PPP Contracts for Environmental Sustainability

"How can PPP contract designs stimulate the environmental sustainability of Dutch road infrastructure?''

university of groningen

faculty of spatial sciences

Colophon

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Summary

This research explores and describes the incentives that PPP contract designs give towards the environmental sustainability of Dutch road infrastructure. It does this by comparing two cases, one case with a Design-Build (DB) contract and the other with the more integrated Design-Build-Finance-Maintain (DBFM) contract. Data on both cases were collected using semi-structured interviews and analyzing project documents. The interviews provided information about the incentives that the responsibility for designing and constructing, maintaining, and financing the infrastructure gives for environmental sustainability outcomes. When analyzing the data it could be concluded that integrating the design, construction, and maintenance phases stimulate the implementation of a life-cycle approach with the use of more sustainable and robust materials, whereas a finance component may counteract environmental sustainability outcomes. Finally, it is important to implement other stimulants at different levels to achieve environmental sustainability in infrastructure projects.

Keywords: PPP, Environmental sustainability, DB, DBFM, Incentives, Rijkswaterstaat

1. Introduction

1.1 Background

Urban areas are facing increasing challenges from climate change that form threats to human comfort and environmental justice (Demuzere et al. 2014). In adapting to these changing circumstances, the Dutch Directorate-General for Public Works and Water Management, Rijkswaterstaat, wants to become more sustainable. The public agency has the aim to limit greenhouse gas emissions to a minimum and become energy neutral so that their impact on the environment will become as small as possible (Rijkswaterstaat, 2020). This can be seen in the delivery of their infrastructure projects, where sustainability plays a more prominent role now than ever. According to Rijkswaterstaat, even more progress regarding sustainability can be made when collaborating with the market in so-called Public-private partnerships (PPPs) (Rijkswaterstaat, 2020). Public-private partnerships are long-term integrated contracts that are used for the provision of public infrastructure (Hueskes, Koppenjan & Verweij, 2019). In these contractual arrangements between the public and private sectors, the private sector has responsibility for significant aspects of the building and operation of an infrastructure (Iossa, Spagnolo & Vellez, 2007). Infrastructure here may refer to both economic infrastructure (e.g., motorways and railways) and social infrastructure (e.g., schools and hospitals) (Grimsey & Lewis, 2004). In the context of this thesis, however, infrastructure will refer to one specific type of economic infrastructure, namely road infrastructure.

Hueskes, Koppenjan, and Verweij (2019) emphasize that using the capacities and resources from the private sector leads to better performance, lower prices, and faster delivery times of public infrastructure projects. The concept of ''performance'' here, can be approached in different ways. Several authors address the performance of PPPs in terms of sustainability, like Kumaraswamy and Anvuu (2007) for example. In their article, it is stated that the long term character of PPPs provides opportunities to include long-term project goals such as sustainability since contractual parties are more willing to cooperate and build good relationships on longer-term contracts, whereas this is less the case in short term projects. The article from Hueskes, Verhoest, and Block (2017) also focuses on sustainability performance. Here, a sustainability framework with sustainability criteria and indicators is used to discuss the role of PPPs in achieving sustainability goals and outcomes. Furthermore, in the article from Koppenjan (2015), it is stated that using private investments for new and existing public infrastructures can contribute to the reduction of the emissions of greenhouse gases and the adaptation to climate change due to the long-term and large scale lock-in of low-carbon and climate-resilient technologies (Koppenjan, 2015). The focus in the article from Koppenjan on the environmental side of sustainability will also be implemented in this research, since a considerable amount of past researches have already put their focus upon economic sustainability performance of PPPs, like for example Du, Wu and Zao (2018) or Morea and Balzarini (2018).

Because the articles mentioned above imply that PPPs may have a positive influence on sustainability outcomes, the question arises of what the driving forces are behind the sustainability performance of PPPs. Hueskes, Verhoest, and Block (2017) point out that the chosen contract design can provide incentives to stimulate the sustainability of infrastructure. Various functions and responsibilities such as design, construction, financing maintenance, and/or operation are often bundled into one contract and transferred to the private sector. As a result, life-cycle costs could be taken into account which may improve the sustainability performance of PPPs (Hueskes, Verhoest & Block, 2017) since this provides incentives to think beyond the design stage and build in energy-reducing and waste-minimizing features (Grimsey and Lewis, 2004). Sustainability considerations could for instance already be included in the project by private parties in an early stage, as this may reduce their costs in maintenance and operation (Koppenjan, 2015).

When articles address the relationship between PPPs and the sustainability of infrastructure, little attention is given on how the exact contract form or design of the PPP gives incentives towards sustainability outcomes (Hueskes, Verhoest, and Block, 2017; Ugwu and Haupt, 2007; Koppenjan and Enserink, 2009). By comparing two cases with different contract designs, this thesis can contribute to discover the incentives that different contract designs give for environmental sustainability in Dutch road infrastructure.

1.2 Research problem

This research aims to study the incentives that PPP contract designs give to stimulate the environmental sustainability of Dutch road infrastructure. It does this on the basis of a comparative case study of two cases of road infrastructure PPPs, each using a different contract design from the contracts described in the articles by Siemiatycki (2009) and Culp (2011). These contract designs are Design-Build (DB), where the private side is only responsible for the design and construction of the infrastructure, and the more integrated Design-Build-Finance-Maintain (DBFM) which adds the financing and maintenance to the responsibilities of the contractor.

In order to investigate this topic, the following research question is proposed: *How can PPP contract designs stimulate the environmental sustainability of Dutch road infrastructure?* To answer this question, the following sub-questions need to be studied: *what are the main characteristics of the DB and DBFM contracts*? (1), *to what extent is environmental sustainability included in the researched infrastructure projects?* (2) and *what incentives do the PPP contract designs provide for environmental sustainability?* (3). Through providing insights on PPP contract designs for sustainability, this research has the goal to increase the sustainability of road infrastructure and the environment.

1.3 Reading guide

Firstly, chapter two will define the concept of environmental sustainability, especially in relation to road infrastructure. Next to this the two studied contract designs and their characteristics will also be explained here. Chapter three contains the methods of data collection including a description of the data collection process, an elaboration of the selected cases, and an overview of the stakeholders interviewed. The fourth chapter discusses the results of the primary and secondary data collection. Chapter five concludes the found results and will give some recommendations for the public authority and further research. Chapter six shows some points of discussion for this thesis.

2. Theoretical framework

2.1 Defining sustainability

First of all, the concept of ''sustainability'' must be defined. Sustainability has been interpreted and used in different ways. The core of many concepts of sustainability is that sustainable development implies a move towards economic prosperity, environmental protection, and social equity (Silvius et al, 2012). These are also known as the three e's, three p's (People Planet Profit) or the triple bottom line (Elkington, 2007), commonly known as the Brundtland Report (WCED, 1987).

Since there is a recognized need to incorporate sustainability considerations in infrastructure projects in order to create low-carbon and climate-resilient infrastructure (Hueskes et al, 2017; Koppenjan, 2015), this research will have its focus on the environmental side of sustainability.

2.2 Assessing environmental sustainability

Making a complete assessment of environmental sustainability is very ambitious, if not impossible. Therefore, sustainability indicators are essential for setting targets, monitoring progress, and determining relative performance (Hueskes, 2013). In order to compose relevant and suitable indicators for this research, it is important to define what environmental sustainability means in relation to road infrastructure.

According to Villalba-Romero et al (2015), environmental sustainability with respect to transport infrastructure is, in principle, focused on minimizing the effects on the environment. The article by Koppenjan and Enserink (2009) follows this line of thought and states that environmental sustainability refers to the impact of public infrastructures on the urban population (e.g. health and safety), urban environments (e.g. air quality and water quality), and the wider surroundings (e.g. ecological impacts). This research will build upon this definition of environmental sustainability from Koppenjan and Enserink since it is aimed at public (road) infrastructure and the impact of it on three aspects, which creates a complete and coherent view on the environmental sustainability of road infrastructure. In addition to this, the structure of the sustainability framework from Hueskes et al (2017) will be used, dividing environmental sustainability into three levels: main categories, sub-criteria, and examples of indicators. The threefold environmental sustainability definition from Koppenjan and Enserink will be implemented into the framework as main categories. In the article's *key performance indicators and assessment methods for infrastructure sustainability* from Ugwu and Haupt (2007) and *sustainability in project management* from Silvius et al (2013) several environmental sustainability indicators and criteria are discussed and described. These will be implemented into the framework as the sub-criteria and examples of indicators. The environmental sustainability framework resulting from this can be found in *table 1* below.

The framework not only consists of indicators related to environmental sustainability outcomes but also involves indicators concerning the sustainable development of road infrastructures. Sustainable development can be described as ''development that meets the needs of the present without compromising the ability of future generations to meet their own needs'' (WCED, 1987). Furthermore, sustainable development could be viewed as the process by which the end goals of ''sustainability'' are achieved (Villalba-Romero et al, 2015). According to Lenferink et al (2012), sustainable development of infrastructure can be stimulated by means of integrated contracts because of the life-cycle optimization incentives provided. ''Life-cycle optimizations'', or a ''life-cycle approach'' is regularly mentioned when addressing environmental sustainability or sustainable development of infrastructure. This approach is aimed at improving integration between the different phases of the project (Lenferink et al, 2008). It provides incentives to think beyond the design stage and build in energy-reducing and waste-minimizing features (Grimsey and Lewis, 2004). By incorporating and integrating sustainability considerations throughout the whole life-cycle, the integrated life-cycle stages could enable a more sustainable planning process and product (the road infrastructure) (Lenferink et al, 2012). An example of this is a ''cradle to cradle'' approach in which resources are used and recycled within the project in an optimal way during the various stages (Villalba-Romero et al, 2015).

Category *(first level)*	Sub criteria *(second level)*	Examples of indicators *(third level)*
Urban population	Health	E.g. hearing damage due to noise pollution E.g. spread of diseases due to air quality
	Safety	E.g. safety of the construction site (accidents, injuries, fatalities) E.g. safety standards of the construction E.g. road safety (congestion)
Environments	Water	E.g. water quality E.g. re-use of water
	Air	E.g. air quality E.g. greenhouse gas emissions
	Energy	E.g. amount of energy used E.g. use of renewable energy
	Materials & design	E.g. use of environmentally friendly (recyclable) materials E.g. life-cycle optimizations (innovative use of materials) E.g. amount of waste produced E.g. design in harmony with the surroundings
Wider surroundings	Land degradation	E.g. deforestation (extent of tree felling) E.g. pollution due to construction E.g. loss of arable land
	Loss of biodiversity	E.g. the extent of loss of habitat or feeding grounds E.g. reference to the protection of species

Table 1: Environmental sustainability framework for road infrastructure.

2.3 Types of PPP contract designs

This research aims to study the possible incentives that PPP contract designs can give towards the environmental sustainability of road infrastructure described above. Different contract designs can give incentives to invest in optimizations that improve the contribution of the infrastructure to sustainable environmental objectives (Koppenjan, 2015). This research will investigate the Design-Build (DB) and Design-Build-Finance-Maintain (DBFM) contract designs. The selection of these contract types is based upon the four main contract designs in delivering transportation infrastructure through Public-Private Partnerships as described by Siemiatycki (2009). He describes the following contract designs: Design-Bid-Build (DBB), Design-Build (DB), Design-Build-Finance-Operate (DBFO) and Built-Own-Operate (BOO). Since this research has its focus on the more integrated type of PPP contracts, the traditional DBB contract design is not included, as team integration is scarce here because design and construction are undertaken by different entities (Pellicer et al, 2016). The DB contract, however, is included in this research.

In contrast to the DB and DBB contract designs, the DBFO and BOO models, represent much more of a break with tradition, giving more control and risk to the private sector (Siemiatycki, 2009). From these two contract designs, this article will have its focus on a variation of the DBFO model, namely the DBFM contract. This because operation often includes tolling, which is generally not included in the Netherlands because of the historical availability of a good national highway network without tolling (Lenferink et al, 2012). The DBFM contract typically includes maintenance instead of operation, and is a frequently used contract design for Dutch road infrastructure PPPs. The BOO design, which is more often used in the US, will not be studied as this thesis focuses on Dutch practices (Lenferink et al, 2012).

Within these types of contract designs, numerous variations are possible. Although these variations will be accounted for, this research will have its focus on the DB and DBFM contract designs. In *Table 2* the distribution of responsibilities and tasks between the public and private parties are shown for the contracts. This table is copied from Siemiatycki (2009), removing the contracts that are not studied in this thesis. After this, the further characteristics of the contracts and their possible incentives towards environmental sustainability are described.

	Greater public responsibility ⟷	**Greater private responsibility**
	Design-Build (DB)	**Design-Build-Finance-Maintain (DBFM)**
Who defines performance specifications?	The public sector	
Who designs and constructs the infrastructure?	The public sector hires a contractor or concession team to design and build the infrastructure to meet public performance specifications using a competitive tendering process	
Who finances the infrastructure?	The public sector, through tax revenue, debt financing, bonds, etc.	The private sector, possibly with some public subsidy
Who maintains the infrastructure?	The public sector	The private sector maintains the infrastructure, usually over a period of 15 to 20 years
Who owns the infrastructure?	The public sector	Typically the public sector
Who gets return on the investment?	The public sector	The private sector through user fees and/or fixed government payments over the life of the operating contract

Table 2: PPP contract designs (Siemiatycki, 2009)

2.3.1 DB

Design-build, or design and construct, is a PPP contract design whereby the public party contracts with a single entity to perform both design and construction under a single DB contract (Janssens, 1991). In the selection and proposal process, the public party sets qualifications for the project, including a basic set of design requirements and performance standards, which may include environmental sustainability considerations. This prequalification process can provide assurance to the public party that its contracting partner has the technical expertise to address environmental sustainability challenges (Culp, 2011). With single responsibility for the design and construction, the private parties are in a good position to provide innovative project solutions for these possible sustainability requirements. Additionally, as private parties are normally selected on the basis of best-value rather than lowest price, DB provides opportunities for private parties to pursue green objectives in addition to those relating to time, cost and quality (Molenaar et al. 2010). Furthermore, the DB method involves an overlap in the design and construction phases of the project. This enables the private parties to achieve efficiencies in the design and construction schedule, saving time, and thus for example energy consumption (Culp, 2011).

In a DB contract, the private party is fully responsible for the design of the project and bears all risks associated with design errors or defects. If the project fails to perform, the public party has a contract claim against the private party (Culp, 2011). In order to prevent errors related to environmental sustainability and achieve a sustainable construction environment, the inclusion of sustainability-related clauses in the early project stages is important. These are unambiguous sustainability specifications that are included in the contract which commits the stakeholders to work towards sustainability objectives. (Ugwu and Haupt, 2007; Enache-Pommer and Horman, 2009).

Since the public party retains the risks associated with long-term functionality and maintenance, they will also have an interest in a good design to reduce these costs (Culp, 2011). However, since the private party has no control over project maintenance and will not assume risks associated with long-term operations, there might be an absence of a long-term vested interest in the project (Culp, 2011).

2.3.2 DBFM

In a DBFM contract, the private partner or consortium is integrally responsible for designing, building, financing, and maintaining the infrastructure (Lenferink et al, 2012). In comparison with the DB contract design, the contract adds maintenance to the responsibilities of the private party, which is typically 15 to 20 years following the design and construction of the project. This should stimulate the integration of optimizations between the design, build, and maintenance stages. During the design phase, the DBFM contract not only incentivizes the private party to think about the consequences of the design for successful realization but also stimulates to involve considerations about the optimal maintenance of the infrastructure (Rijksoverheid, 2020).

Because the private party is also responsible for the maintenance of the project, sustainability considerations could for instance already be included in the project by private parties in an early stage, as the private party will be responsible for any high maintenance or repairs bills (Koppenjan, 2014). As an effect, this may bring critical maintenance knowledge into design. Techniques such as a life-cycle analysis or energy modeling are used to evaluate the impact of design features over the life of the facility. With this knowledge, better decisions can be made resulting in a more sustainable and efficient performing infrastructure (Dahl et al, 2005). The construction costs could for example be higher due to the use of more robust and recyclable materials, while this may reduce the maintenance costs because the used materials require less maintenance, can be re-used, or consume less energy (Pianoo, 2020).

Next to maintenance, a DBFM contract transfers a finance component to the private responsibilities (Culp, 2011). Private parties usually take care of the pre-financing of the infrastructure and have to lend from banks or other financial institutions. In exchange, the financiers want to have particular certainties. They keep a close look on the compliance of the terms and the refund of the debt. This vigilance is extra insurance that the market will realize the infrastructure like it is agreed in the contract (Rijksoverheid, 2020). The finance component in Dutch DBFM contracts may therefore merely serve as an incentive to guarantee private actor’s performance (Lenferink et al, 2012). Next to this, since investments in infrastructure are costly, an investment in less sustainable, but also less expensive infrastructure may be more cost-effective (Koppenjan, 2014). Furthermore, since there are fewer contractors available who have the financial capability or desire for a DBFM project, this may result in less competition when compared to the other methods. This lack of competition may result in less innovative environmental sustainability considerations (Culp, 2011).

2.4 Conceptual model

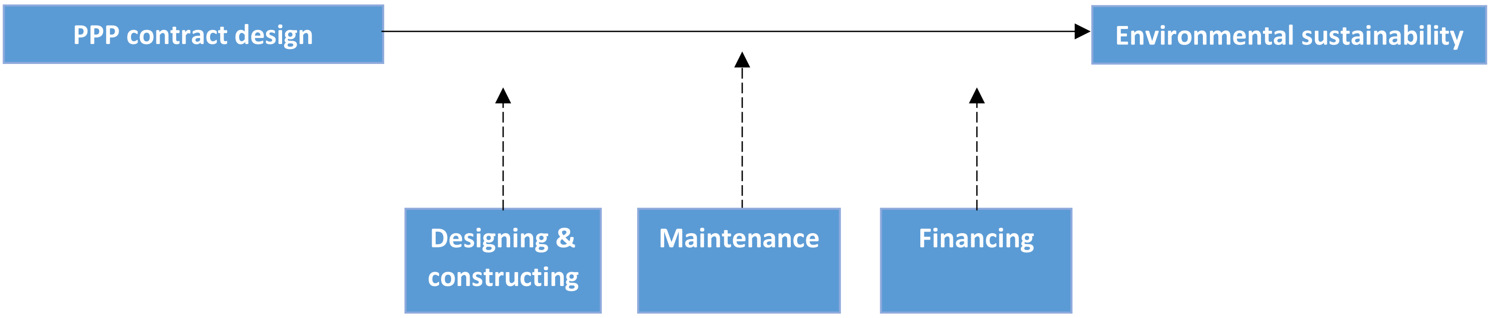

Figure 1. Conceptual model

The conceptual model showed in *figure 1* shows the relationship between the dependent and independent variables of the thesis. The model shows how the performance of road infrastructure in terms of environmental sustainability is influenced by the incentives that the type of PPP contract design gives. These incentives are based on variables from table 2 and will be identified by analyzing primary data.

3. Methods

3.1 Method

This research uses a comparative case study. This provides a good position to analyze the common threads, differences, and patterns between the two cases so that the incentives from the different contract designs towards environmental sustainability can be identified. Furthermore, it is suitable because of the in-depth character which allows going into important details on the subject of environmental sustainability and contract designs (Clifford, et al., 2016). Initially, this study also involved a design-build-maintain (DBM) case and thus had the intention to compare three cases. However, during the data collection, it came to the surface that this case was barely aimed at environmental sustainability and therefore not suitable for this research. Another recent DBM case of Dutch road infrastructure with approximately the same scope and where environmental sustainability played a prominent role was very hard to find. Therefore, this research became a comparative two-case study.

3.2 Data collection

This research uses both primary and secondary data. As secondary data, project documents from the cases are used to analyze the presence of environmental sustainability in the projects. These were freely accessible via the Rijkswaterstaat website (see appendix 2). In order to identify the incentives that lay behind the environmental sustainability measures and outcomes, primary data is collected by means of semi-structured interviews. The respondents are key actors involved in the projects from both the private and public parties. In this way, both perspectives are covered which prevents the data from being one-sided. These actors are mainly committed to sustainability, the environment, and contract designs. The participants are gathered through contacting the companies or agencies the actors are employed at, or personally via the social platform LinkedIn. Due to the removal of the initial DBM case and the accessory interviews, four respondents were left. Nevertheless, these respondents provided a great deal of information and a complete view as they were involved throughout the whole project from quite transcending functions.

Although a list of predetermined questions is prepared, semi-structured interviews allow interviews in a conversational manner, offering participants the chance to explore issues they feel are important (Clifford, et al., 2016). These interviewee-specific views on the cases are important for this research since the interviewees have different functions within the projects at different employers, with each different opinions, emotions, and insights. Therefore, the interviews needed to be flexible.

This research was conducted during The COVID-19 pandemic. This had some unforeseen consequences for the data collection and further research. First of all, meeting in person was not allowed or possible, making face-to-face interviews impossible. Instead, the interviews were conducted via diverse telecommunications applications. The preferred platform from the interviewee was leading in this. Being unable to carry out the interviews in person may have led to a loss of perceived emotions and facial expressions of the interviewees for an improved understanding of the answers given (Clifford, et al., 2016). Finally, the exceptional circumstances made gathering participants challenging as uncertainties for them and their employers made that other affairs were given precedence over participating in research. Flexibility in the data collection was therefore needed. The content of the interviews was for example somewhat shortened and the preferred time slots were completely left to the participants.

3.3 Case selection

The two road infrastructure projects researched are the expansion of the *A1 Apeldoorn - Azelo* and the construction of the new *A16 Rotterdam*. Both projects are tendered by the Dutch Directorate-General for Public Works and Water Management, Rijkswaterstaat. This creates some uniformity between the cases which both have a different contract design. The project *A1 Apeldoorn - Azelo* has a Design-Build contract, whereas the project *A16 Rotterdam* has a Design-Build-Finance-Maintain contract. Both cases are selected on the bases of their environmentally sustainable character. An overview of both cases and respondents can be found in tables 2 and 3.

3.3.1 A1 Apeldoorn – Azelo

The expansion of the *A1 Apeldoorn - Azelo* is tendered to contractor Heijmans. The A1 is an important highway connecting economic zones within and outside the Netherlands. The project includes the widening of the current A1 with multiple lanes. Next to this multiple viaducts are widened, two new viaducts are constructed, the service areas along the road are improved and the highway will be adapted to the connecting roads. Environmental sustainability is high on the agenda during this project. The aim is to use the expansion of the A1 to invest in sustainability and improve the quality of the environment. Within these goals, there is a lot of attention for the integration of the infrastructure into the environment, biodiversity, and energy-saving measures (Rijkswaterstaat, 2020).

3.3.2 A16 Rotterdam

The construction of the new *A16 Rotterdam* is tendered to the consortium De Groene Boog, including contractors Besix, Dura Vermeer, Van Oord, and Mobilis TBI. The project involves the construction of a new highway of 11 km between the A13 at Rotterdam The Hague Airport and the A16/A20. Environmental Sustainability is one of the great pillars of this project. It has for example the ambition the become one of the world's first energy-neutral routes, including the newly built tunnel. Since the highway runs through a variety of nature and green areas (polder-landscapes, parks, and forests), a lot of effort is put into minimizing the effects of the road on the environment and integrating the highway into the landscape in an optimal way (Rijkswaterstaat, 2020). In 2020 the project was rewarded with the 'Duurzame Parel' (sustainable pearl), an award for building projects which pay a considerable amount of attention to sustainability (Rijkswaterstaat, 2020).

Case	Contract type	Public authority	Contractor(s)	Type of construction	Budget	Current phase
A1 Apeldoorn - Azelo	DB	Rijkswaterstaat	Heijmans	Widening road	€ 127 million	Construction
A16 Rotterdam	DBFM	Rijkswaterstaat	De Groene Boog: - Besix - Dura Vermeer - Van Oord - Mobilis TBI	New road	€ 496 million	Construction

Table 3: overview of cases

Case	Name in thesis	Organization	Occupation	Interview date
A1 Apeldoorn - Azelo	R1-A1	Rijkswaterstaat	Advisor sustainability/ advisor contract management	June 2nd, 2020
	R2-A1	Heijmans	Environmental coordinator	June 3rd, 2020
A16 Rotterdam	R1-A16	Rijkswaterstaat	Contract manager	April 29th, 2020
	R2-A16	De Groene Boog (Besix)	Manager MVO	May 7th, 2020

Table 4: overview of interviewees

3.4 Ethical considerations

In order to act ethically, the participants were informed in advance about the intentions, objectives, and the data processing of this research. Next to this, they were formally asked if the interviews could be recorded. Afterward, every interviewee signed a document confirming they are aware of the use of the interview and the data processing. The elaborated transcripts were sent back to the respondents so that they could review their given answers in order to make sure no harm is done. They were informed about their rights to change factual inaccuracies and remain anonymous.

Some ethical considerations about the quality of the data include that the participants were possibly not willing to share everything due to political interests or answers that could lead to disagreements between involved stakeholders. Next to this, the respondents could have interests to promote the sustainable character of the projects to the outside world. This may have lead to biased responses concerning sustainability.

3.5 Instruments for data analysis

In order to analyze the data gathered from the interviews properly and to make sure all the relevant factors are addressed, a coding tree is created which can be found in Appendix 1. The interviews were recorded on a mobile phone and transcribed afterward. After this, the ATLAS.ti coding software was used to code the interview.

4. Results

This section firstly discusses how environmental sustainability looks like in the two cases. It does this by analyzing project documents. Table 5 shows the level in which the categories from Koppenjan and Enserink (2009) and the sub-criteria derived from Ugwu and Haupt (2007), and Silvius et al (2013) from the theoretical framework are represented in the projects. The criteria get classified with either a ++, +, ±, or a - depending on their presence in the projects. After this, the incentives (or disincentives) that the contract designs from the cases provided for achieving environmental sustainability are analyzed. These came to the surface during the interviews and were then coded with one of the labels from the coding tree (see appendix 3). These codes are partly based on the variables in table 2. In this way, the incentives are categorized into the following categories: responsibility for designing and constructing, responsibility for maintenance, and responsibility for financing. Finally, some other stimulants are discussed shortly.

4.1 Environmental sustainability in the projects

This section describes the most important environmental sustainability measures and considerations in the projects.

4.1.1 A1 Apeldoorn - Azelo

First of all, several measures are implemented in the A1 project in order to reduce noise nuisance, both during and after construction. These include placing several noise barriers, heightening embankments, and using a type of asphalt that mutes the sound of cars driving over it. During construction, techniques regarding driving into the ground of piles were implemented to limit noise nuisance. Furthermore, the drillings are carefully planned so that the breeding season is not disturbed. The construction site itself is closed off in such a way that the impact on the environment is limited (Rijkswaterstaat, 2017).

Secondly, a considerable amount of effort is spent on integrating the infrastructure into the environment. The road is designed as a so-called ''parkway'', it is adapted to a park-like environment and includes wide bio-diverse berms. At places where the infrastructure crosses nature areas, animal-friendly crossings and viaducts are implemented to improve upon their safety and habitat. These measures are implemented in such a way that the road becomes part of the landscape. Trees and other natural structures that are removed, or water bodies that disappear, are being restored and replaced in larger quantities. A water storage area of 20.000 m^3 is for example included in the design, compensating the impact on the IJssel river. Due to the wide bio-diverse berms, the infiltration capacity along the infrastructure is increased. On top of this, because of the type of asphalt, the excess water will be a lot cleaner (Rijkswaterstaat, 2017).

In order to be as energy-neutral as possible, energy-efficient lights will be placed at places where this is necessary. The project has the goal to use primarily green energy. Therefore, a solar park in the armpit of an exit is included in the design. Finally, the project aims to limit the use of materials and wants to make use of renewable or recyclable materials that don't provide problems for health or milieu (Rijkswaterstaat, 2017).

4.1.2 A16 Rotterdam

When looking at the A16 Rotterdam project, the so-called ''balance zero'' has to make sure that hearing, smelling, and seeing the road is minimalized. Measures to achieve this include placing noise barriers, putting parts of the road in between embankments of 4.5 meters high, and constructing a tunnel of 2.2 kilometers long. A similar kind of asphalt as used in the A1 project is implemented to reduce the traffic noise. Furthermore, during construction, they try to push sheet pilings instead of drilling, which reduces the noise level (Rijkswaterstaat 2016).

The construction of the tunnel shows how much attention is paid on integrating the road into the environment. From a traffic point of view, this would not have been necessary but additional money and effort were spent here to minimalize the effects of the road on the environment. The roof of the tunnel is fully planted to create recreational space and promote biodiversity. Next to this, several other crossings for animals are implemented to not only protect and maintain but also even improve the habitat for animals. Inside the tunnel, an innovative type of asphalt is used which reflects daylight. Because of this, fewer lights have to be implemented inside the tunnel, saving energy. This contributes to the ambition of becoming completely energy neutral. The project also makes use of sustainable led-lights which are placed along with the infrastructure, but only where necessary. Furthermore, the project aims to use HVO diesel for their vehicles and machinery, which is better for the environment (Rijkswaterstaat, 2016).

Along the whole road, a lot of green structures are implemented to make it fit into the surroundings. The road has even four different appearances, adapting to the four different areas it runs through. The removal of the habitat of animals is compensated 1:1, in total compensating almost 19 hectares. The construction of several animal crossings in combination with the green structures makes that the total nature values in the area will be increased. Finally, waste separation and recycling is performed at the construction site (Rijkswaterstaat, 2016).

Population	A1	A16
Health	++	++
Safety	+	+

Environments	A1	A16
Water	+	+
Air	±	±
Energy	+	++
Materials & design	±	++

Wider surroundings	A1	A16
Land degradation	+	+
Loss of biodiversity	+	++

	Legend
++	Very much present in project
+	Present in project
±	Somewhat present in project
-	Not present in project

Table 5: Environmental sustainability in the projects with legend

4.2 Distribution of responsibilities

Contract designs can be classified according to the extent that the tasks, risks, and responsibilities of former public service provision are transferred to the private partner (Koppenjan and Enserink, 2009). This section describes how the responsibility for these factors stimulated or discouraged environmental sustainability outcomes in the projects.

4.2.1 Responsibility for designing and constructing

In both contract designs, the contractors are responsible for the design and construction. Following the literature, this puts the contractors in a good position to pursue green objectives in the design aimed at the construction (Molenaar et al. 2010). When looking at the A1 Apeldoorn - Azelo project, R1-A1 states that the responsibility for designing and constructing incentivizes the contractor to limit the impact of the road and the construction of it on the environment, since they are responsible for certain flaws or nuisance created for the environment. In this project, this led for example to the inclusion of the noise-reducing measures and being as clean as possible during the construction in terms of CO2 emissions and energy use. R2-A1 states that the responsibility for designing and constructing makes that they as a contractor are incentivized to make optimizations in the design, partly to promote sustainability during the construction. This optimization, he states, mainly means: ''can it be less''. ''Every cubic meter concrete or kilo steel that you save, automatically saves machinery that has to drive it around. Therefore you save Fuel, CO2, energy, and other emissions''.

When looking at the A16 Rotterdam project, R1-A16 also believes that environmental sustainability considerations are included in the design by the contractor in order to limit the impact of the construction on the environment. He states that the consortium is incentivized to include these into the design since they are also responsible for the construction flaws, nuisance, or possible costs that come with it. However, he states, other things such as contract specifications also play a big role here. R2-A16 believes that bundling designing and constructing mainly creates room for optimizations and efficiencies. This saves emissions and energy as R2-A1 describes above.

''Transferring too much responsibilities to the side of the contractor is not always beneficial for a project '' ~ R2-A16

4.2.2 Responsibility for maintenance

As compared to the A1 project, maintenance is added to the responsibilities of the contractor in the A16 DBFM project. This could incentivize the private party to involve considerations about the optimal maintenance of the infrastructure (Rijksoverheid, 2020). According to R1-A16, the goal was indeed to let the contractors think about the maintenance phase during the design as this should benefit the life-cycle of the project, which according to Grimsey and Lewis (2004) provides incentives to think beyond the design stage and build in energy-reducing and waste-minimizing features. R2-A16 confirms that the M-component stimulates to think about the life-cycle of the project, he gives the following example from the project: ''when we apply a more sustainable and robust kind of asphalt, we have to replace it fewer times during the maintenance phase, which means it saves you money and effort there. Therefore you are incentivized to make more sustainable decisions with regard to the life-cycle of the materials''. Having to replace asphalt fewer times not only saves money and materials, but it also reduces the use of fuels, energy, CO2, and other emissions, which is more environmentally friendly. R2-A16 states that the life-cycle incentives from the M-component also stimulate to aim for recyclability of materials. They are currently working on a so-called material passport. This is a database containing which materials are located where, and when they might have to be replaced. In this way, you exactly know which materials come free, which then can be reused or recycled in a sustainable way. However, R2-A16 also states that the incentive for using sustainable and robust materials comes from the so-called milieu cost indicator calculation (MKI-berekening) which obligates you to look for one hundred years lifespan of the infrastructure (see 4.3).

The project A16 Rotterdam has the ambition to become completely energy neutral. According to R1-A16, the measures and considerations to achieve this were included in an early phase, also aiming for the maintenance period. In this phase, the road has to maintain its energy neutrality. R1-A16 also states that not all sustainability considerations are life-span exceeding: ''the contract includes a maintenance period of 20 years, but the construction of the tunnel for example must have a 100 years life-span, that is fixed''. Following his thought, the M-component in the basis ensures that the design and construction stick together, but is also no guarantee for environmental sustainability outcomes. ''You always have to deploy extra stimulus for this'', he says.

The contractor in the DB A1 Apeldoorn - Azelo project does not bear the responsibility for maintenance. R2-A1 does not believe that the contract design is all-determining for integrating the different phases. ''If Rijkswaterstaat wants to achieve sustainability through the maintenance phase, the cost-effectiveness should be less important in order to give the contractor space and opportunity to make the link between design, construction, and maintenance''. Furthermore, he believes that the M-component is not necessarily an incentive for a life-cycle approach. Despite the relatively short run time of the A1 contract, they also have attention for the life-cycle with sustainable and recyclable materials in their project**.** They for example recycle and remove asphalt in an innovative way so that it returns into the asphalt chain with better quality.

''It is primarily about giving private parties as much space as possible to make optimizations in their design with regard to construction and maintenance'' ~ R1-A16

4.2.3 Responsibility for financing

In the A16 project, the consortium is also responsible for partly financing the project. According to Lenferink et al (2012), the finance component in a DBFM contract merely serves as an incentive to guarantee the private actor's performance. Respondent R2-A16 even fears that the F-component counteracts environmental sustainability outcomes. He states that the (pre)financing mainly serves as an incentive for finishing the project as soon as possible. In this way, the loans are paid rapidly and the paid interest is limited. According to him, time then becomes holy, and when you make time-related choices this conflicts with sustainability considerations. He gives the following example: ''when constructing a road, settlings may occur in the soil. With an eye on environmental sustainability, we then put sand or ground on it as preload to prepare the ground, this costs time. Instead, you could also put EPS there, a light plastic material. This saves time but has a lot of impact on the environment''. R2-A1 also believes that the F-component counteracts sustainability, as is brings time pressure with it. He states that financial interests can be very transcending, which is not always beneficial for other project goals. R1-A16 from Rijkswaterstaat addresses that there is a current movement towards contracts where the F-component is less included into the contract, so that you keep the advantages of DBM, but leave the financing to the government again.

''The construction world remains a world of revenue'' ~ R2-A1

4.3 Other stimulants

As stated above, the contract design is not all-determining for integrating the different phases and incentivize environmental sustainability. Extra stimulants have to be deployed for this. During the interviews, some of these were repeatedly emphasized. These were initially not included in this study, but are shortly described here due to their strong effect.

First of all, respondents R1-A16 and R2-A16 repeatedly emphasized the importance of a milieu cost indicator calculation (MKI-berekening). This lets contractors calculate the impact of the material and energy use on the environment for a life-span of one hundred years. In this way, they are incentivized to limit the impact of energy use and materials on the environment in the long term, independently of a maintenance component.

Secondly, the A16 project had an EMVU (economic most beneficial execution) pot reserved. This includes extra money for innovations and improvements during the construction, also regarding environmental sustainability. This financial incentive stimulates to keep innovating on sustainability throughout the whole life-span of the project.

5. Conclusion and recommendations

5.1 Conclusion

The PPP contract design incentivizes the environmental sustainability of Dutch road infrastructure in several ways. First of all the responsibility for both design and construction stimulates contractors to limit the impact of the road and the construction of it on the environment, since they are responsible for certain flaws or nuisance created for the environment. This for example stimulates to reduce noise nuisance. Furthermore, the bundling of design and construction incentivizes to make optimizations in the design so that the use of materials is limited. With respect to environmental sustainability, this means saving fuel, energy, CO2, and other emissions. This is in line with the statements of Culp (2011), who addresses that the overlap in the design and construction phases of the project enables private parties to achieve efficiencies in the design, saving for example energy consumption.

When maintenance is included in the contract, this stimulates contractors to think about the life-cycle of the project, for example by using robust materials such as more sustainable asphalt. Having to replace asphalt fewer times not only saves money and materials, but it also reduces the use of fuels, energy, CO2, and other emissions, which is more environmentally friendly. This is in line with the argument of Hueskes, Verhoest, and Block (2017), who state that life-cycle costs due to the inclusion of maintenance into the contract may improve the sustainability performance of PPPs. In contrast to this, however, the results show that the maintenance component in a contract is not all-determining for applying a life-cycle approach. It ensures that design and construction stick together, but is no guarantee for environmental sustainability outcomes. Extra stimulants, therefore, have to be given, such as the milieu cost indicator calculation which forces contractors to look at the impact of materials and energy use on the environment for a hundred-year lifespan.

The (pre) financing of the infrastructure by private parties primarily counteracts environmental sustainability outcomes. It mainly serves as an incentive for finishing the project as soon as possible, and time-related choices often conflict with sustainability. This is in compliance with the thoughts by Lenferink et al (2012) who state that the finance component merely serves as an incentive to guarantee private actor's performance.

Considering the above, it can be concluded that using a DBFM contract might be more beneficial for achieving long-term environmental sustainability outcomes since the maintenance component incentivizes to think beyond the design and construction stage. The DB contract on the other hand mainly stimulates to achieve optimizations and efficiencies between designing and constructing, making it more suitable for achieving environmental sustainability in less complex projects.

5.2 Recommendations for Rijkswaterstaat

From the conclusions drawn above, certain recommendations can be made for Rijkswaterstaat in order to pursue environmental sustainability outcomes in their infrastructure project through contract designs. First of all, they should continue to reconsider the use of the F-component as it is included in a DBFM contract. Cost and time-related considerations may counteract on implementing environmental sustainability measures and innovations. Next to this, you want to keep the advantages that the M-component gives towards the life-cycle of the infrastructure. Therefore a Design-Build-Maintain contract may be considered where you keep the advantage of integrating the design, construction, and maintenance phases, but leave the financing to the public authority again.

Secondly, it is advisable to keep including extra stimulants for environmental sustainability such as the MKI calculation or the EMVU pot. Where the MKI calculation forces you to look for a hundred-year life-span regarding environmental impact at the front, the EMVU pot saves space and money for innovations for sustainability during the project.

5.3 Recommendations for future research

This research only focused on the Design-Build and Design-Build-Maintain contracts. However, within these contracts numerous variations are possible. Since the conclusions state that a finance component may counteract environmental sustainability outcomes, more research could for example be conducted on the influence of the DBM contract towards environmental sustainability. In this way, the influence of the maintenance component without being (possibly) counteracted by financing can be researched.

Furthermore, during the interviews, the effect of the procurement procedure on environmental sustainability outcomes was repeatedly emphasized. In this research, there was no initial focus on this. Future research with a better theoretical understanding might be done on the influence of these procedures on environmental sustainability.

Finally, in the conclusions, it is stated that including maintenance in the contract is no guarantee for environmental sustainability outcomes. Extra incentives have to be implemented for this throughout the project. Analyzing the role of such additional stimulants would be interesting to investigate in further research.

6. Discussion and reflection

For answering the main research question in a very convincing way, this research did not have a lot of participants. A larger number of participants would have given the results more strength. Next to this, doubts can be placed at comparing the A1 Apeldoorn - Azelo project with the A16 Rotterdam project, as the first concerns widening a road whereas the latter includes the construction of a new road which is a more complex project. Furthermore, this research analyzed the influence of the contract design on environmental sustainability considerations and outcomes in the projects. However, a lot of the incentives for this probably came from other aspects such as contract specifications.

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Appendix 1: Interview

Vooraf

- Nog een keer kort uitleggen wie ik ben en wat ik doe
- Toestemming vragen om interview op te nemen
- Benadrukken dat ik het interview uittyp en het transcript zal opsturen, zodat de participant de mogelijkheid krijgt deze aan te passen op feitelijke onjuistheden
- Vragen om de overeenkomst van deelname te onderteken

Introducerende vragen:

- Waarom is deze specifieke contractvorm gekozen voor dit project? (DBFM)
- Wat waren voor jullie de grote voordelen van dit type contract?

Contractspecificaties

- Is duurzaamheid m.b.t. tot milieu en omgeving opgenomen in de contractspecificaties van dit project en zo ja, in welke vorm? (prestatie-eisen, criteria, doelen etc.)
- Zijn deze gerelateerd aan:
  - Milieuaspecten (zoals lucht- en waterkwaliteit, bepaalde mate van CO2 uitstoot, energieverbruik, afvalproductie)
  - Omgevingsaspecten (zoals ontbossing, verlies van leefgebied voor dieren, vervuiling van de omgeving door de constructie)
  - Gezondheid en veiligheidsaspecten (zoals geluidsoverlast, veiligheid van de constructie, het voorkomen van files)
- Was er ruimte voor interactie met de aannemers/ Rijkswaterstaat over de duurzaamheid van het project?
- Werd er gebruik gemaakt van een competitieve dialoog tijdens de aanbesteding? Zo ja, hoe werd duurzaamheid m.b.t. milieu en omgeving opgenomen in deze procedure?
- Zijn er beloningen opgenomen in het project op basis van duurzame prestaties?

Verantwoordelijkheden

- Zijn duurzaamheidsafwegingen m.b.t. omgeving en milieu meegenomen in het design van het project?
- Denkt u dat duurzaamheidsafwegingen m.b.t. omgeving en milieu zijn opgenomen in het design door het consortium, omdat zij ook verantwoordelijk zijn voor de constructie en de kosten hiervan?
- Zijn deze duurzaamheidsafwegingen in het design ook gericht op het verminderen van de impact van de constructie fase op de omgeving en het milieu? Zoals bijvoorbeeld vervuiling, afvalproductie en geluidsoverlast?
- Denkt u dat duurzaamheid in dit project gestimuleerd wordt door het feit dat het consortium ook verantwoordelijk is voor het onderhoud en de bijbehorende kosten? (is dit een prikkel)
- Denkt u dat het consortium ook gestimuleerd wordt om duurzaamheidsafwegingen in het project op te nemen vanwege hun investeringen? (voorfinanciering)
- Hoeveel vrijheid had het consortium in het bedenken van hun eigen oplossingen en afwegingen voor duurzaamheid m.b.t. milieu en omgeving? Of zijn deze richtlijnen vooral gegeven door de private partijen?
- Hadden de private partijen in het consortium meer expertise op het gebied van duurzaamheid? Waren ze innoverend op dit gebied?

Lengte en Flexibiliteit

- Wat was de lengte van het contract?
- Gaf de lengte van het contract een stimulans voor duurzaamheid op de lange termijn, zoals een levenscyclus benadering met duurzame en recyclebare materialen (bijv. een keer asfalt i.p.v. twee keer)?
- Hoe flexibel is het contract?
- Is er genoeg ruimte om te reageren op een veranderde omgeving of klimaatverandering?
- Hoe blijft deze infra duurzaam in de toekomst?
- Waren deze afwegingen al in een vroege projectfase gemaakt?

Afsluiten

- Bedanken
- Nogmaals benadrukken terugsturen transcript en overeenkomst
- Vragen of de participant de scriptie wilt ontvangen als deze af is

Appendix 2: Project documents

Project	Document name	Author	Date of publishing	Pages
A1 Apeldoorn - Azelo (DB)	Tracébesluit A1 Apeldoorn - Azelo	Rijkswaterstaat	May 2017	110
A16 Rotterdam (DBFM)	Tracébesluit A16 Rotterdam	Rijkswaterstaat	June 2016	159

Appendix 3: Coding tree