Reasons for Contract Changes in Implementing Dutch Transportation Infrastructure Projects: An Empirical Exploration

Verweij, S., Van Meerkerk, I.F. & Korthagen, I.A. (2015). Reasons for Contract Changes in Implementing Dutch Transportation Infrastructure Projects: An Empirical Exploration. *Transport Policy*, 37 (1), 195-202.

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Abstract

An important contributor to cost overruns of infrastructure projects is contract changes after the construction contract has been concluded. Using mainly descriptive statistics and non-parametric tests, real project data were analyzed from forty-five Dutch transportation infrastructure projects with a total construction contract value of over € 8.5 billion. First it was explored if we could find evidence for the presumption that contractors bid low on contracts to recover the loss of bid profit by claiming contract change costs in the project implementation. We conclude that we could not find evidence for the opportunistic behavior of contractors. Second, the different sizes and reasons for the contract changes were explored. We conclude that: scope changes are the most significant reason for contract changes, followed by technical necessities; smaller projects tend to have higher relative contract change costs; and contract changes due to omissions in the contract are more present in smaller projects than in larger projects. The results of the analysis suggest among other things that policymakers and planners should pay more attention to flexible contracting, and to the contract management of smaller projects.

Keywords

Transportation Infrastructure Project; Contract Change; Scope Change; Construction Claims; Contract Omission

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1. Introduction

Research has revealed that the implementation of transportation infrastructure projects worldwide is characterized by cost overruns (Flyvbjerg, Bruzelius & Rothengatter, 2003; Odeck, 2004; Skamris Holm & Flyvbjerg, 1997). The Netherlands are no exception (Cantarelli, 2011; Cantarelli, Flyvbjerg & Buhl, 2012; Cantarelli, Molin, Van Wee & Flyvbjerg, 2012; Cantarelli, Van Wee, Molin & Flyvbjerg, 2012). These studies have inquired into the effect of project type, project size, the length of project implementation and geographical location on cost overruns. It was found that for the Netherlands, amongst other things, cost overrun is most severe for road projects, and more severe for smaller projects than for larger projects (Cantarelli, Van Wee, Molin & Flyvbjerg, 2012). Such findings provide important patterns that can be used in the procurement of future projects: Flyvbjerg (2006; 2007) and Flyvbjerg, Garbuio and Lovallo (2009) stressed how these patterns can be used for reference class forecasting to curb strategic misinterpretation and overoptimistic biases in policymaking and planning for future projects. For example, Cantarelli, Van Wee, Molin & Flyvbjerg (2012) showed that Dutch road projects have an average cost overrun of 18.6%, and this finding can inform transport infrastructure policymakers and planners about the possibility that – and the possible extent to which – their planned project costs may be too low.

An important explanation for cost overruns that is adduced in the literature is contract changes and extensions relative to what was laid down in the contract between the principal and the construction contractor. After the conclusion of construction contracts, i.e. in the implementation phase, contracts often need to be changed or extended so as to respond to changing conditions and uncertainty in the context of the project (cf. Verweij & Gerrits). As Badenfelt puts it: “given that future aspects of work can never be fully predicted or described, [...] contracts [are] [...], irrespective of their complexity and sophistication, [...] by nature incomplete” (2011, p.568). According to Olsson (2006), studies have showed that the changes and extensions are one of the key contributors to cost overruns of projects. Unsurprisingly then, research has been conducted into the sizes and reasons for contract changes (e.g. Alnuaimi, Taha, Al Mohsin & Al-Harthi, 2010; Cox, Morris, Rogerson & Jared, 1999; Hsieh, Lu & Wu, 2004; Ibbs, 1997; Taylor, Uddin, Goodrum, McCoy & Shan, 2012). In a review of literature, Sun and Meng (2009) show that a wide variety of reasons has been identified and that the literature is characterized by a wide variety of taxonomies to characterize these reasons. Some single studies identified as many as 80 different reasons, ranging from external (e.g. environmental, political and economic factors) to organizational (e.g. related to processes and people) and project-internal (e.g. design and planning) causes. Most studies, however, originate from the

United States and the United Kingdom, and studies into contract changes originating from Continental Europe are very few in numbers (Sun & Meng, 2009).

The present paper offers a contribution by conducting an analysis of new empirical data into the size and reasons for contract changes and extensions in the Netherlands, as also suggested by Cantarelli, Van Wee, Molin and Flyvbjerg (2012). Given the sheer breadth of reason classifications in the literature, we make no attempt to conform to any of them. One of the reasons for the wide variety may be that different organizations or projects in different countries use different systems for classifying reasons. Most studies are single-country and based on project documentation and database records (Sun & Meng, 2009), which perhaps explains how these different classifications enter into the literature. In this respect, the present study is no exception. The data we analyze comes from Rijkswaterstaat, which is the major public procurer of transportation infrastructure projects in the Netherlands, and concerns 45 projects with a total construction contract value of more than € 8.5 billion. Rijkswaterstaat uses a four-part classification of reasons for contract changes. We will conform to this classification because changing it will distort the actual meaning of the data and can lead to drawing wrong conclusions. Our analysis is thus empirically-driven, but we believe that the analysis can still provide planners of transportation infrastructure projects with insights as to where additional project costs can be expected (e.g. Motawa, Anumba & El-Hamalawi, 2006).

Contract changes can be problematic for public planners of transportation infrastructure projects as they can result in cost overruns of projects. Ways through which policymakers and planners try to mitigate the size of contract changes include public-private partnerships (PPPs) and innovative ways of transportation infrastructure procurement (e.g. Commissie Private Financiering van Infrastructuur, 2008). The idea of public-private partnerships, for instance, is that by making the private contractor integrally responsible for the design, construction, and/or finance and maintenance of the project, optimizations can be achieved between these elements, resulting in inter alia less expensive contracts for governments. However, it is suggested that despite the PPP and innovative contracting efforts of public procurers, the realized gain at the contract closure between the government and the contractor is often impaired or lost due to contract changes in the implementation of the project. One hypothesized explanation is that contractors try to recover their reduction of the bid profit – they accept this reduction to win the contract – by claiming additional work after the contract award (Mohamed, Khoury & Hafez, 2011), an argument that can be traced back to the 1960’s Banwell Report and before (see Holt, Olomolaiye & Harris, 1995). “Especially in a competitive bidding scheme and public funded projects, it is not unusual for contractors to bid low on a project and hope to recover the loss through negotiations or claims” (Ho & Liu, 2004, p.94). Policymakers and planners of Dutch transportation infrastructure projects sometimes also have this presumption, although they cannot or do not substantiate this with analyses of real data. Using the Rijkswaterstaat data, we explore if we can find evidence for this presumption.

In this paper then, the following two questions are answered: *(1) is there a relation between lower bids by contractors and the size of contract changes and (2) what are the sizes of and reasons for contract changes in transportation infrastructure projects?* The paper is further structured as follows. Section 2 briefly describes the data collection and the project selection. Section 3 provides the data and the operationalization of the data. In Section 4 we first look into the relationship between lower contractor bids and the size of contract changes and extensions. Thereafter, in Section 5 we break the analysis of contract changes down into the different reasons for contract changes, thus addressing the second question. Section 6 comprises the conclusions and the discussion and defines some areas for further research.

2. Data-collection and project selection

Rijkswaterstaat is the executive agency of the Dutch Ministry of Infrastructure and the Environment that is responsible for the main transportation network. Rijkswaterstaat employs around 9,000 people and has an annual turnover of approximately € 5 billion. It manages over 4,500 km of highways, nearly 2,800 viaducts, 23 tunnels and nearly 750 bridges (Rijkswaterstaat, 2012; 2013). It is the procurer of major transportation infrastructure in the Netherlands. Since 2010/2011, Rijkswaterstaat integrated all its data about its projects into a single database. The data that are analyzed in this paper are derived from this database.

Access to and publishing about the data was allowed, in consultation with Rijkswaterstaat and providing the projects are anonymized. Administrators of the project database and Rijkswaterstaat managers and experts were consulted during the research process and results of analyses were discussed with them, so as to increase the practical relevance of the study. Also, this increased the reliability of our analysis as we were able to discuss outliers and missing data. An additional advantage of this cooperation was that by analyzing data that are used by organizations in their management of transportation infrastructure projects, our research contributed to informed-evidence-based management practice, closing the gap between research and practice (Rousseau, 2006). As the project database is not designed to facilitate empirical, comparative research, considerable effort was required to prepare the data for analysis. Specifically, the data that were used in the present analyses were scattered across the database system, the projects contained many contract-ID’s that were created by project managers but not actually used to administer contract changes, and some contracts were allocated to a project but where not actually construction contracts and/or contained no data.

The Rijkswaterstaat project database contained 46 projects for which a construction contract was concluded (i.e. contracts that have been signed) and for which Rijkswaterstaat is the main principal. As said, the conclusion of the construction contract marks the start of the implementation phase of a project. For this research we focus on the construction contract as this is the main contract in a transportation infrastructure project. This is also evident from the data: the total value of the construction contracts of the 46 projects is € 8,567.562 million (93.5%) whilst the total value of the other contracts (such as consultant hiring contracts and advertisement contracts) is € 600.396 million (6.5%); and the average construction contract has a value of € 122.393 million compared to € 0.931 million for the other contracts. After checking the data for extreme cases and outliers, it was decided to exclude one of the 46 projects from the analysis. This case concerns an extreme case, which has a contract value of € 3.899 million and a total value of contract changes of € 19.099 million. This is equivalent to nearly 490% of the contract value, which is well above the average (see Section 3). After checking with Rijkswaterstaat, it was found that this concerns a project in which an emergency situation occurred. Consequently and in contrast to the other 45 projects, a contract was rapidly made and closed with a construction company so as to quickly respond to the situation, in the knowledge that the contract would be extended considerably thereafter. No standard procurement and decision-making process was gone through. Besides the extreme case, one case appeared to be an outlier having a contract value of € 17.279 million and a total value of contract changes of € 20.429 million. This is equivalent to nearly 120% of the contract value. No substantial reason validated the exclusion of this case and statistically the analyses with and without the case led to similar patterns and results; the outlier has therefore been included in the analyses.

3. Methodology

Our analysis is based on quantitative cross-sectional data that were available for the projects. The majority of the 45 projects are road projects (84.44%) or partly road projects (8.88%), and the majority of projects has a Design and Construct (D&C) contract (68.89%). Other project types were bridges and tunnels; other contract types were Design, Build, Finance and Maintain (DBFM), traditional contracts (RAW) and Alliances. DBFM is a form of public-private partnership. It is a long-term concessional contract where the contractor is made integrally responsible for designing, building, partly financing and maintaining the infrastructure (e.g. Grimsey & Lewis, 2004).

The data are measured at January 1st 2014. First, for 36 projects information is available about the value of the contract that Rijkswaterstaat estimated prior to the tender.[1] We refer to this as the 'procurement estimation'. The procurement estimation is an indicator of the bids that Rijkswaterstaat expected the contractors to submit. Second, the initial contract value, as Rijkswaterstaat coins it, is the value of the contract that was eventually concluded between Rijkswaterstaat and the contractor. We refer to this simply as the 'contract value'. We calculated the difference between the procurement estimation and the contract value for the projects, which we use as a proxy for the lower bids by contractors. We refer to this as the 'procurement result'. The 'relative procurement result' for each project is then calculated by dividing the procurement result by the procurement estimation. Third,

[1] Projects for which procurement data were missing (in 6 cases) or inaccurate (as the type of contract changed after the procurement estimation – in 3 cases) could not be included in the analysis.

quantitative data were available about the sizes and reasons for the 'contract changes' in the implementation of the project. The size of contract changes refers to either the number of contract changes or the value of contract changes. To be able to compare the cases for their relative size of contract changes, in the analyses the 'relative contract changes' in terms of value is used. Specifically, per construction contract a list of contract changes was available, including information about the size of each contract change and the reason for each contract change. This list contained all the contract changes that occurred from the moment that the contract was concluded (i.e. the signing of the contract) up to January 1st 2014. Regarding the size of the contract changes it should be noted that a contract change does not necessarily have costs associated with it. Regarding the reasons for the contract changes, Rijkswaterstaat identifies four possible reasons (Minister van Verkeer en Waterstaat, 2005): (1) omissions in the original contract, (2) technically necessary changes, (3) changes in laws and regulations, and (4) scope changes (cf. Sun & Meng, 2009). The definitions of these reasons are provided in Table 1, as well as the definitions of the other variables that are the focus of the analysis. The operationalization is derived from the project database and from internal documents of Rijkswaterstaat. The descriptive statistics of the cross-sectional data are provided in Table 2.

Table 1: the operationalization of the variables

Variables	*Unit*	*Description*
Procurement estimation (PE)	k€	The value of the construction contract(s) of the project expected by Rijkswaterstaat prior to the tender.
Contract value (CV)	k€	The value of the construction contract(s) of the project at contract closure between Rijkswaterstaat and the contractor.
Procurement result (PR)	k€	The difference between the procurement estimation and the construction contract value.
Relative procurement result (RPR)	%	Dividing the procurement result by the procurement estimation.
Contract changes (CC)	N	The number of the contract changes after the closure of the construction contract(s).
	k€	The value of the contract changes after the closure of the construction contract(s).
Relative contract changes (RCC)	%	Dividing the value of contract changes by the contract value.
Omissions (OM)		Omissions are changes that have to be made in/to the contract because the contract appeared incomplete, unclear, or contained incorrect or conflicting contract terms.
	N	The number of the contract changes due to omissions in the contract.
	k€	The value of the contract changes due to omissions in the

		contract.
Technical necessities (TECH)		Technical necessities are changes in the physical and/or technical conditions under which the project is being implemented (e.g. changes in the ground conditions or the availability of materials), requiring additional work so as to finish the project.
	N	The number of the contract changes due to technically necessary changes.
	k€	The value of the contract changes due to technically necessary changes.
Laws and regulations (LAW)		This concerns changes that occur in laws and regulations that require stricter requirements, so that the contract may have to be changed to meet these requirements.
	N	The number of the contract changes due to changes in laws and regulations.
	k€	The value of the contract changes due to changes in laws and regulations.
Scope (SCO)		Here the scope of the contracted work is extended with the purpose to achieve e.g. a faster completion of the project, cost advantages, reducing traffic obstructions and logistic advantages.
	N	The number of the contract changes due to scope changes.
	k€	The value of the contract changes due to scope changes.

Table 2: procurement estimation, contract value and contract changes

	N	*Min.*	*Max.*	*Mean*	*St. Dev.*
Procurement estimation (k€)	36	1,184	867,434	157,890.75	194,954
Contract value (k€)	45	1,184	1,454,948	190,303.62	347,771
Procurement result (k€)	36	-5,100	350,200	46,540.97	78,278
Contract changes (numbers)	45	1	407	62.31	85.36
Omissions	45	0	107	7.13	18.16
Scope	45	0	216	25.49	43.61
Technical necessities	45	0	89	17.16	25.82
Laws and regulations	45	0	25	1.78	4.47
Contract changes (k€)	45	0	225,530	25,452	45,581
Omissions	45	0	36,339	1,416	5,506
Scope	45	0	128,090	14,609	28,302
Technical necessities	45	0	55,293	6,578	12,645
Laws and regulations	45	0	96,233	2,849	14,452

Relative contract changes (%)	45	0	118.20	22.37	24.48
Relative omissions	45	0	63.85	2.66	10.08
Relative scope	45	0	84.05	11.23	17.40
Relative technical necessities	45	0	45.02	7.84	10.94
Relative laws and regulations	45	0	11.93	0.65	2.10

The mean procurement estimation of the projects is k€ 157,891. The total contract value of the 45 projects is € 8,563.663 million (i.e. over € 8.5 billion) with a mean of k€ 190,304. The mean procurement result is k€ 46,541.[2] The total number of contract changes is 2804 (with a mean of 62.31) with a total value of € 1,145.351 million (i.e. over € 1.1 billion) and a mean of k€ 25,452. Table 2 also shows that the mean relative contract change costs is 22.37%. This number shows the mean score of the relative contract change costs for the 45 projects.

Table 2 further provides the descriptive statistics for the different reasons for contract changes. But before analyzing those in Section 5, the next section first addresses the first research question, enquiring into the relationship between the procurement result and the value of the contract changes, so as to see if evidence can be found for the presumption that contractors try to recover their reduction of the bid profit. In Section 5 the analysis of contract changes is broken down into the different reasons for contract changes.

4. Do higher procurement results have more contract changes?

To test whether there is a relation between lower bids by contractors and the size of contract changes, we used the relative procurement result of the projects as defined in Table 1. In Table 3 the statistics for the 36 projects are provided.

Table 3: statistics for the relative procurement result

	N	*Min.*	*Max.*	*Mean*	*St. Dev.*	*Skewness (SE)*	*Kurtosis (SE)*
Relative procurement result	36	-19.51	58.58	23.78	19.72	-0.03 (.39)	-.76 (.77)

The relative procurement result shows a normal distribution. As it concerns a small sample, we used the Shapiro-Wilk test to test for normality, which was found not significant ($p = 0.33$), meaning that the distribution does not significantly differs from a normal distribution. The average relative procurement result is nearly 24%. This means that for the average project the value of the construction contract expected by Rijkswaterstaat prior to the tender is almost a quarter higher than the value of the construction contract after contract closure. Or in other words: the value

[2] The mean contract value for the 36 projects of which procurement estimation data are available is k€ 111,349.80. The mean procurement result of k€ 46,540.97 can be calculated by subtracting the mean contract value of the 36 projects from the mean procurement estimation.

for which projects are contracted is almost a quarter lower than Rijkswaterstaat calculated. Following the assumption in the literature (e.g. Mohamed, Khoury & Hafez, 2011), this could indicate that the contractors bid lower to win the contract, to recover their reduction of the bid profit by claiming additional work after the contract award. To analyze whether there is a relationship between the relative contract changes and the relative procurement result, a Pearson's correlation analysis was conducted.

The resulting Pearson's correlation of 0.07 suggests a very weak positive relationship between the relative contract changes and the relative procurement result. However, this relationship is not significant ($p = 0.69$). This means that we do not find evidence for the assumption of opportunistic contractors. In the next section we go deeper into the sizes and reasons for contract changes.

5. Sizes and reasons of contract changes

Going back to descriptive data in Table 2 it can be seen that the average project has a number of 62.31 contract changes. With a mean of 25.49, scope changes are the dominant reason for contract changes followed by technical necessities (17.16), omissions (7.13) and laws and regulations (1.78). The remaining 10.75 average contract changes per project are contract changes for which no reason was specified in the data. These remaining contract changes, though, have no costs associated with them and are therefore not of primary interests to us. Looking at the reasons for contract changes in terms of their contribution to the relative contract change costs of 22.37%, the same pattern can be observed: scope changes are dominant (11.23), followed by technical necessities (7.84), omissions (2.66) and laws and regulations (0.65).

Alternatively, looking at the values for the four reasons of contract changes, the pattern is somewhat different: laws and regulations involve on average more costs (k€ 2,849) than omissions (k€ 1,416); scope changes (k€ 14,609) and technical necessities (k€ 6,578) are still the most significant. Moreover, dividing the value of the contract changes by the number of contract changes (i.e. looking at the 2804 instances of contract changes instead of the projects), the average laws and regulations contract change involves k€ 1,603 (i.e. 2,849 divided by 1.78), followed by scope (k€ 0,573), technical necessities (k€ 0,383) and omissions (k€ 0,198). Thus, in terms of the average contract change value, laws and regulations are the most expensive. This suggests that laws and regulations are not the most common of reasons for contract changes and extensions, but if they occur they can be of significant size.

However, this does not take into account that, as indicated by the high standard deviations in Table 2 for laws and regulations and for omissions, the high average k€ value per laws and regulations contract change is caused by a few such contract changes which occurred in projects with a high contract value. It is important therefore to relate the different reasons for contract changes to the sizes of the respective projects. We therefore made groups of projects based on their contract value and based on their relative contract changes. The reasons for the contract changes amongst these groups are compared.

To conduct this analysis, first it was examined if the projects show a normal distribution in terms of the relative contract change costs (i.e. the bottom rows in Table 2). This was not the case: the data were positively skewed (1.90) and the Shapiro-Wilk test was significant on the 1% level. Therefore it was decided to use the Kruskal-Wallis ANOVA test in the following analyses for comparing different groups of projects. This non-parametric test works with ranks. The lowest score in the data – including all groups – is given a rank of 1; the next lowest score is given a rank of 2, and so on. In case of similar scores (this is referred to as ties), average ranks are assigned. The tests are carried out on the ranks rather than the actual data (Conover & Iman, 1981; Field, 2009). The Kruskal-Wallis ANOVA test calculates whether the mean ranks for the groups differ significantly.

We performed analyses for two different groupings of the projects. The first clustering (Clustering-A) is constructed based on the sizes of the projects in terms of their contract values. We follow Cantarelli, Van Wee, Molin & Flyvbjerg (2012) and define the following groups:

1. Small projects: a contract value of < € 50 million (N=21);
2. Medium projects: a contract value of € 50 < 112.5 million (N=8);
3. Large projects: a contract value of € 112.5 < 225 million (N=7);
4. Very large projects: a contract value of > € 225 million (N=9).

The second clustering (Clustering-B) emerged from the data and is constructed based on the relative contract changes of the projects. Based on the Q-Q Plot, four clusters of projects were identified:

1. Low: projects with relative contract change costs of 0-7.47% (N=15);
2. Medium: projects with relative contract change costs of 9.85-22.66% (N=15);
3. High: projects with relative contract change costs of 29.29-40.87% (N=10);
4. Very high: projects with relative contract change costs of 60.34-118.23% (N=5).

These two groupings allow us to take into account the size of the projects (both in terms of the contract values and in terms of the total contract changes) when looking at the different reasons for the contract changes. These different categorical groups might result in relations that are not linear; relations for the substantially different groups can more specifically be analyzed. The differences between the four groups in both Clustering-A and -B are significant according to the Kruskal-Wallis ANOVA test (0.00), which strengthens the case for the clustering. The statistics for Clustering-A are provided in Table 4 and the statistics for Clustering-B are provided in Table 5.

Table 4: statistics for the relative contract change costs (Clustering-A)

Group	*N*	*Mean RCC*	*St. Dev.*	*Std. Error*	*Min.*	*Max.*
Group 1: small projects	21	26.04	29.43	6.42	0.00	118.23
Group 2: medium projects	8	22.77	19.67	6.96	0.96	60.34
Group 3: large projects	7	21.95	24.32	9.19	0.87	70.20
Group 4: very large projects	9	13.78	15.16	5.05	0.00	40.87
Total	45	22.37	24.48	3.65	0.00	118.23

Table 5: statistics for the contract value (Clustering-B)

Group	*N*	*Mean CV*	*St. Dev.*	*St. Error*	*Min.*	*Max.*
Group 1: low RCC costs	15	274,366.87	482,479.64	124,575.71	3,270.00	1,454,948.00
Group 2: medium RCC costs	15	187,788.80	325,459.71	84,033.33	5,112.00	1,310,789.00
Group 3: high RCC costs	10	136,322.00	194,438.68	61,486.91	2,375.00	644,481.00
Group 4: very high RCC costs	5	53,621.60	51,749.72	23,143.18	1,184.00	122,215.00
Total	45	190,303.00	347,770.91	51,842.63	1,184.00	1,454,948.00

Recall from Table 2 that the average project has k€ 25,452 contract change costs which amounts to 13.37% of the average contract value. However the relative percentage of contract change costs for the projects is substantially higher: 22.37%. This difference seems to support the findings of Cantarelli, Van Wee, Molin & Flyvbjerg (2012) who found that cost overruns in Dutch projects tend to be more severe for smaller projects than for larger projects. However, this relationship was not significant. We further examined this relationship between contract value and contract change costs.

Looking at Table 4 it appears that smaller projects (Groups 1 to 3) indeed have higher contract change costs (with means from 22 to 26%) than larger projects (Group 4 with a mean of 13.78%). According to the Kruskal-Wallis ANOVA the differences between the four groups are not significant (0.76). Interestingly, the groups in Table 5 seem to show a similar pattern: the mean contract value of Group 4 is € 53.6 million, followed by Group 3 (€ 136.3 million), Group 2 (€ 187.8 million) and Group 1 (€ 274.4 million). This indicates that smaller projects indeed have higher contract change costs. However, the differences between these four groups are also not significant according to the Kruskal-Wallis ANOVA test (0.66) (cf. Cantarelli, Van Wee, Molin & Flyvbjerg, 2012).

In addition to Clustering-A and -B, we also looked whether there are differences between different contract types, in particular between DBFM which is considered the favorable public-private partnership option by policymakers in the Netherlands (Commissie Private Financiering van Infrastructuur, 2008), and the other contract types. A glance at the five DBFM projects in our dataset shows an average contract change costs as a percentage of the contract value of 2.4% for the DBFM projects, which is considerably less than the 22.37% for the total of 45 projects. However, we argue that no bold conclusions can be made based on these figures. The projects are still being implemented and the final numbers are far from being known: DBFM contracts typically last for about 20-30 years.[3] We now turn to the sizes and reasons for contract changes and extensions.

[3] Of the 45 projects, 32 projects have been delivered, i.e. a completeness of 100%. For 2 projects, the project delivery dates were not available. The other 11 projects had an average completeness level (i.e.

Tables 6 and 7 below show the mean share of the different reasons of contract changes for the four groups. For example, looking at Table 7 for Clustering-B, in Group 2 about 46.48% of the relative contract changes are caused by scope changes, whereas technical necessities take up 45.43%, laws and regulations 5.20% and omissions 2.88%. Overall, scope changes take up the biggest share of the relative contract changes (i.e. 43.45%), closely followed by technical necessities (40.78%). Omissions and laws and regulations only take up a small part of the relative contract changes (8.52% and 2.81% respectively). The data in the Tables 6 and 7 are depicted in Figures 1 and 2, respectively.

Table 6: distribution of the different reasons for contract changes (Clustering-A)

Groups	*N*	*LAW*	*SCO*	*TECH*	*OM*
Group 1: small projects	21	1.55	27.31	56.12	10.25
Group 2: medium projects	8	1.07	67.68	20.22	11.04
Group 3: large projects	7	2.29	38.89	50.96	7.85
Group 4: very large projects	9	7.70	63.13	15.32	2.74
Total	45	2.81	43.45	40.78	8.52

Table 7: distribution of the different reasons for contract changes (Clustering-B)

Groups	*N*	*LAW*	*SCO*	*TECH*	*OM*
Group 1: low RCC costs	15	.00	34.44	41.56	10.66
Group 2: medium RCC costs	15	5.20	46.48	45.43	2.88
Group 3: high RCC costs	10	4.84	52.21	38.52	4.43
Group 4: very high RCC costs	5	.01	43.89	28.96	27.14
Total	45	2.81	43.45	40.78	8.52

dividing the number of months from contract closure up to January 1st 2014 by the planned delivery dates) of 61%. We tested whether the level of completeness is significantly different for the four groups of both clusters (using Kruskal-Wallis). This was not the case.

Figure 1: distribution of the different reasons for contract changes (Clustering-A)

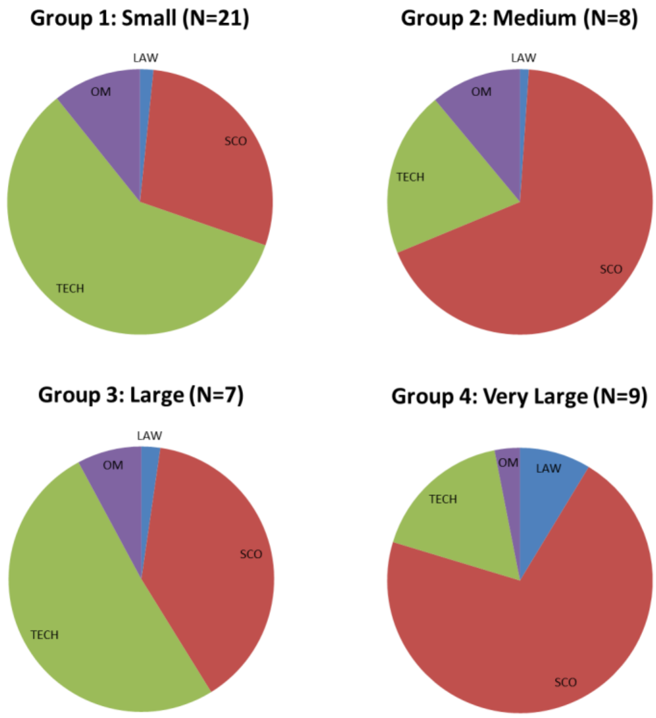
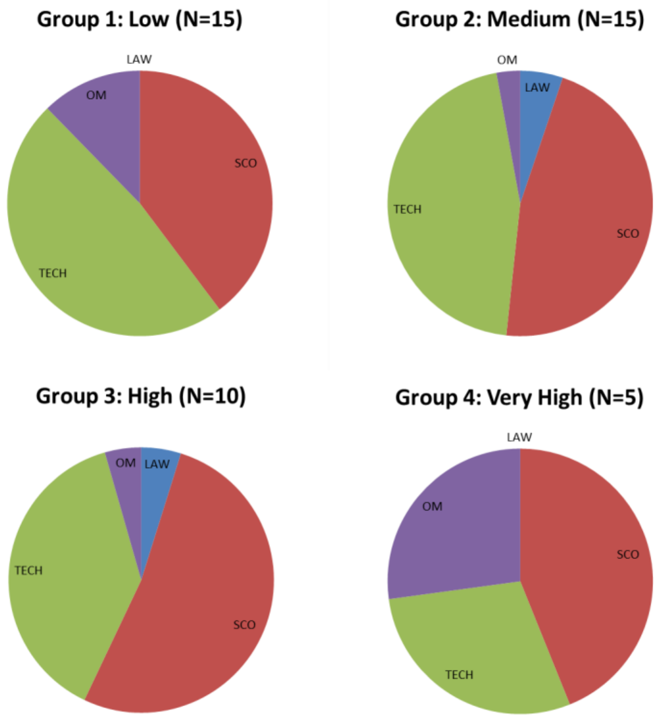


Figure 2: distribution of the different reasons for contract changes (Clustering-B)



It was tested whether there are significant differences between the groups with regard to the reasons for contract changes. For Clustering-A, the Kruskal-Wallis ANOVA test returned two significant relationships. The groups are different with regard to technical necessities ($p < 0.05$) and with regard to scope ($p < 0.05$).

Looking at Figure 1, it cannot be said that contract change costs due to technical necessities and scope changes increase with project size, because the similar patterns of Groups 1 and 3 differ from the similar patterns of Groups 2 and 4. Looking at the diagrams in Figure 1, it does seems that contract changes due to omissions play a bigger role in smaller projects than in larger projects. That is, the very large projects (Group 4) have fewer omissions than the other three groups but this relationship appeared to be not significant. For Clustering-B, the test returned one significant relationship: the groups are different with regard to laws and regulations ($p < 0.05$). Again, looking at Figure 2, the similar patterns of Groups 1 and 4 differ from the similar patterns of Groups 2 and 3 with regard to changes due to laws and regulations. Thus, although some significant relations were found, they are not linear.

6. Conclusions and discussion

In this article, the aim was to empirically explore if we could find evidence in the data for a relationship between lower bids by contractors and the size of contract changes, and to explore the size and reasons for contract changes as there are few Continental European empirical studies on this matter. Before presenting the conclusions, we first mention the limitations of the study. First, there is the relative small sample size, which partly explains the relatively low number of significant relationships and the rather descriptive nature of the study. It is hard to get big datasets in this field of research, and we encourage future research to make the effort. The cooperation with Rijkswaterstaat in building this dataset has at least provided a dataset. In such databases with a small amount of unique cases, standard deviations can be quite high. Therefore, the standard deviations were reported throughout the empirical sections, and the analyses, when possible, were based on relative values such as the relative contract changes and relative procurement results. Second, the fact is that several projects in the dataset are still being implemented. This means that for some projects probably more contract change costs could be incurred in the future, especially in the case of long-term contracts such as DBFM that typically last for several decades. An area for future research, requiring additional data collection, is to analyze a larger set of concluded transportation infrastructure projects so as to test if there is a relationship between the procurement result and the value of contract changes in the project implementation. However, we believe that, within the constraints of this research, we can draw some meaningful conclusions.

In the introduction we set out to answer two questions. The first one is as follows: is there a relationship between lower bids by contractors and the size of contract changes? Based on the analysis of the relationship between the procurement result (i.e. the difference between the procurement estimate and the contract value) and the value of the contract changes, we conclude that there is no evidence for the presumption that contractors try to recover the reduction of the bid profit by claiming contract changes in the implementation of the project. This also raises the question as to whether the assumption is correct in the first place that it is the behavior of contractors that causes the differences between the contract value and the procurement estimation. An area for future research is the qualitative investigation as to how and why certain procurement estimates are arrived at, not only by contractors, but also by principals. One factor that could further influence the creation of certain procurement estimates is, for instance, innovations in transportation infrastructure procurement and contracting. Because of data limitations we have not been able to study this relationship, but we suggest that it is an interesting avenue for future research, especially because policymakers and planners of infrastructure expect these innovations to lower project costs.

The second question was: what are the sizes of and reasons for contract changes in transportation infrastructure projects? Having distinguished between four types of reasons – i.e. omissions, scope changes, technical necessities, and laws and regulations – and having analyzed the total of 2804 contract changes in the 45 projects, three conclusions are drawn. First, both in terms of the number of contract changes and their value, scope changes are the most significant reason of contract changes in transportation infrastructure projects, closely followed by technical necessities; laws and regulations are the least significant reason of contract changes. However, if present, they can entail large costs. Second, it was also found that projects with a relative high value of contract changes tend to be the smaller projects. Third, in the smaller projects, omissions take a bigger share as compared to the larger projects.

The results indicate first and foremost the important contribution of scope changes (and technical necessities) in the contract change costs of infrastructure projects. Infrastructure projects are inherently complex, which means that contracts cannot foresee all eventualities in implementation (Verweij & Gerrits, 2014; Badenfelt, 2011). This finding draws our attention to the importance of devising more flexible contractual arrangements between contractors and principals. Indeed, scope changes and technical necessities (and also laws and regulations) are reasons for contract changes that are at least partly outside the sphere of influence of projects. Flexible contracts which have explicitly incorporated in them the possibilities that e.g. project implementation plans can be changed (scope changes) or that the conditions under which projects are implemented change (technical necessities) may be well capable of dealing with these uncertainties (e.g. Cruz & Marques, 2013). DBFM contracts are considered an attractive option by policymakers and planners of infrastructure projects (e.g. Commissie Private Financiering van Infrastructuur, 2008) and the data seem to indicate that DBFM contracts have indeed lower contract change costs. Although these projects are still being implemented and the final numbers are not yet known because the DBFM contracts typically last for about 20-30 years, the figures suggest that DBFM contracts may be better able to deal with changing project conditions, resulting in fewer contract changes. Tempered enthusiasm is appropriate here, however (Reynaers & Verweij, 2014): only few DBFM transportation infrastructure projects are being (and have been) implemented in the Netherlands thus far, and more research has to be conducted into them.

The implication of the second conclusion is that, although the attention of policymakers and planners of infrastructure projects tends to go to the large, mediagenic (either in a good or a bad way) projects, more contract change costs (as percentages of the contract value) might be expected from the smaller projects (cf. Cantarelli, Van Wee, Molin & Flyvbjerg, 2012). In these smaller projects, and this is implied from the third conclusion, especially omissions in the contracts seem to contribute to the contract change costs. This pattern could be indicative of public procurers putting less means and expertise in the drafting of high-quality, omissions-free contracts in smaller projects than in larger projects. This was confirmed by experts within Rijkswaterstaat. The less experienced managers are often assigned to smaller projects as these are less complex and less risky, which provides these managers with an easier environment to develop more skills and experience. Although this is understandable, perhaps smaller projects are entitled to a bit more attention from their principals.

Acknowledgments

We are indebted to Rijkswaterstaat for providing the project data and the research facilities, and for being available for consultation during the research process. In particular, we thank Mieke Hoezen and Freek Wermer for their constructive feedback and their guidance in the research process. The contents of this paper do not necessarily represent the view of Rijkswaterstaat, and are thus the researchers' responsibility.

References

Alnuaimi, A.S., Taha, R.A., Al Mohsin, M. & Al-Harthi, A.S. (2010) 'Causes, effects, benefits, and remedies of change orders on public construction projects in Oman', *Journal of Construction Engineering and Management, 136*(5), pp. 615-622.

Badenfelt, U. (2011) 'Fixing the contract after the contract is fixed: A study of incomplete contracts in IT and construction projects', *International Journal of Project Management, 29*(5), pp. 568-576.

Cantarelli, C.C. (2011) *Cost overruns in large-scale transport infrastructure projects: A theoretical and empirical exploration for the Netherlands and worldwide*, Delft, Trail Research School.

Cantarelli, C.C., Flyvbjerg, B. & Buhl, S.L. (2012) 'Geographical variation in project cost performance: The Netherlands versus worldwide', *Journal of Transport Geography, 24*, pp. 324-331.

Cantarelli, C.C., Molin, E.J.E., Van Wee, B. & Flyvbjerg, B. (2012) 'Characteristics of cost overruns for Dutch transport infrastructure projects and the importance of the decision to build and project phases', *Transport Policy, 22*, pp. 49-56.

Cantarelli, C.C., Van Wee, B., Molin, E.J.E. & Flyvbjerg, B. (2012) 'Different cost performance: Different determinants? The case of cost overruns in Dutch transport infrastructure projects', *Transport Policy, 22*, pp. 88-95.

Commissie Private Financiering van Infrastructuur. (2008) *Op de goede weg en het juiste spoor: Advies van de commissie private financiering van infrastructuur,* Den Haag, Commissie Private Financiering van Infrastructuur.

Conover, W.J. & Iman, R.L. (1981) 'Rank transformations as a bridge between parametric and nonparametric statistics', *The American Statistician, 35*(3), pp. 124-129.

Cox, I.D., Morris, J.P., Rogerson, J.H. & Jared, G.E. (1999) 'A quantitative study of post contract award design changes in construction', *Construction Management and Economics, 17*(4), pp. 427-439.

Cruz, C.O. & Marques, R.C. (2013) 'Flexible contracts to cope with uncertainty in public-private partnerships', *International Journal of Project Management, 31*(3), pp. 473-483.

Field, A. (2009) *Discovering statistics using SPSS,* London, Sage.

Flyvbjerg, B. (2006) 'From Nobel prize to project management: Getting risks right', *Project Management Journal, 37*(3), pp. 5-15.

Flyvbjerg, B. (2007) 'Policy and planning for large-infrastructure projects: Problems, causes and cures', *Environment and Planning B: Planning and Design, 34*(4), pp. 578-597.

Flyvbjerg, B., Bruzelius, N. & Rothengatter, W. (2003) *Megaprojects and risk: An anatomy of ambition*, Cambridge, Cambridge University Press.

Flyvbjerg, B., Garbuio, M. & Lovallo, D. (2009) 'Delusion and deception in large infrastructure projects: Two models for explaining and preventing executive disaster', *California Management Review, 51*(2), pp. 170-193.

Grimsey, D. & Lewis, M.K. (2004) *Public private partnerships: The worldwide revolution in infrastructure provision and project finance*, Cheltenham, Edward Elgar.

Ho, P.S. & Liu, L.Y. (2004) 'Analytical model for analyzing construction claims and opportunistic bidding', *Journal of Construction Engineering and Management, 130*(1), pp. 94-104.

Holt, G.D., Olomolaiye P.O. & Harris, F.C. (1995) 'A review of contractor selection practice in the U.K. construction industry', *Building and Environment, 30*(4), pp. 553-561.

Hsieh, T., Lu, S. & Wu, C. (2004) 'Statistical analysis of causes for change orders in metropolitan public works', *International Journal of Project Management, 22*(8), pp. 679-686.

Ibbs, C.W. (1997) 'Quantitative impacts of project change: Size issues', *Journal of Construction Engineering and Management, 123*(3), pp. 308-311.

Minister van Verkeer en Waterstaat. (2005) *Enquête bouwnijverheid.* (Tweede Kamer, 2004-2005, 28 244, no. 109), Den Haag, Sdu Uitgevers.

Mohamed, K.A., Khoury, S.S. & Hafez, S.M. (2011) 'Contractor's decision for bid profit reduction within opportunistic bidding behavior of claims recovery', *International Journal of Project Management, 29*(1), pp. 93-107.

Motawa, I.A., Anumba, C.J. & El-Hamalawi, A. (2006) 'A fuzzy system for evaluating the risk of change in construction projects', *Advances in Engineering Software, 37*(9), pp. 583-591.

Odeck, J. (2004) 'Cost overruns in road construction - what are their sizes and determinants?', *Transport Policy, 11*(1), pp. 43-53.

Olsson, N.O.E. (2006) 'Management of flexibility in projects', *International Journal of Project Management, 24*(1), pp. 66-74.

Reynaers, A. & Verweij, S. (2014) 'Kritisch kijken naar kansen: De schaduwzijden van DBFMO', *ROmagazine, 32*(4), 32-34.

Rijkswaterstaat. (2012) *Rijkswaterstaat: About us*. Retrieved from: http://www.rijkswaterstaat.nl/en/images/Factsheet%20About%20Us_tcm224-340516.pdf.

Rijkswaterstaat. (2013) *Annual review Rijkswaterstaat: 2012*. Retrieved from: http://www.rijkswaterstaat.nl/en/images/tcm_224-344727.aAa.Annual%20Report%20Rijkswaterstaat%202012_tcm224-344727.pdf.

Rousseau, D.M. (2006) 'Is there such a thing as 'evidence-based management'?', *Academy of Management Review, 31*(2), pp. 256-269.

Skamris Holm, M.K. & Flyvbjerg, B. (1997) 'Inaccuracy of traffic forecasts and cost estimates on large transport projects', *Transport Policy, 4*(3), pp. 141-146.

Sun, M. & Meng, X. (2009) 'Taxonomy for change causes and effects in construction projects', *International Journal of Project Management, 27*(6), pp. 560-572.

Taylor, T.R.B., Uddin, M., Goodrum, P.M., McCoy, A. & Shan, Y. (2012) 'Change orders and lessons learned: Knowledge from statistical analyses of engineering change orders on Kentucky highway projects', *Journal of Construction Engineering and Management, 138*(12), pp. 1360-1369.

Verweij, S. & Gerrits, L.M. (2014) 'How satisfaction is achieved in the implementation phase of large transportation infrastructure projects: A qualitative comparative analysis into the A2 tunnel project', *Public Works Management & Policy,* http://dx.doi.org/10.1177/1087724X13518743.