frequently based on the fact that cost overruns are a frequent occurrence. Overcoming the problem of discrepancy in the definition of key terms and methods for calculating overruns would enable proper monitoring of the progress in the estimation of costs, as well as the comparison of experience between individual economies. This could enable us to differentiate reasons and magnitude of overruns that are universal from those that are inherent to individual countries. Instead of emphasizing specificities of individual countries, non-uniform presentations of reasons actually hide these specificities, reducing contribution of comparisons, which in turn incites negative perceptions about infrastructure investments.

We invite professional associations dealing with project management to clearly define in their guidelines the terms such as initial costs, final costs, cost overrun, cost structuring and keeping record of construction costs. All project specificities that are emphasized in this paper on the basis of literature overview should be clearly emphasized in the estimates. We expect that an unrelenting emphasis on these requests will over time result in comparable reports on the realisation of projects. This would enable better representativeness of samples, i.e., of research results, more accurate comparison of individual projects, and better understanding of reasons behind cost overruns. It would be unrealistic to expect that these efforts will fully eradicate erroneous and insincere estimations, but they will certainly contribute to the improvement of public perceptions about infrastructure investments. The relaxation of negative perceptions that burden infrastructure investments is the precondition for an objective estimation of costs, i.e., for lower overruns in the realisation of projects. Thus a gap would be reduced between the efforts invested by participants in the realisation of public infrastructure projects and negative criticism of the public, the latter being quite frequent after realisation of such projects. This would enable better preparation of cost estimators and planners, and more comfortable decision making. Finally, such an improved perception would generate a positive public sentiment, which would in turn contribute to general wellbeing and development of the community.

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