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Do public-private partnerships perform better? A comparative analysis of costs for additional work and reasons for contract changes in Dutch transport infrastructure projects

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ABSTRACT

An important reason to procure transport infrastructure projects through Public-Private Partnerships (PPPs) is that they are expected to have a better cost performance compared to regular infrastructure procurement. However, the evidence for this is weak. Therefore, this article analyzes the cost performance (in terms of costs for additional work caused by contract changes during project implementation) of Design-Build-Finance-Maintain (DBFM) projects versus Design and Construct (D&C) projects. DBFM is considered a type of PPP and D&C is not. Data were collected on 58 projects from the Project Database of Rijkswaterstaat and analyzed using non-parametric tests. The results show that DBFM-projects have a significantly better cost performance than D&C-projects, especially concerning costs for additional work due to technical necessities. Because scope adjustments are the main reason for contract changes across the D&C- and DBFM-projects, cost performance can be improved particularly by curbing scope adjustments costs.

1. Introduction

Over the last decades, Public-Private Partnerships (PPPs or P3s) have become increasingly popular with policymakers (European PPP Expertise Centre, 2015). This is particularly true for the development and management of transport infrastructure such as highways, waterways, and railways. In Europe, for instance, transport infrastructure is invariably the largest sector in the PPP-market in value terms (European PPP Expertise Centre, 2018, 2019). One major reason for procuring transport infrastructure through PPPs is that it is expected that PPP-contracts incentivize the private partner to develop and manage transport infrastructure at lower costs. For instance, the Dutch Ministry of Finance has estimated that Design-Build-Finance-Maintain (DBFM) projects – a contractual type of PPP that is considered the default PPP-option in the Netherlands (Rijksoverheid, 2018) – achieve cost savings in terms of value-for-money between 10 and 15% (Ministerie van Financiën, 2016).

However, the evidence for the costs savings of infrastructure procurement through PPPs, compared to regular infrastructure procurement, is rather weak. In general, research shows that there is a lack of supporting evidence for the increased value-for-money of PPPs (Boers et al., 2013). It is also often easily overlooked or conveniently ignored that the assessments of value-for-money are conducted ex-ante and that the ex-ante estimates do not necessarily materialize (Verweij, 2018). One reason is that, over the course of project implementation, contract changes are made to accommodate events or situations that were not foreseen at the moment the contract was signed. As a result of contract changes, the cost advantage of PPPs over regular infrastructure procurement may potentially even be nullified (cf. Van Elst and Van Montfort, 2018).

In fact, it is even argued that contract changes or extensions are one of the key contributors to cost overrun in infrastructure projects (Olsson, 2006). Research has therefore been conducted into the sizes of and reasons for contract changes (e.g., Alnuaimi et al., 2010; Cox et al., 1999; Hsieh et al., 2004; Ibbs, 1997; Love et al., 2017; Taylor et al., 2012; Verweij et al., 2015). The research on contract changes, though, has mainly focused on the U.K. and the U.S. and studies into contract changes in Continental European projects are relatively scarce (Sun and Meng, 2009). More important, however, is that the studies have not looked into the question whether PPP-projects actually achieve a better cost performance – in terms of less contract change costs after the contract award – than regular infrastructure procurement. The comparison

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between PPPs and regularly procured infrastructure projects, in terms of contract changes and the costs for additional work that stem from them, is lacking.

There is thus a lack of evidence about (1) the *actual cost performance* of PPP-projects compared to regularly procured infrastructure projects – an increase of which is at the core of the motivation for public procurers to enter into PPPs in the first place – and about (2) how *contract changes* relate to cost performance. Therefore, it is important to gain more insight into whether PPP-projects have lower (or higher) and different costs associated with contract changes after the contract was signed, compared to infrastructure projects that are not procured through PPPs. This is the aim of the present article.

In this article, we analyze the contract change data of 58 transport infrastructure projects in the Netherlands that are procured by Rijkswaterstaat, the executive agency of the Dutch Ministry of Infrastructure and Water Management. The analysis focusses on the comparison of projects with a Design-Build-Finance-Maintain (DBFM) contract versus projects with a Design and Construct (D&C) contract. The latter is also known as the Design-Build (DB) contract. D&C-contracts are the standard form of contracting by Rijkswaterstaat since 2008 (Lenferink et al., 2013), and DBFM started to take of in the Netherlands in 2007 (Eversdijk and Korsten, 2015). Although the private contractor is integrally responsible for infrastructure construction and design in both D&C and DBFM (Culp, 2011), DBFM is considered a type of PPP whereas D&C is not (Yescombe, 2007, 2013; e.g., Rijksoverheid, 2018). The reason is that private financing is considered an essential element in PPPs, which is present in DBFM but not in D&C. To address the two deficits of evidence, the two central questions in this article are as follows: ***(1) do DBFM-projects perform better in terms of the costs for additional work caused by contract changes compared to D&C-projects***, and ***(2) do DBFM-projects have different reasons for contract changes than D&C-projects?***

In Section 2, we will discuss the theoretical background of the paper. In Section 3, we will explain the data collection and methods. This is followed by the results of the analysis in Section 4, where we focus on evaluating the cost performance of D&C versus DBFM in terms of costs for additional work caused by contract changes (Section 4.1) and on the differences between D&C and DBFM in terms of the reasons for the contract changes (Section 4.2). Finally, in Section 5, we discuss the results and present the conclusions.

2. Background: DBFM versus D&C

2.1. Cost performance

Several arguments may be identified as to why contractual types of PPP, such as DBFM, would result in better cost performance (cf. Verweij and van Meerker, 2020). First, in addition to the construction of the infrastructure, the responsibility for the infrastructure design and maintenance is also transferred to the private partner. According to the *'economies of scope'* argument (De Bettignies and Ross, 2004), this bundling of tasks (design, build, and maintenance) in a DBFM-contract incentivizes the private partner to invest in good designs that will have lower maintenance costs later on (Martimort and Pouyet, 2008). The improved infrastructure design will then lead to less contract changes and hence less costs for additional work after the contract award. In D&C-contracts, the private contractor is less incentivized to develop improved designs, because he is not responsible for maintenance costs occurring after project completion (Culp, 2011). The argument is that projects with a DBFM-contract will therefore have fewer costs for additional work caused by contract changes, hence have a better cost performance. Because improved designs may ask for new procedures for project construction and maintenance that may require some financial investments by the private partner (Martimort and Pouyet, 2008), DBFM-contracts require a certain size to achieve value-for-money through improved designs. For this reason, and because governments can normally borrow money against lower interest rates (Leruth, 2012), DBFM is only considered in the Netherlands for projects over €60 million (Ministerie van Financiën, 2013).

Second, according to the *'private financing'* argument, because he bears the risks for project design and construction (De Palma et al., 2009), the private partner in DBFM may have to finance the costs caused by additional work due to contract changes occurring in the implementation phase. This increases uncertainty – 'will the financiers provide the loan and at what interest rate?' – and transaction costs – e.g., resources spent on negotiating loans with the banks for the additional work caused by contract changes, and the interest costs for the loans – which may incentivize the private partner to try to limit contract changes (Verweij and van Meerker, 2020). In D&C-contracts, the private financing argument does not apply; instead, the public procurer pays for the additional work caused by contract changes. Contractors may therefore try to put down claims for required additional work with the public procurer, as part of their 'business model' (Mohamed et al., 2011; cf. Verweij et al., 2015). This may increase the costs for additional work caused by contract changes in the project. The business model in DBFM focusses instead on the economies of scope and life-cycle optimization (Lenferink et al., 2013).

Third, according to the *'shadow of the banks'* argument, because they are generally risk-averse (Demirag et al., 2011), equity providers will demand a high quality of risk management from the private construction consortium (Culp, 2011). The equity provider, who finances the activities of the private partner in a DBFM-contract, "provides an additional level of diligence for effective project execution" (Culp, 2011, p. 237). As a result, more emphasis may be placed on risk management (Verweij and van Meerker, 2020). That is, in the tendering phase the private consortium will have to explicate its risk management plan, which allows the public procurer to select a partner with the best risk management skills. In the implementation phase, the consortium will be better able to identify and mitigate risks. Because D&C-contracts do not involve private financing, this effect of the shadow of the banks is absent there. Based on these three arguments, it could be expected that DBFM-projects have a better cost performance in terms of the costs for additional work caused by contract changes, than projects with a D&C-contract. In our analysis in Section 4.1, we will test whether or not there is evidence for this expectation.

2.2. Reasons for contract changes

In their literature review of studies into the causes of contract changes in construction projects, Sun and Meng (2009) identified a wide variety of change reasons and ways to classify them. Verweij et al. (2015) later observed that many of the studies focus on the analysis of projects in a single country, with every country or study using different systems to classify contract changes, which may explain the variety of classifications in the literature. In the Netherlands, Rijkswaterstaat uses a classification with four categories for national transport infrastructure projects: contract omissions, technical necessities, changing laws and regulations, and scope adjustments (Minister van Verkeer and Waterstaat, 2005). They are defined in Table 1.

In their report for the Dutch parliament about 15 years ago, Rijkswaterstaat analyzed construction contracts with a total initial value of approximately €431 million and found that the contract changes amounted to a total of €38.5 million in costs for additional work, which is 8.9% of the sum of the values of the initial contracts (Minister van Verkeer and Waterstaat, 2005). Rijkswaterstaat found that scope adjustments (in Euros) were the main reason for contract changes, followed by technical necessities, contract omissions, and finally changing laws and regulations. A decade later, Verweij et al. (2015) analyzed 45 projects procured by Rijkswaterstaat with a total initial contract value of approximately €8564 million and found that the projects' contract changes amounted to a total of €1145 million in costs for additional work, which is 13.4% of the sum of the values of the initial contracts. In line with the analysis by Rijkswaterstaat, Verweij et al. (2015) also

Table 1
Reasons for contract changes (see Minister van Verkeer and Waterstaat, 2005).

Reasons	Description
Contract Omissions	Changes have to be made in/to the original contract because it appeared incomplete, unclear, or contained incorrect or conflicting contract terms.
Technical Necessities	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 to finish the project.
Changing Laws and Regulations	Changes occur in laws or regulations that ask for stricter design or construction requirements, so that the contract has to be changed to meet these requirements.
Scope Adjustments	The scope of the contract is extended with the purpose of achieving, e.g., a faster completion of the project, cost advantages, reducing traffic obstructions, or logistical advantages.

found that scope adjustments are the main reason for contract changes, followed again by technical necessities. The analyses by Rijkswaterstaat (Minister van Verkeer and Waterstaat, 2005) and Verweij et al. (2015) thus showed similar results. Due to limitations in their datasets – i.e., the number of DBFM-projects was too low – they were, however, unable to analyze the sizes and reasons for contract changes in D&C- and DBFM-contracts comparatively. This is what the present article thus adds to the literature.

Based on literature and informed by discussions we had with Rijkswaterstaat practitioners at the Procurement Centre for Civil Engineering, there are several reasons for why it may be expected that DBFM-contracts have different reasons for contract changes than D&C-contracts (Sections 2.2.1 to 2.2.4). In the analysis in Section 4.2, we will explore whether there is empirical evidence for these expectations.

2.2.1. Contract omissions

It could be argued that costs for additional work due to contract omissions are present in DBFM-contracts more than in D&C-contracts. Both DBFM and D&C became prevalent practice in the Netherlands about a decade ago (Eversdijk and Korsten, 2015; Lenferink et al., 2013). The difference between them, however, is that DBFM is applied only to large and complex projects (Lenferink et al., 2013; Ministerie van Financiën, 2013). As a consequence, D&C-contracts are more widespread in the Netherlands than DBFM-contracts (Verweij et al., 2015). Although standard contracts for DBFM are in place for quite some years now (Janssen et al., 2010; Rijkswaterstaat, 2018), which can increase the quality of contracts and therefore reduce contract omissions (Van den Hurk, 2015), the relatively low number of DBFM-contracts means that Rijkswaterstaat project managers have been exposed to DBFM less so than to D&C. This means that learning experiences with DBFM are more limited than with D&C (Lenferink et al., 2013).

However, Rijkswaterstaat managers expect that DBFM-projects have less costs for additional work caused by contract omissions. They argue that, because the success of PPPs depends largely on whether the procurer has been able to create a fully specified contract (see De Palma et al., 2009), and exactly because DBFM is applied to large and complex projects that are more in the spotlights, more resources are allocated to 'getting the contract right'. This argument is supported by the previous analysis by Verweij et al. (2015). They found that "projects with a relative high value of contract changes tend to be the smaller projects" and that "in the smaller projects, omissions take a bigger share as compared to the larger projects" (2015, p. 201). They reasoned that, in turn, this could mean that "public procurers [put] less means and expertise in the drafting of high-quality, omission-free contracts in smaller projects than in larger projects" (2015, p. 202). Because as said the smaller projects do not have DBFM-contracts (Ministerie van Financiën, 2013), this suggests that contract omissions are less present in DBFM than in D&C. We therefore expect that projects with DBFM-contracts have less costs for additional work due to contract omissions than projects with D&C-contracts.

2.2.2. Technical necessities

Technical necessities are caused by changes in the physical and/or technical conditions under which the project is implemented (Minister van Verkeer and Waterstaat, 2005). Examples could include events such as unexpectedly complex cable and pipeline configurations, extreme weather conditions, old explosives encountered during construction, or weak soil conditions (Verweij, 2015). Such risks concern the design and construction phases of projects. Because risks associated with design and construction are with the private construction consortium in D&C-contracts as well as in DBFM-contracts (Culp, 2011), it can be argued that there will be no real difference between the two contract types regarding the presence of contract changes due to technical necessities. We therefore expect no significant differences regarding technical necessities.

2.2.3. Changing laws and regulations

Changing laws and regulations may result in stricter design or construction requirements that ask for changes to the contract in order to accommodate these requirements (Minister van Verkeer and Waterstaat, 2005). For example, in the Netherlands the National Tunnel Standard, which specifies the safety requirements for tunnels, was recently updated (Scholten et al., 2016). For transport infrastructure projects that included tunnels and which had already entered their implementation phase, this meant that the safety requirements became stricter, possibly causing a need for changes in tunnel design translating into a contract change (see e.g., Verweij and Gerrits, 2015).

Because DBFM-projects include the maintenance of the transport infrastructure, their contracts span much longer time periods than D&C-contracts (Yescombe, 2007). Changing a law or regulation is generally a lengthy process that is not easily completed within the time span of a D&C-contract. DBFM-contracts, in contrast, cover time periods that may in fact be lengthier than the time needed to bring a regulatory change from initiation to implementation. Therefore, it could be argued that DBFM-contracts are more exposed to changing laws and regulations. However, because the analysis in this article focusses on the design and construction phases only (which are about the same length in DBFM and D&C), we expect no significant differences between DBFM and D&C regarding contract changes due to changing laws and regulations.

2.2.4. Scope adjustments

Scope adjustments involve the extension of a contract with the aim to increase the efficiency, effectiveness, or quality of the project (Minister van Verkeer and Waterstaat, 2005). In both D&C and DBFM, the public procurer provides a 'functional specification' of the project scope. This means that he does not impose on the private construction consortium how the requested product or service should look like exactly (i.e., what the solution should be), but that he specifies the needs and functions that he wants to see served by the consortium (De Haan et al., 2017). This is a major difference with the traditional Design-Bid-Build contracts, where the public procurer is responsible for the project design (Culp, 2011). The difference between the D&C and DBFM contract types, however, is that the scope of a DBFM-project is more inclusive than that of a D&C-project (Lenferink et al., 2013). This comes back to the 'economies of scope' argument (see Section 2.1). As a consequence of the more inclusive nature of a DBFM-contract, Rijkswaterstaat managers argue that there is less to 'add to' the contract (i.e., 'less to extend') once it has been signed, compared to D&C. Additionally, because of the private financing in DBFM, it will be less attractive in general – it is costly – for the construction consortium to claim costs for additional work disguised as scope adjustments (see Section 2.1). For these reasons, it could be argued that contract changes due to scope adjustments are present less in DBFM-projects than in D&C-projects.

3. Data and method

3.1. Data collection

The data were collected from the Project Database of Rijkswaterstaat. The database is used by Rijkswaterstaat managers for project accounting and for reporting to the organization's leadership on the progress and outcomes of their projects. This means that it is likely that the data represent the actual cost performance of the projects as accurately as possible, perhaps more so than interviews or surveys where response bias remains an issue, and that the analyses in this article bear direct relevance to the practices of Rijkswaterstaat. Access to the Project Database was allowed, provided that the data and results are anonymized and cannot be traced back to specific persons or projects. Data collection took place between April and July 2018 by the first author of this article.

The database contained a total of 298 highway-related projects. Amongst these were programs containing multiple small projects or activities, innovation projects, and small activities such as the placement of sound barriers or road signage placements (173 projects). These 173 projects were not selected because they do not classify as transport infrastructure projects. Furthermore, projects devoid of sufficient data, projects without a normal procurement and decision-making process (e.g., calamity projects), without a construction contract, or projects with a construction contract other than D&C or DFBM (e.g., Design-Bid-Build), were also not selected (67 projects). This resulted in 58 transport infrastructure projects for which data were available. Nine projects have a DBFM-contract (15.5%) and 49 projects have a D&C-contract (84.5%). All projects involve contracts awarded and signed between 2006 and 2016.

For all the 58 transport infrastructure projects, the data collection and analysis focused on the design and construction phases. This is what we define as the 'implementation phase' in this study. By focusing explicitly on the design and construction phases of the DBFM- and D&C-projects only, we wanted to ensure that the comparison was as fair as possible, as the two contract types differ significantly due to the inclusion of maintenance and finance in DBFM (Culp, 2011). At the moment of data collection (the reference date for all projects was March 1st, 2018), five projects had not fully finished their implementation phases: two DBFM-projects and three D&C-projects. We calculated the completeness of the projects as a percentage of the implementation phase measured in days between the signing of the contract and the official recommissioning of the transport infrastructure. In cases where the construction had finished and the transport infrastructure was recommissioned before March 1st, 2018, the project completeness was 100%. For the five uncompleted projects, the completeness ranged from 26% to 55%, using the *planned* recommissioning date by Rijkswaterstaat (at March 1st, 2018) as the reference date. The average completeness of the nine DBFM-projects was 87% and for the D&C-projects it was 96%. We conducted a Pearson correlation analysis to check whether project completeness showed a relationship with cost performance, which was not the case (non-significant value of .16). Therefore, we included the five incomplete projects in the study.

3.2. Data measurement

The analysis focusses on seven variables: (1) cost performance, (2–5) costs for additional work due to contract omissions, technical necessities, changing laws and regulations, and scope adjustments, (6) contract type, and (7) project size.

For the first research question, *cost performance* is measured as the sum of the costs for additional work caused by contract changes that occurred in the project after the contract was signed (i.e., in the implementation phase of the project), as a percentage of the initial value of the project's design and construction contracts. Projects may involve multiple contracts, but the main contract is either D&C or DBFM. To illustrate, one project had a total of two design and construction contracts: one of approximately k€19500 and one of approximately k€94500. The initial contract value of the project is thus approximately k€114000. The total sum of costs for additional work caused by contract changes, for the two contracts together, was almost k€13500, which translates into a cost performance of almost 12%. Higher percentages indicate lower performance.

For the second research question, we are interested in the different distributions of the costs for additional work of projects over the four *reasons for contract changes*. Therefore, we measured the costs for additional work per reason as the percentage of the total sum of the costs for additional work caused by contract changes in a project. This takes into account that projects have different sizes. In the above-mentioned D&C-project, *contract omissions* accounted for almost k€500, *technical necessities* for about k€1700, there were no contract changes due to *changing laws and regulations*, and *scope adjustments* accounted for almost k€11300. This translates into 3.7%, 12.6%, 0%, and 83.7% respectively, of the relative share in additional work costs for the different reasons of contract changes. Hence, the four reasons together add up to 100% of the costs for additional work. In this way, we could compare whether the different reasons have a different weight in the costs for additional work for the two types of contracts.

The *contract type* is a nominal variable: D&C or DBFM. The analyses in this article focus on the differences between D&C- and DBFM-projects regarding: their cost performance (variable 1) and the distribution of the costs for additional work over the four reasons of contract changes (variables 2–5).

Because DBFM-contracts, as explained in Section 2.1, are considered only for projects with larger sizes (Ministerie van Financiën, 2013), we also included *project size* as a variable. It is measured as the initial contract value of the project, i.e., the sum of the initial value of the project's design and construction contracts at the moment the contract was signed (e.g., k€114000 for the project we used as an example here). The 49 projects with a D&C-contract have an average project size of k€75900 with a standard deviation of k€92263. The size of the D&C-projects ranges from k€2375 to k€416132. The nine DBFM-projects have an average size of k€631428 with a standard deviation of k€576337. Their project sizes range from k€121424 to k€1454948.

We conducted analyses for three different sets of projects. The first set contains all transport infrastructure projects. We call this the 'all-inclusive set' (N = 58). In the second set, because DBFM is only considered as an option by Rijkswaterstaat – through the application of a public-private comparator (Ministerie van Financiën, 2013) – for projects of > €60 million, only projects with a size above €60 million are included. We call this the 'Rijkswaterstaat policy set' (N = 27). The third set only contains projects with a size of > €112.5 million, which are defined as (very) large projects by Cantarelli et al. (2012). We call this the 'large projects set' (N = 20). All nine DBFM-projects are included in this latter set, whilst only 11 D&C-projects are in this set (i.e., the largest ones, which are highly comparable in terms of size with the DBFM-projects).

3.3. Data analysis

To compare the different sets of projects, we opted for the Mann-Whitney *U* Test for two reasons. First, our data are not normally distributed. This characteristic of the data violates the assumptions for running parametric statistical tests. Second, our dataset is relatively small. The non-parametric Mann-Whitney *U* Test is recommended when the data are not normally distributed and when it concerns a small sample size (Nachar, 2008).

4. Results

4.1. Cost performance

We analyzed the differences between the projects with a D&C-contract and a DBFM-contract regarding the cost performance. The descriptive statistics and results are provided in Table 2.

The results show that DBFM-projects have average costs for additional work caused by contract changes of 6.24% of the initial contract value of the projects. Projects with D&C-contracts have, depending on the set, average costs for additional work caused by contract changes ranging from 24.27% to 27.19%. The tests indicate that the differences between DBFM and D&C are significant for each of the three sets. We can therefore conclude that projects with DBFM-contracts perform better than projects with D&C-contracts, in terms of additional costs incurred after the signing of the contract between the public and the private project partners.

4.2. Reasons for contract changes

We analyzed the differences between D&C and DBFM regarding their distributions of the costs for additional work of projects over the four reasons of contract changes. The descriptive statistics and results of the analyses for the three sets are provided in Tables 3–5. The statistics are also visualized in Fig. 1. The percentages express the contract change reasons as a share of the total cost performance (see Section 3.2). For example, the cost performance in D&C-projects is on average for 9.84% caused by contract omission, while this is 4.88% in DBFM-projects (see Table 3).

A first general observation is that scope adjustments are the main reason for costs for additional work across all projects, followed by technical necessities (see also Fig. 1). This confirms the results from the study by Verweij et al. (2015). Second, the statistics in the three tables indicate that *contract omissions* and *technical necessities* are more important reasons for contract changes in projects with D&C-contracts than in projects with DBFM-contracts (see also Fig. 1). That is, the mean percentages are higher for D&C than for DBFM. The difference between D&C and DBFM regarding technical necessities is significant for the 'all-inclusive set' (Table 3). However, when project size is taken into account (i.e., the 'Rijkswaterstaat policy set' and the 'large projects set'), the difference is no longer significant (Tables 4 and 5). Third, regarding *changing laws and regulations*, the statistics suggest that this is a more important reason in DBFM-projects than D&C-project (Tables 3 and 4). However, the difference becomes smaller when the smaller D&C-projects are excluded from the set (see Fig. 1). In the 'large projects set', the mean percentage of changing laws and regulations is even slightly higher for D&C than DBFM (Table 5). This could suggest that costs for additional work caused by changing laws and regulations are more prominent in larger projects (cf. Verweij et al., 2015). Fourth, the statistics show that *scope adjustments* are a more important reason for costs for additional work in DBFM-projects compared to D&C-projects (see also Fig. 1). The difference between D&C and DBFM is significant for the 'all-inclusive set' (Table 3). However, when project size is taken into account, the difference is no longer significant (Tables 4 and 5).

5. Discussion and conclusion

Our study answers not only to the call for more systematic and comparative evaluations of the performance of PPPs (e.g., Hodge and Greve, 2007), but also to more recent calls to systematically evaluate if PPPs actually achieve higher performance ('add value') compared to transport infrastructure projects not procured via PPP (Boers et al., 2013). These studies are rare (Atmo et al., 2017; Rodrigues and Zucco, 2018). Theoretically, it can be argued that projects with DBFM-contracts are expected to benefit from the effects of 'economies of scope', 'private financing', and 'shadow of the banks' and therefore achieve a better cost performance than D&C-projects (see Section 2.1). These arguments are often echoed by policymakers promoting PPPs (Hodge and Greve, 2007). Our results confirm that DBFM-projects indeed achieve a better cost performance. This positively answers our first research question. DBFM-projects have an average cost increase, as a result of additional work caused by contract changes in the design and construction phases of projects of 6.24%, but this is a significantly better performance than projects with a D&C-contract. However, care is needed in drawing too big conclusions from this finding. The international literature contains only a small number of studies that analyzed the costs incurred in the design and construction phases of PPP-projects versus those of regularly procured infrastructure (Atmo et al., 2017; Oliveira dos Reis and Cabral, 2017), or that comparatively analyzed the cost performance of road transport projects specifically (Chasey et al., 2012; Meduri and Annamalai, 2013), and those studies produce contradictory results. Therefore, we conclude that, for now, the evidence in the international literature at large for the cost advantage of PPPs over regular infrastructure procurement remains mixed and scarce. Much more comparative research is needed into the actual cost performance of PPP-projects compared to regularly procured transportation infrastructure projects.

We furthermore analyzed whether DBFM-projects have different reasons for contract changes than D&C-projects. This was our second research question. Following Verweij et al. (2015), we studied four different reasons – contract omissions, technical necessities, changing laws and regulations, and scope adjustments – and examined their relatively weight in costs for additional work for each project. First, we

Table 2
Results comparative group analyses for cost performance (%).

	Total	D&C	DBFM	Mann-Whitney U	Significant Difference (2-tailed)? (p-value*)
All-Inclusive Set					
N of projects	58	49	9		
Costs for additional work (% of contract value)					
Mean	21.85	24.72	6.24	95.00	Yes (.007)
SD	23.42	24.32	5.80		
Rijkswaterstaat Policy Set					
N of projects	27	18	9		
Costs for additional work (% of contract value)					
Mean	20.21	27.19	6.24	28.00	Yes (.005)
SD	21.90	23.73	5.80		
Large Projects Set					
N of projects	20	11	9		
Costs for additional work (% of contract value)					
Mean	16.16	24.27	6.24	15.00	Yes (.007)
SD	17.94	20.59	5.80		

* Sig 2-tailed: $p \leq .05$.

Table 3
Results comparative group analysis 'all-inclusive set' for distribution across change reasons (%).

	Total	D&C	DBFM	Mann-Whitney U	Significant Difference (2-tailed)? (p-value*)
Contract Omissions					
N of projects	58	49	9		
Costs for additional work (% of total costs for additional work)					
Mean	9.07	9.84	4.88	166.00	No (.227)
SD	19.41	20.36	13.16		
Technical Necessities					
N of projects	58	49	9		
Costs for additional work (% of total costs for additional work)					
Mean	35.26	39.10	14.31	111.00	Yes (.018)
SD	32.24	32.59	21.24		
Changing Laws and Regulations					
N of projects	58	49	9		
Costs for additional work (% of total costs for additional work)					
Mean	3.01	2.70	4.68	241.00	No (.567)
SD	9.41	8.64	13.43		
	Scope Adjustments				
N of projects	58	49	9		
Costs for additional work (% of total costs for additional work)					
Mean	50.94	46.31	76.13	339.00	Yes (.011)
SD	36.92	35.84	34.04		

* Sig 2-tailed: $p \leq .05$.

Table 4
Results comparative group analysis 'rijkswaterstaat policy set' for distribution across change reasons (%).

	Total	D&C	DBFM	Mann-Whitney U	Significant Difference (2-tailed)? (p-value*)
Contract Omissions					
N of projects	27	18	9		
Costs for additional work (% of total costs for additional work)					
Mean	5.35	5.58	4.88	54.00	No (.176)
SD	16.32	18.04	13.16		
Technical Necessities					
N of projects	27	18	9		
Costs for additional work (% of total costs for additional work)					
Mean	22.83	27.09	14.31	49.00	No (.106)
SD	23.01	23.24	21.24		
	Changing Laws and Regulations				
N of projects	27	18	9		
Costs for additional work (% of total costs for additional work)					
Mean	3.97	3.61	4.68	71.00	No (.631)
SD	10.52	9.17	13.43		
Scope Adjustments					
N of projects	27	18	9		
Costs for additional work (% of total costs for additional work)					
Mean	67.86	63.72	76.13	110.00	No (.145)
SD	32.38	31.69	34.04		

* Sig 2-tailed: $p \leq .05$.

expected based on the literature that DBFM-projects have less costs for additional work caused by contract omissions than projects with D&C-contracts. Surprisingly, our results indicate that there are no significant differences between DBFM and D&C. Second, regarding technical necessities, because they involve changes caused by physical and technical risks in the design and construction phases of projects (Minister van Verkeer and Waterstaat, 2005), we expected no difference between DBFM and D&C. However, our results suggest that changes due to technical necessities are present less in DBFM-projects. A possible explanation could be that, because of the involvement of private financiers in DBFM who demand strong risk management skills from the private partner (Culp, 2011; Demirag et al., 2011), the private construction consortium has to put more time and effort into the identification and mitigation of the risks, resulting in comparatively lower costs for additional work due to technical necessities. Third, concerning changing laws and regulations, we expected no real differences between DBFM and D&C. Our results support this. Fourth, we argued from the literature that scope adjustments are probably present less in DBFM. Our results, however, show that scope adjustments are the main reason of costs for additional work – which confirms previous research (Verweij et al., 2015) – but in DBFM more so than in D&C. Importantly, because contract and scope stability are important especially in DBFM-projects, which have long-term contracts and life-cycle optimization that is expected from this (European PPP Expertise Centre, 2015), scope adjustments may have a negative impact on the cost performance over the full duration of the contracts (including infrastructure maintenance and/or operation). Future research should study this possible impact. We consulted project managers from the Procurement Centre for Civil Engineering at Rijkswaterstaat about the finding. They hypothesized that risks causing technical necessities and contract omissions are with the private partner, perhaps more so in DBFM than in D&C and that, therefore, when a private consortium wants to claim costs for additional work, it has to argue towards the principal that it is because of scope adjustments required by the project principal.

In this article, we used quantitative, real project data. These data are hard to come by, because it is not publicly available and because of

Table 5
Results comparative group analysis 'large projects set' for distribution across change reasons (%).

	Total	D&C	DBFM	Mann-Whitney U	Significant Difference (2-tailed)? (p-value*)
Contract Omissions					
N of projects	20	11	9		
Costs for additional work (% of total costs for additional work)					
Mean	6.83	8.43	4.88	27.50	No (.095)
SD	18.83	23.00	13.16		
Technical Necessities					
N of projects	20	11	9		
Costs for additional work (% of total costs for additional work)					
Mean	23.91	31.76	14.31	27.00	No (.095)
SD	24.69	25.42	21.24		
Changing Laws and Regulations					
N of projects	20	11	9		
Costs for additional work (% of total costs for additional work)					
Mean	4.89	5.05	4.68	43.00	No (.656)
SD	12.09	11.55	13.43		
Scope Adjustments					
N of projects	20	11	9		
Costs for additional work (% of total costs for additional work)					
Mean	64.38	54.76	76.13	73.00	No (.080)
SD	35.69	35.59	34.04		

* Sig 2-tailed: p ≤ .05.

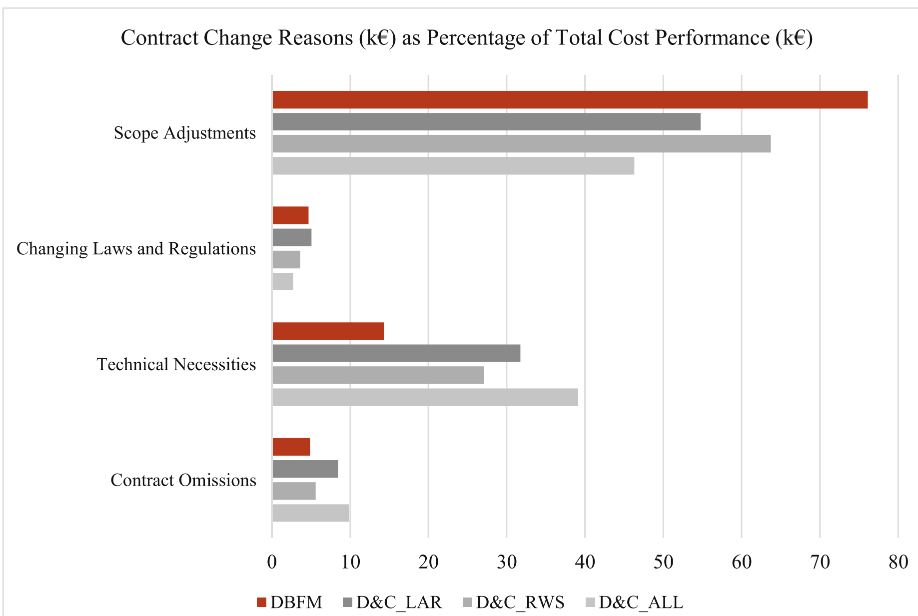

Fig. 1. Contract Change Reasons (k€) as a Percentage of Total Cost Performance (k€). Notes: D&C_LAR = subset of D&C-projects in the large projects set; D&C_RWS = subset of D&C-projects in the Rijkswaterstaat policy set; D&C_ALL = subset of D&C-projects in the all-inclusive set.

confidentiality issues (cf. Chen et al., 2016). Data on DBFM-projects are especially scarce because of the limited number of DBFM-projects in existence. This is why we could analyze only nine DBFM-projects. Although these nine projects represent well the DBFM-practice and -experiences of Rijkswaterstaat so far, it is important to continue the collection of real project data about DBFM-projects that are currently being procured by Rijkswaterstaat, as well as by other regional and local governments procuring transportation infrastructure (Chen et al., 2016). The lack of real project data about DBFM is an important reason why the current literature on the relationships between PPP-contracts (or contract characteristics more generally) on the one hand, and PPP-performance on the other hand, is characterized by the use of perception-based survey and/or interview data (see Chen et al., 2016; e.g., Clifton and Duffield, 2006; Klijn & Koppenjan, 2016; Warsen et al., 2018). Such studies generally lack objective measures of performance. Herein lies an important contribution of the present study. The limitation is, however, that we lack insight in the real motivations and explanations for the contract changes – the project-based 'underlying story' so to say (cf. Cicmil et al., 2006).

This also implies that our interpretation of the results for the second research question should be considered with care. Future research should focus on combining quantitative analyses of the cost performance of DBFM versus D&C with qualitative case studies to identify the real reasons behind the contract changes. This includes investigating the relationship between the contract formation process (bidding, procurement, negotiations) and the contract changes that occur in project implementation. After all, the foundation for a good contract and partnership between public and private partners is laid at the start of the collaboration. It also includes analyzing the relationships between the risk profiles of the projects and risk management on one hand and cost performance on the other hand. The risks transferred to the private partner, how risks are allocated between the private partners in a consortium, and how they are managed, may affect the contract changes that are needed and hence cost performance. Such an analysis may shed more light on the actual existence of the 'shadow of the banks' effect in DBFM-projects. Finally, future studies can also pay more attention to other measures of performance, as a focus on cost performance is of course narrow (cf. Liu et al., 2016). Research into the actual added cost performance of PPPs is important in the legitimization of the choice to procure transport infrastructure through PPPs. However, increased cost performance is not the only motivation for PPPs. Other objectives may also define their success, such as innovation and stakeholder satisfaction (Hodge, 2010; Hodge and Greve, 2017; Liyanage, 2016).

Several implications for transport policy practice, and public procurers specifically, can be derived from the results of our study. First, scope adjustments are the main reason for costs for additional work caused by contract changes in transport infrastructure projects (Verweij et al., 2015). In the pursuit of better project cost performance, and to reap the benefits of the life-cycle optimization in DBFM, an advantage can be gained particularly by curbing scope adjustments costs. We recognize here, however, that, as said, other PPP-objectives need to be considered as well, because scope adjustments may be deliberately implemented to achieve other project-related advantages. Second, we found that DBFM-projects outperform D&C-projects regarding costs incurred in the design and construction phases of projects (cf. Atmo et al., 2017; Oliveira dos Reis and Cabral, 2017; Whittington, 2012). However, due to the design of our study, this result provides only a partial view on the cost performance of DBFM. More research is needed into the cost performance of PPPs after they have completed their full contract duration, which includes their maintenance and operation phases (Liu et al., 2016), and which should also include the cost performance for the private partners in the PPPs.

CRediT author statement

Stefan Verweij: Conceptualization; Data Collection; Writing-Original Draft; **Ingmar van Meerkerk:** Methodology; Analysis; Writing-Reviewing and Editing.

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