How a projects' organization stimulates innovation in public private infrastructure development

A qualitative comparative analysis of DBFM cases in Dutch infrastructure development

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Abstract

The Netherlands has a tradition with public-private-partnerships in infrastructure devolvement. Recently, this resulted in a growing amount of Design- Build- Finance & maintain (DBFM) contracts. With the introduction of this type of contract, it was hoped that projects would see evenly spread risks, an increase of efficiency and innovations provided by the market. This research focusses on organizational features within DBFM contracts that stimulate, steer and facilitate innovation. Under these contracts, the organization of projects is a public-private affair. It is relevant in the light of societal challenges like congestion and the sustainability of infrastructure. This thesis answers the question if necessary or sufficient conditions, or configurations of conditions can be found to explain the presence of technical product or process innovation in public-private infrastructure projects. The conditions accounted for are the deployment of public project management, the procurement result and the consortium composition. A Qualitative Comparative Analysis is used in order to assess these conditions (separately, and combined in configurations). Hypothesized is a relation between over-deployment of stakeholder and technical management and the occurrence of innovation through the reduction of risk and complexity. However, no evidence for this is found in this thesis. The composition of consortia is measured in the amount and the size of firms that are part of the consortia. This condition turns out to have a strong relation with the occurrence of innovation, where consortia with fewer relatively small firms stimulate it. However, the most important conclusion of this thesis lies not in the separate conditions. Surprising results are found if the focus shifts from hypothesizing single conditions, towards assessing configurations of conditions in analyzing drivers for innovation. So, this thesis concludes with the recommendation that future research should focus on configurations of condition, in hypothesizing and analyzing the occurrence of innovation.

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List of abbreviations

BE-raming ..... Bedrijfseconomische-raming
DBFM ..... Design- Build- Finance- & Maintain
DC ..... Design & Construct
EC ..... Engineer & Construct
NCW ..... Netto Contante Waarde
NPV ..... Net Present Value
OECD ..... Organization for Economic Cooperation and Development
PBL ..... Plan Bureau van de Leefomgeving
PBC ..... Performance based contracts
PPP ..... Public Private Partnership
QCA ..... Qualitative Comparative Analysis
RWS ..... Rijkswaterstaat
SME ..... Small and Medium Enterprise
TPP ..... Technical product and process

Chapter 1. Introduction

1.1) Background

Public-private partnership in infrastructure projects.

The Netherlands has a tradition of public-private partnerships (or at least of an interdependency between public and private actors) in infrastructure projects (Klijn, 2009). Public-private partnership (PPP) often occurs because of financial and functional benefits (Koppenjan, 2005). Examples are a potential for increased value for money, increased efficiency, the division of risks, a shared skillset, and learning opportunities (Bovaird, 2004; Caloffi *et al.,* 2017; Himmel and Siemiatycki, 2017). In infrastructure development, partnerships can furthermore originate from the need to join resources from different parties, thus creating interdependencies (Klijn & Teisman, 2003). Collaboration in PPP are (potentially) beneficial, but also increases the amount of actors and the complexity of a project. The increased complexity poses strategical and organizational barriers in infrastructure development. These barriers stem from what Jacobs (1992, in Klijn & Teisman, 2003) calls the 'guardian' and 'commercial' syndrome for respectively the public and private domain. Jacobs refers to fundamental differences in the roles and actions of public and private parties, these differences make PPP complicated, but very exciting at the same time.

The possibilities and challenges in the field of mobility are changing. Instead of new developments and construction in the infrastructure network, society is heading towards the need of major renewal of it (Verrips & Hoen, 2016; Willems *et al*, 2016). Adequately addressing challenges of congestion, the environment and accessibility, during and in combination with the renewal can create huge public value. As the PBL 'Planbureau voor de Leefomgeving' suggests, innovation and flexibility are important aspects for infrastructure development in order to capture this public value in the future (Verrips & Hoen, 2016). The main topics of interest in this thesis are organizational features that stimulate innovation in infrastructure projects. As introduced below, the public perspective is interesting, this results in a focus on the deployment of project management conducted by the public party. From a private perspective, the composition of consortia influences the organizational features of infrastructure development. These different aspects are related to the possibilities of collaboration and innovation later on in this thesis.

Concerning innovation in infrastructure development public and private parties have different roles. On one hand, the focus of public parties on the 'common good', from their 'guardian perspective' stimulates governments to develop projects in for example connectivity and safety. On the other hand, it stimulates governments to control and regulate, threatening the potential for change in their quest for a reliable infrastructure network (Verbong & van der Vleuten, 2004). This duality finds its origin in what Savini *et al.* (2015) refer to as the paradox between enablement and control that is inherently present in planning. This duality is one of the reasons why a focus of public organizations in stimulating innovation is interesting.

Like in the article of Koppenjan (2005), public-private partnership in infrastructure is operationalized as: organized cooperation through binding agreements. Examples of these agreements are contracts or joint ventures. Although these type of agreements might undermine partnership in the "ideal speech situation" as posed by Habermas (Brand & Gaffikin 2007), contracts provide a framework in

which organizational barriers are minimized and risks and responsibilities are allocated between the parties. This 'contractual form' of PPP is something that is often used in infrastructure development (Klijn, 2009), examples of contracts used in Dutch PPP projects range from Design and Construct (D&C) to Design-Build Finance-Maintain (DBFM) contracts (Klijn, 2009).

Since the communicative turn (Healey, 1996), the market and society are more involved in infrastructure planning, the governance of projects is no longer a top down activity, and different forms of public-private partnerships (PPP) have emerged. These partnerships change the roles of actors (Klakegg, Williams & Shiferaw, 2016) and even though an extensive amount of literatures on public-private partnership exists, challenges remain. This thesis adds to the literature on public private partnerships and focusses on innovation in public private infrastructure projects. The goal of this thesis is to assess configuration of conditions that stimulate innovation in public private infrastructure development. The conditions revolve around the organization of projects and the public and private perspectives on innovation. In the next section the three conditions and innovation in infrastructure projects are further introduced.

With the introduction of PPP, the possibilities for learning and skill complementation between public and private parties are increased and innovation can be stimulated (Lenferink, Tillema & Arts, 2013; Rangel & Galende, 2010). Note that although the focus of this thesis is on public private partnerships, the conditions that are tested for are not specific to PPP and could (in other research) also be assessed in the light of nonpublic private infrastructure development. However, because of the potential for innovation, the duality in roles, and the relevance, public private partnership in infrastructure projects is an interesting scope for the research.

1.2) Innovation in infrastructure

Innovation is an important asset to maximize cost effective solutions in infrastructure projects (Rangel & Galende, 2010), especially when the challenges in, and the context of projects are changing. Private parties seem to have an important role in innovation, this because market factors encourage to innovate on product and process level (Schumpeter, 1961). Although market parties play an important role in innovation, public parties can be important as enablers for innovation as well. Himmel and Siemiatycki (2017) emphasize the potential gain innovation in infrastructure projects hold for public clients. Innovative construction can reduce cost, time, and risk, while increasing the long-term quality of projects. Benefits like these give public parties all the more reason to be aware of the role they play in stimulating innovation.

Defining innovation has often been attempted, the OECD defines innovation as:

''the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations'' (OECD, 2005 p46).

This thesis focusses on public-private projects in infrastructure development. In line with the OECD Tawiah and Russell (2008) specify four types of innovation: product, process, organizational/ contractual and financial innovation. For the purpose of this thesis innovation is defined more concrete. The definition of Technical Product and Process innovation, as posed by the OECD (1996), is used:

"*Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation)….*" (OECD, 1996, p.31)

A clear choice is made to exclude organizational and financial innovation for several reasons. First of all, the OECD definitions provide a clear demarcated explanation of what to include and what to exclude from innovation. Secondly, PPP in itself can even be seen as an organization innovation (Hodge & Greve, 2007). And in order to separate dependent and independent variables, TPP innovation is chosen, and contracts and financial aspects are used as independent or homogenous variables. Finally, one type of innovation can influence the other (Tawiah & Russel, 2008) and contractual and financial contexts are known to influence TPP innovation (Leiringer, 2006). Further explanation of these arguments as well as a typology and potential drivers and inhibitors of TPP innovation can be found in chapter two.

Table 1, Drivers and inhibitors of innovation

TPP innovation in PPP	Potential driving forces	Potential inhibiting forces
Design freedom	• Use of output specifications can stimulate the creativity and freedom of design.	• Increased uncertainty for both client and constructor can be a cause for risk aversive design and increased control • The public parties 'guardian role' stimulates control functions.
Collaborative working	• Creation of win-win situation by complementation of resources and skillsets. • Building of trust and understanding, especially at long-term or early involvement of all parties	• Contractive nature of PPP in infrastructure development. • Fundamental differences in drivers for a project between public and private parties
Risk transfer	• Innovation requires a certain amount of risks	• Risk may be differently interpreted and valued by different parties
Long-term commitment	• Private actors consider life-cycle costs. • Ability to utilize expertise over longer period of time.	• Lock in effect because of payment schemes.

Based on: Himmel & Siemiatycki, 2017; Leiringer, 2006; Klijn & Teisman, 2003; Tawiah & Russel, 2008.

With the introduction of PPP it was hoped that TPP innovation in Infrastructure development was stimulated (Himmel & Siemiatycki, 2017; Klijn & Teisman, 2003). Leiringer (2006) identifies different lines of augmentation on the relation between innovation and PPP, these are displayed in table 1. He concludes that evidence for these arguments is often non-conclusive or disputable, which makes for an interesting topic for research.

Rangel and Galende (2010) set out to find factors that determine innovation in PPP in infrastructure. Three notions from this research are important for this thesis. First of all, their results support the notion that innovation is not an intrinsic part of PPP, but different factors can stimulate it. Secondly, when using a perspective of private parties, three main factors seems to stimulate innovation: The amount of bidders, the type and division of risks and penalties on performance. The third notion (or suggestion) is that when assessing the occurrence of innovation in PPP:

"An interesting future topic of research could be to analyse the influence of other factors such as public incentives and requirements…" (Rangel & Galende, 2010, p54).

This research sets out to do that, which makes it relevant for academia. Caloffi *et al.* (2017) support the interest in the public perspective, as they stress the importance of support by public parties throughout the entire scope of an innovative project. In this thesis, three threads of action are further elaborated on and used as input conditions. These are: the deployment of relevant actors in project management, the procurement result and the consortium composition. And although the scope is further narrowed down later in this document, this thesis essentially focusses on how organization (project management & consortium composition) influences innovation in DBFM projects in infrastructure.

A first important factor when analyzing innovation in infrastructure is project management. In DBFM projects, Rijkswaterstaat provides a project management team throughout the entire scope of the project. These teams are composed of different roles and part of the organization of these projects. It is interesting to assess if different compositions of such teams increase the chances for innovation. Or in other words, can the government stimulate innovation by deploying different management roles?

Next to the capacities used by the government, context is an important factor when assessing innovation and PPPs (Hueskes, Koppenjan, Verweij, 2016; Leiringer, 2006). In the scope of this research there is chosen to neutralize some contextual conditions in order to create a comparable sample of cases. This research will only focus on DBFM(O) projects and will consist of a sample of cases in which the contractual and financial context are homogeneous. Choosing projects with a fixed context provides the opportunity to examine the specifications of projects, and how these factors relate to the occurrence of innovation. The procurement result and the consortium composition are chosen as input conditions.

The consortium composition refers to the amount and kind of firms that form the consortium that is working on a project. The consortium composition is a condition relevant as an organizational aspects of a project, driven from a private perspective. Smaller firms are often seen as driving firms for innovation (see for example Decker el al. 2006; Lu & Sexton, 2006) while a large amount of firms might pose barriers in risk allocation and collaboration, reducing the potential for innovation. The third condition, the procurement result, is defined as the precentral difference in the estimated costs by the

client and the projected cost by a bidder (Verweij et al. 2015). A bid lower than the estimated costs by the client can indicate increased construction or outcome efficiency, which can be caused by innovative methods or products.

In the remainder of this chapter, the three chosen factors are further explained and justified. Then, the research question is stated and a reading guide for the rest of this thesis will be provided. In the second chapter, the outcome condition (being innovation in public-private infrastructure projects) as well as the three input conditions are examined from a theoretical perspective.

1.3) A public perspective

Deployment of public project management in infrastructure projects

Together with the developments in public-private partnerships, the capacities of governments are changing. On one hand, the 'hollowing out of the state' (Rhodes, 1996) decreases the delivering capacity of the government, creating the need for PPP. While on the other PPP can also be a cause of changing government capacities. Debates revolving around the "ownership, operation, regulation and financing" of infrastructure (Lodge & Wedrich, 2014 p3) are identified as part of key policy debates in contemporary governance challenges and in public-private infrastructure projects. In order to deal with these challenges in project development, project management has been transformed towards a more integrated discipline.

The previous paragraph stated that innovation in infrastructure development is needed in order to cope with the future circumstances, challenges, and state of the infrastructure network. One of the methods for governments to steer innovation is through the management of their projects. In the Netherlands at least two governmental bodies are directly involved in developments in the main infrastructure network, i.e. the ministry of infrastructure and water management, as a client, and Rijkswaterstaat (the operating agency of the ministry of infrastructure and water management), as a responsible agency for realization, operation, maintenance and management of the infrastructure network.

Rijkswaterstaat uses an IPM (Integrated Project Management) model in order to manage infrastructure development. In integrated project management a diverse team deals with integrated and complicated challenges within the mangement and scope of the assignment (Rijkswaterstaat, 2016). The method basically consists of five different roles being project manager, manager project control, stakeholder manager, technical manager and contract manager. In this thesis the deployment of each of the roles and the relative under and over deployment (opposed to what can be accepted due to the characteristics of a project) is used as a variable in researching innovation in DBFM projects.

Researching project management from a public perspective is interesting, because it provides insight on how governments act during the implementation phase of infrastructure projects. It is relevant, as it tries to answer the question which configuration of management roles stimulates innovation in infrastructure projects. In order to do this, a systematic analysis is needed and in this thesis, a Qualitative Comparative Analysis (QCA) is used.

1.4) Project specifications & the private perspective

The combination of public project organization and project specific factors is interesting, because certain "behavior" or capacity deployment might be more common in projects with certain specifications. In order to compare, the sample of cases is limited to cases with common attributes. These attributes are referred to as the 'area of homogeneity'. The area of homogeneity consists of factors that are stable throughout all the sample cases. These variables are the time frame (or project phase) and the contractual context. The area of homogeneity is further elaborated on in chapter two. Along with project management, two other conditions; procurement result and consortium composition, are accounted for as independent variables and are further introduced below.

Procurement result

Governments might be able to steer towards, stimulate and facilitate innovation. However, innovation in PPP is often seen as a task for the market parties. Market parties can be triggered and stimulated to use more efficient designs and methods (Caloffi *et al.,* 2017; Hodge & Greve, 2007) so the driving forces of market parties are something to reckon with. A method for assessing the potential that market parties (within the boundaries of a tender) see for (efficiency enhancing) innovation, is assessing the procurement result. Efficiency enhancing innovation is not included as dependent condition (product and process outcome novelty innovation are), however increased efficiency can point towards the use of new products, therefore it is an import factor to take into account as independent condition.

The procurement result is the difference between the expected cost by the client (in this case Rijkswaterstaat) and the eventual agreed upon contract. It is defined as the procurement estimation by the client minus the contract value as offered by the tenderer. If the estimate of the client has a higher expected costs than the eventually agreed upon contract, it could be a sign that the market sees potential for efficiency enhancing innovation. As in earlier work (by Verweij et al. (2015)), this research uses the relative procurement result in order to analyze and compare different cases.

Consortium composition

DBFM contracts are usually bid on by a consortia of firms. In this thesis, the amount and type of companies are used as an input variables in order to construct the condition of consortium composition. A general division between consortia, consisting of (a few) large firms and consortia consisting of multiple smaller firms, is made. This is done because of two lines of reasoning, which are explained below.

First of all, the general idea in the literature is that small and medium enterprises (SME) are drivers for innovation. Reasons are for example that SME are more flexible and adapt easier (Decker el al. 2006; Lu & Sexton, 2006). Through this line of reasoning it can be argued that innovation is stimulated if SME acquire more responsibilities in a consortium. However, claiming that SME are drivers of innovation is not undisputed. Qi et al. (2010), in their research on green innovation, find different results. They see an increase of innovation if the firm size grows. This opposed viewpoint is explained by the drivers of green innovation. These are often non-financial (or at least not directly), but are instead driven by governmental regulation and stimulation, stakeholder demands, and managerial concerns. Innovation in infrastructure projects share some characteristics with green innovation, because they can both be driven by societal concerns or desires. Following the line of reasoning explained by Qi et al. (2010),

larger construction firms are more prone to be influenced by governmental and societal (or stakeholder) pressure, and can in this way be drivers of innovation.

The second argument explaining the interest in the composition of consortia, has to do with the amount of firms in a consortium. Experiences from practice suggest that consortia composed of a large amount of firms reduces the innovative capacity, because risk allocation and sub contracts are inhibitors of innovation. A consortium that is made up out of 2 or 3 firms with different areas of expertise can on the other hand benefit from the complementary skillsets of the different partners, while being small enough to negotiate risk and build trust.

These two lines of reasoning suggest that consortia composed of a low number of small or large companies can both be a driving factor for innovation. In practice the debate arises if tenders should be kept relatively small (by the client) in order to increase chances of smaller firms. The duality in the literature, with on one hand the notion of flexible small firms driving innovation and on the other larger impressionable firms, together with the amount of firms in consortium and the debate in practice make consortium composition an interesting project specification for research.

1.5) Research question and expected results

Research question

The aim of this thesis is to assess the effects of organizational and efficiency enhancing factors that stimulate, facilitate and initiate TPP (technical product & process) innovation in public private infrastructure projects. In order to reach this goal, the main research question is:

Which configuration of input conditions (deployment of public project management, the procurement result and the consortium composition) stimulates the presence of TPP innovation in DBFM infrastructure projects in the Netherlands?

In order to answer this question, the effects of each of the factors on the presence of innovation is hypothesized and research is done using a QCA method. For the sake of guidance and clarification, sub-questions are formulated. The sub-questions mainly focus on the expected effects of each of the three input conditions (project management, procurement result and consortium composition) separately. In order to have a more profound understanding of the main goal of the research, it is important to gather some insights in innovation as well, so the first sub-question is:

- How can TPP innovation in public-private infrastructure projects be classified, and what are major factors in stimulating, facilitating and initiating innovation from a governmental viewpoint?

Then, as said three questions regarding the separate effects of each of the conditions are formulated:

- What is the expected effect of the deployment of public project management on the occurrence of innovation in public-private infrastructure projects?
- What is the expected effect of the consortium composition (in firm size and amount of firms) on the presence of innovation in public-private infrastructure projects?

- What is the expected effect of the procurement result on the presence of innovation in public-private infrastructure projects?

Finally, a last question is stated that focusses on the configuration of all three conditions to combine the findings of the earlier questions into one analysis:

- Can necessary or sufficient conditions or configurations of the above stated conditions (project management, procurement result and consortium configuration) be found to explain the presence of TPP innovation in public-private infrastructure projects?

Expected results

This thesis is expected to show relevant results for planning practice and academia. First of all, a more profound knowledge on the deployment of public project management in (innovative) public-private infrastructure projects is expected. The most important roles for the occurrence of innovation are expected to be identified and knowledge gaps in the relation between the deployment of project management and the occurrence of innovation are expected to be filled. For practice, a second result can be insight in the deployment of different management roles, as management roles complement each other, meaning that devoting extra resources to one of the roles might not be effective without a complementary input in another. A third expected result are differences in management required when different contexts in the field of consortium configuration and procurement results. Relevant for academia are added results from the public perspective (Rangel & Galende, 2010). Furthermore, the configurational characteristics of the research method used, provide possibilities to compare case (by generalization) while still accounting for the complex mechanism behind the cases (Gerrits, & Verweij, 2018). By conducting a systematic comparative analysis, patterns can be deducted that may shine a light on which configuration of conditions work for stimulating innovation. An extra result for practice are insights on the amount and size of firms present in consortia that work on projects where innovation occurs.

1.6) Research method and design

Method & design

In order to answer the main and secondary research questions, a literature study and a Qualitative Comparison Analysis (QCA) are used. The literature will be used to provide background, set boundaries and definitions and create a hypothesis that will be tested using the QCA. The QCA is chosen because (as in the article by Verweij *et al. (*2013)) the goal of this thesis is assessing combined effects of multiple conditions, in this case the project management, the procurement result and the configuration of firms in a consortium. A QCA method provides opportunities to do this, while being able to conduct a more systematic analysis compared to in-depth case study research.

To be able to use a QCA method a large scale database provided by Rijkswaterstaat is used. Data from the dataset was used in order to group and score cases on the in -and -outcome conditions. The combinations of conditions are called sets, and cases have a degree of membership in these sets based on their score for each condition (Verweij et.al., 2013). The relation between conditions is explained with the terms 'necessary' and 'sufficient´ and displayed in truth tables. These tables will be created and analyzed in the fourth chapter of the thesis, after which the main research question is answered and conclusions are drawn.

The legitimization of the degree of membership as well as the creation of sets are essential in order to create scientific value and are therefore an important part of this research. If done properly, this research method provides a systematic analysis of the relation between the three input conditions, and the presence of innovation in public private infrastructure projects.

Figure 1 shows a schematic view of the research design. As said, operationalizing the explanatory and outcome conditions is an important step and will be further specified in the next chapters.

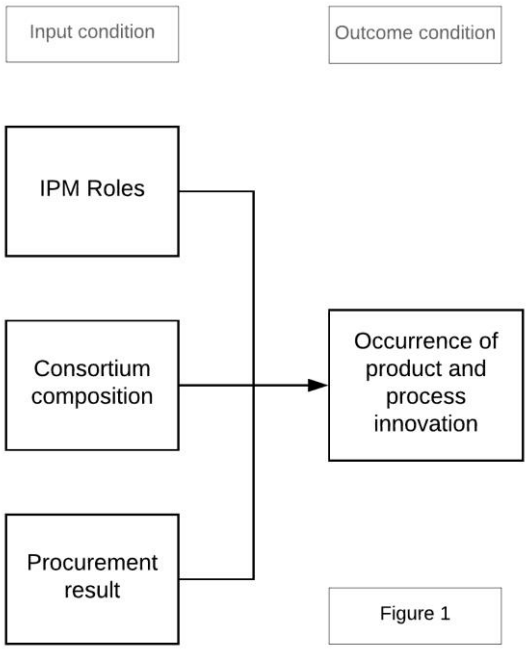


Figure 1

1.7) Reading guide

This thesis consists of seven chapters, references, and appendixes. In the second chapter a theoretical framework is created. Theory on PPP is used to define and PPP in Dutch infrastructure projects. Then the relation between PPP and innovation is examined, in order to create a framework and typology on (the stimuli for) innovation in infrastructure projects. Theory on all three input conditions is used to further operationalize the conditions and to create hypotheses on how each of the factors will influence the presence of innovation.

In chapter three the methodology is explained. It revolves around operationalization of the condition in order to make them fit the QCA. In chapter four the calibration and description of data as well as the preliminary results are presented. Then, the truth table analysis is done in order to find necessary and sufficient configurations of conditions. Chapter five and six consist of discussions, conclusions and remarks. And chapter seven, the last chapter of this thesis, consist of a short reflection on the process of writing this thesis and of certain decisions made in the process.

Chapter 2. Theoretical framework

This chapter contains a theoretical framework of the different conditions included in this research. Innovation, project management, procurement result, and consortium composition are described in sequence, as well as their expected relation with innovation. From a theoretical perspective, this chapter will furthermore contain some typologies on for example innovation and contracts, as well as useful definitions. By creating these frameworks and providing some extra theoretical background, the goal of this chapter is achieved. The goal of this chapter is to state hypotheses on the relation between the input conditions and the occurrence of innovative practices in public-private infrastructure projects.

2.1) Innovation in public private infrastructure projects.

Definitions and theory

In order to reach the goal described above, a clear understanding and definition of innovation is needed. Innovations are classically seen as novelties that increase economical gain, this can be done by the reduction of cost or by increasing the outcome quality or quantity (Schumpeter, 1961). In infrastructure, the increasing demand for quality on one hand, and the aim to reduce life cycle costs on the other, pose potential benefits for innovators (Tawiah & Russel, 2008). Still, innovation in PPP is difficult to pin down.

An important aspect of innovation is that the novelties or significant improvements made, are introduced on the market (Leiringer, 2006). In infrastructure development, innovation can occur in each phase of a project, from the initial planning stages to the design, construction, and maintenance. Project innovation can be categorized into four categories, which are; product, process, organizational/contractual and financial innovation (Tawiah & Russel, 2008). In this thesis the decision is made to focus on technical innovation as defined by the OECD (Leiringer, 2006). This means that there is a focus on product and process innovation and that contractual and financial innovation are excluded. This is done for several reasons.

First of all, it makes sense to choose between different types of innovation and the role (as input or output conditions) they play in the research. This because the occurrence of one type of innovation can be a stimulant for other types of innovation (Tawiah & Russel, 2008). Meaning that, for example, innovation in organization or financing could stimulate product and process innovation. Furthermore, the focus on technological product and process innovation provides a clear and accepted definition which is needed for the analysis. The OECD defines Technical Product and Process (TPP) innovation as follows:

"*Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organizational, financial and commercial activities. The TPP innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period under review*". (OECD, 1996, p31)

The choice for TPP innovation as outcome condition is also based on the empirical findings after consulting Rijkswaterstaat experts. Within Rijkswaterstaat knowledge on technical innovation is better collectable because there seems to a reasonably good consensus on what to call TPP innovation. The definition and typology of innovation that is chosen is further explained in the next paragraph.

Typology & framework

In order to gain a better understanding of what is meant with TPP innovation and what is included in this research, a typology is made. The categorization of Tawiah and Russel (2008) and the OECD (2005) is used. They highlight what is understood as product and process innovation (see table 2). In their typology, the OECD (1996) as well as Tawiah and Russel (2008) and Leiringer (2006) use a measurement on the extent of the impact of innovation. In this thesis the expert opinion of technical project managers is used in order to determine what is seen as an innovation, this resulted in innovation described as (radical) process improvement and outcome novelties. Examples are measurement tools in the tender process, and novel types of asphalt that are introduced. Tawiah and Russel describe outcome novelty innovation as innovation that revolves around the introduction of whole new ideas, or the combination of existing ideas into new products or processes.

Type of innovation	**Table 2, Typology of innovation**
Product	• Advanced construction products, components, materials and their assemblies. • Use of advanced technology and systems in the operating and maintenance phase • Novel designs and concepts • Use of advanced technology and systems in the operating and maintenance phase
Process	• Use of advanced construction technologies, methods, measuring, lifting, and assembling devices • Off-site fabrication and novel construction methods leading to reduced off-site activities • Novel methods of pacing and/or sequencing of construction activities leading to compressed project/program schedules • Creative service delivery methods

Source: (Tawiah and Russel, 2008, p176, titled: *table 1. Types of project innovation*)

Within the TPP innovation that is described above, a further distinction is made between innovation driven by clients (in this case Rijkswaterstaat) and innovation that originates from the own incentives of market parties. Because in PPP innovation is not only expected to be driven by the client, but PPP is also so expected to drive market parties to innovate out of their own incentives. Market parties can

for example use innovative practices to gain market share over their competitors, or to reduce time or cost of processes.

Leiringer (2006) describes what he calls 'often heard arguments' on how PPP stimulates innovation. He names four; *design freedom, collaborative working, risk transfer and long-term commitment* (see table 1, chapter 1). Especially the 'freedom of design' argument, suggests that proving more (contractual) freedom can stimulate the occurrence of innovation. This because, market parties are more creative and devote more resources towards research and design in comparison to their public counterparts. Furthermore, market parties are driven to innovate, because of their competitive characteristics (towards other market parties) (Leiringer, 2006). It is interesting to learn whether the lines of reasoning described above hold true for outcome novelty innovation in infrastructure projects, or whether innovation only occurs when it is explicitly part of the assignment posed by the client.

In the rest of this thesis, a typology of four categories of innovation is used: 1) client driven product innovation, 2) client driven process innovation, 3) market driven product innovation 4) market driven process innovation. In the next three paragraphs (2.2, 2.3 and 2.4) the explanatory conditions are further examined and a line of reasoning on how each of these conditions relates to the main arguments on the occurrence and typology of technical product and process innovation is created.

2.2) Deployment of public project management

Deployment of public project management and the IPM model.

There are many different definitions of a project and of project management (Turner 2008). Although the precise definition is not part of the essence of this research, a project is regarded a project if it is an undertaking, that creates a unique result and worked on by a temporarily organized project team (Turner, 2008; Pinto, 2010). Project management is a tool to bring about change and organisation to this project team. It is strongly connected to infrastructure development, because infrastructure is often renewed in a project based manner. Project management is no longer seen as only a delivery system or 'toolbox', but it has evolved into a more integrated management strategy (Pinto & Winch, 2016). In order to cope with these changes and developments in project management, Rijkswaterstaat uses an IPM strategy.

Turner (2008) emphasizes that projects are undertaken to bring about change. Furthermore, because of the temporal and unique nature of projects (opposed to standardised production processes), it is an ideal organizational structure for innovation to thrive in. The most vivid example of this are pilot projects. However, stimulating innovation in projects is not easy. On one hand, the temporal and unique nature of projects makes a project more agile and objective driven, which provides opportunities for innovation. On the other hand, project are also susceptible to unknowns and risks that standardized production processes are not familiar with. Project management and infrastructure development are both about "converting vision into reality" (Turner, 2008, p2). Project management is a tool that provides a framework for the organisation of the scope, cost, time and quality management of the planning and the risk allocation of a project.

Research in the deployment of FTE towards the IPM roles is relevant for managing, stimulating and facilitating innovation in projects. Goffin and Mitchell (2016) recognize this relevance in their book on innovation management, they stress the importance of ´people and organisation' as one of the five

aspects of the pentathlon framework (a framework of five key elements for successful innovation). From a public perspective, decisions on the role and the deployment of personnel can be an interesting method in stimulating and managing innovation in DBFM projects. In this research, the relation between the deployment of FTE towards the IPM roles and the occurrence and type of innovation is assessed.

IPM roles

The basis of the IPM model lies in recognizing and balancing different interests in a project and dealing with this within the scope of the project. An example given by Rijkswaterstaat (Rijkswaterstaat 2016) are tensions between technique, contract and stakeholder management. In this paragraph different roles in the IPM model and their relation with the theory on innovation are discussed. The IPM model consists of five roles: project manager, manager project control, environmental manager, technical manager and contract manager.

In the document 'Rolprofielen IPM' (profile of roles IPM) (Rijkswaterstaat 2016), each of the five roles are elaborated on and a specification of tasks, responsibilities, and function specific remarks is provided. In table 3 an overview of the responsibilities and main tasks of the roles is given. Table 3 does not provide a complete overview of all tasks, because some tasks and responsibilities overlap. However, it still provides an insight on how project the IPM model is operated at Rijkswaterstaat. The tasks in the IPM roles coincide with the five aspect of a project, being (1)organisation, (2) scope, (3) cost, (4) time, and (5) and quality (Turner, 2008). The five aspects are numbered and integrated in table 3.

Table 3, Project management at Rijkswaterstaat

IPM Role	Tasks and responsibilities
Project manager (1,2,3,4,5)	**Main tasks revolve around:** leadership, ultimate responsibility, and managing project management. **Responsibilities are:** • The timely, correct and complete delivery and evaluation of the entire project. • The planning and organization of the project assignment. • Steering and assigning the project management. • A smart project assignment and organization. • The project manager is ultimately responsible for risks, quality, and internal and external communication of the entire project.
Manager project control (2,3,4)	**Main tasks revolve around**: evaluation, risk management, and planning and project control. **Responsibilities are:** • Financial management, timely payment, risk management, scope management and document management. • The proper control of the project assignment in accordance with (SMART) agreements.

Stakeholder management (1,5)	**Main tasks revolve around:** stakeholder analysis, communication, information and complaints **Responsibilities are:** • Internal/external relationship management • Adequate information exchange between the project organization and the Stakeholders. • Responsible for environmental factors, such as a communication plan, stakeholder analysis, stakeholder strategy.
Technical manager (5)	**Main tasks revolve around:** technical expertise, design, and specification. Furthermore, tasks revolve around technical control and reports. Notable tasks are also innovative characteristics and relation with knowledge partners. **Responsibilities are:** • The execution of the technical process and the accordance with the assignment (carried out by the contractor) • The coordination, direction, and advice for the commissioning of the technology in the project. • The implementation of mitigating/compensating measures. • The management of engineering firms and quality requirements of products • The realization of the program of requirements • The technical manager is responsible for the integral safety
Contract manager (1,2)	**Main tasks revolve around:** contract negotiations, tenders, contract control and market involvement **Responsibilities are:** • Exploration, preparation, drafting, tendering, awarding and the execution of contracts. • Market orientation, exploration and consultation. • Managing the contract towards the realization of the contract scope. • Contract-related products, such as a market scan and a procurement plan.

Source: Rijkswaterstaat (2016) and Turner (2008)

IPM roles, project management and innovation.

In infrastructure development, governments are usually the client of a project. In the case of (DBFM) projects in the Dutch main road network, two governmental bodies play their part. The ministry of infrastructure acts as the client and Rijkswaterstaat acts as the manager and operator, the ministry and Rijkswaterstaat are present as (part of) the public parties in all the cases assessed in this thesis. Next to the public parties, a contractor or consortium fulfills the responsibilities of the DBFM aspects. Innovation in infrastructure projects happens within the (governmental) organization of the project, and can be stimulated through actions of the project management team. In the rest of this paragraph, a framework on the relation between project management and innovation is created.

Projects with multiple stakeholders, like PPP in infrastructure development are prone to what Lodge and Wedrich (2014) call 'multi-organizational sub-optimization'. Which essentially entails the losses in optimization, because of the lack communication and institutional differences. In order to minimize

this, extensive coordination between parties is necessary. It goes beyond creating contracts and includes partnership, trust-building, networking, and mediating (Grotenbreg & van Buuren, 2016; Lodge & Wedrich, 2014). As you can see in table 3, both the stakeholder and the contract manger play a part in minimizing this sub-optimization by increasing the collaboration between internal and external stakeholders. Stakeholder and contract management can not only increase performance of PPP (as is described above), but it also relates to innovation. Managing internal and external stakeholder relations, is beneficial for collective working, risk transfer and long-term commitment, which are (as seen in table 1, chapter 1) all drivers for innovation. With regards to collaborative working, well-coordinated partnerships can furthermore stimulate the complementation of resources and skills, as well as trust and motives (Leiringer, 2006).

Lodge and Wedrich (2014) introduce four administrative capacities as a state's problem solving capacity. They also recognize the importance of the administrative capacities in innovation. Some of these capacities bear resemblance with the roles and tasks of the IPM model in project management. This overlap, together with studies on the administrative capacities and innovation, are used to explain the relation between project management and innovation in infrastructure development.

Especially the relation between what Lodge and Wedrich (2014) call the coordinative capacity and stakeholder management, and what Lodge and Wedrich (2014) call the analytical capacity and technical management is clear. Other IPM roles are not so directly linked towards one of the administrative capacities. Table 4 provides an overview of the connection between the two capacities and the IPM roles, where the black lines show possible overlap between IPM responsibilities and capacity indicators.

Grotenbreg and van Buuren (2016) have specified the use of administrative capacities in infrastructure as means of public support for innovation. Their findings suggest that an extensive deployment of coordination can increase the occurrence of innovation through network management, stakeholder involvement, lobbying and negotiation. Himmel and Siemiatycki (2017) and Rangel and Galende (2010) also recognize the importance of coordination in order to: utilize different roles public and private parties have, and to maximize the complementation of each other's skillsets, resources, and motives that drive innovation.

Hypothesizing the relation between a high deployment of contract management and the increased occurrence of innovation can be tricky. The reason for this is that contract management, together with the management of project control, have a role in the 'control and regulation' system of projects. In planning, a well-functioning control and regulation system is essential in order to manage risks and stimulate investment. On the other hand, control and regulation are not often associated with innovation (Savini *et al*., 2015). This complex role of control and regulation in infrastructure development is also recognized by Savini et al. (2015). They claim that there is a fundamental tension within planning, between control and enablement. The potential of enabling innovation through (self)organization and partnership is recognized, while planning also fundamentally revolves around controlling the environment and the actions of actors in it. This duality makes it tricky for both contract management and management project control to predict the relation between the deployment these roles and the occurrence of innovation.

Table 4, Administrative capacities and IPM roles

IPM roles and responsibilities (based on table 3)	Capacities and indicators capacity related actions
Technical management	**Analytical**:
• The execution of the technical process and the accordance with the assignment (carried out by the contractor)	Commission studies
• The coordination, direction and advice for the commissioning of the technology in the project.	Share public information and expertise
• The implementation of mitigating/compensating measures.	Supply information for permit application
• The management of engineering firms and quality requirements of products	Support subsidy or grant application
• The realization of the program of requirements	Investigate possibilities for innovation
• The technical manager is responsible for the integral safety.	Conduct market consultation
Stakeholder management	**Coordination**
• Internal / external relationship management	Information provision, advice, Organize workshops and meetings
• Adequate information exchange between the project organization and the Stakeholders.	Involve relevant actors
• Responsible for environmental factors, such as communication plan, stakeholder analysis, stakeholder strategy.	Maintain relations with actors involved
	Negotiate and lobby

Sources: Grotenbreg and van Buuren (2016); Lodge and Wedrich (2014)

As said, the analytical capacity coincides with the tasks of the technical manager. It refers to the knowledge and (technical) expertise, which public parties have in ongoing and future projects and problems (Lodge & Wedrich, 2014). Analytical capacity is important for stimulating innovation in two ways. It is important to understand the potential for each innovation in terms of technical novelties, as well as the potential risks and rewards. The interpretation, classification and division of risks can also be positively affected by coordination between parties. Reducing (the fear of) risks through technical knowledge and coordination is important, because risk is often seen as one of the main inhibitors for successful innovation in PPP (see for example Himmel & Siemiatycki, 2017 and Brinkerhoff & Brinkerhoff, 2011). However, taking risks is necessary. Grotenbreg and van Buuren (2016) recognize that accepting risks (opposed to regulation) can stimulate innovation. The recognition of risks as a driver of innovation is also seen in table 1. Due to the argumentation described above, it is expected that an increase in technical management can relate to the occurrence of innovation. Risk reduction trough technical expertise is also done by the client (Rijkswaterstaat). A project management team may deploy extra technical expertise in innovative projects, in order to minimize the technical risks of novelties and increase understanding and collaboration between partners. For clients in particular, extra technical expertise might be deployed to assess, inform, evaluate and manage technical risks if market parties introduce innovative solutions in a projects' design.

Relation between the deployment of public project management and innovation.

From the section above, one can conclude that it is expected that the deployment of stakeholder and technical management can stimulate technical product and process innovation, while the effect of management project control and contract management is less clear. The role of the project manager has a focus on managing the project team. This becomes more complex when projects become more complex, so in innovative projects the role of a project manager could increase. In chapter four, three different analyses are done. The first focuses on cases with higher than expected stakeholder management, in order to test the following hypothesis: extensive stakeholder management is related to innovation because of a better internal and external coordination in a project. The second analysis tries to confirm the expectations that technical management and innovation are related as described above and the third focuses on the (unknown) relation between contract management and innovation and tests the relation in different contexts.

2.3) Procurement result

Definitions, theory and typology

The procurement result is, (as explained in chapter one) the difference between the estimate made by the client and the value of the contract. In this thesis we use the relative procurement result which is defined below:

$$\frac{(\text{Procurement estimation} - \text{contract value})}{\text{Procurement estimation}} = \text{Relative procurement result}$$

The procurement estimation is the expected costs by the client, and the contract value is the eventual result of the bid after contract negotiations. Or in other words the contract value is the minimum price at which the contractor is willing to take on the contract. When the first and later are deducted from each other this gives us the procurement result. In order to be able to compare projects, the relative procurement results are calculated (Verweij et al., 2015).

Verweij et al. (2015) calculated the relative procurement result at infrastructure projects by Rijkswaterstaat, and found that for their sample the average result is around 24%. This means that the average contract value is 24 percent lower than the corresponding estimate by Rijkswaterstaat. In their research it was suggested that a low procurement result could be caused by unrealistically low bids by contractors (which would then be renegotiated after winning), however no evidence of this was found. So, another reason for the ability of firms to bid lower than the estimate is suggested.

Relation between procurement results and innovation

A contract value lower than the original procurement estimation can be caused by a bidder that believes it is able to enhance efficiency and therefore reduce costs. Through this line of reasoning the relative procurement result can be a sign of efficiency enhancing innovations. However, the relative procurement result can also be influenced by other factors, for example market developments and business operations. This thesis sets out to find if a low procurement results and the increased efficiency that goes with that, is a condition that is a necessary or sufficient for the occurrence of product and process innovation. It is not expected that the procurement result will influence the client driven innovation, this because innovations that are part of the assignment by the client are included

in both, the procurement estimation and the eventual contract value. It is interesting to see if a high procurement result will lead to TPP innovations that are market driven. If the increased efficiency is indeed caused by outcome novelty innovation, it can have an effect on the willingness of firms to develop these 'radical' innovations.

2.4) Consortium composition

Definitions, theory and typology

In chapter one an interesting duality is suggested regarding the relation of a consortiums' composition and the occurrence of innovation. In this paragraph an overview of the literature on consortia compositions and how it drivers or inhibits innovation is given. In order to provide a clear overview, four types of consortia are distinguished. (1) consortia with many small firms, (2) consortia with may large firms, (3) consortia with few small firms and (4) consortia with few large firms. These quadrants provide a useful starting point for clarifying the literature on consortium composition and innovation.

The discussion about firm size is relevant because of the duality in argumentations that lead to the occurrence of innovation. Spescha (2018) explains two lines of reasoning, one towards smaller businesses as drivers for innovation, while the other opposing argument favors larger firms. Small firms are said to be more agile, faster in communication and better in change. Furthermore, SME firms are thought to be more driven to innovate, this because SME firms use their innovative capacity as competitive advantage in order to gain market share. A market with a multitude of SME firms innovating with the goal of gaining market share over their competitors lead to competition in innovation (Goffin & Mithchell, 2016). This competition is beneficial for the market as a whole (Spescha, 2018).

The second line of reasoning originates from the Schumpeter idea of economies of scale. Large companies have access to more resources and can devote these towards R&D, which then drives innovation. However, companies with a large market share compete on their efficiency, which is a result of the increasing returns to scale. The drive for innovation (in order to gain market share and compete) seems smaller in a market with fewer large companies (Spescha, 2018). However, as Qi et al. (2010) show, this might not be the case for all types of innovation. Qi et al. (2010) research 'green innovation' (innovation toward increased sustainability), they argue that large companies are prone to public opinion and political pressure and are driven to innovate in order to increase their 'popularity' (and trough this their financial results). Although TPP innovation in infrastructure construction is not necessarily 'green' innovation, societal issues (like congestion, sustainability and nuisance) are often motives for it. So, following the same line of reasoning as for green innovation, public opinion and political pressure can also be a reason to innovate in infrastructure projects.

Goffin and Mitchell (2016) add to the duality described above. They find that on one hand, smaller companies tend to have a higher proportional production of new products, while on the other hand R&D budgets and the amount of patens seems to be higher in large firms. So it is unclear what the relation between firm size and the occurrence of innovation in infrastructure construction is.

Next to the firm size, a consortium is composed out of a multitude of firms, this is a second interesting aspect in relation to innovation. As in PPP the combination of resources and skill sets of different firms is a beneficial factor for consortia. However, with more firms in a consortium transaction costs are

expected to rise. A division between two types of consortia is used in this thesis. There are consortia consisting of a small number of firms, that complement each other's skill sets (with different areas of expertise) and consortia with a large number of firms, with overlap in expertise. The large number of firms make risk allocation a difficult task, furthermore the amount of subcontracts and negotiations increase. As is further explained below, both the risk allocation and the subcontract potentially inhibit innovation.

Relation between Consortia composition and innovation

In order to assess the expected effects of the consortia composition on innovation. The arguments mentioned above are further elaborated on. They are linked to some of the drivers and inhibitors of innovation that are shown in Table 1 (chapter 1).

Small firms can be linked to the freedom of design argument, especially the creative aspects of it (Spescha, 2018). A small amount of firms is beneficial on the aspect of *collaborative working* and *risk transfer*, this because the amount of firms is small enough to build trust and allocate risks among partners, while the firms still stimulate the complementation of skillsets. On the other hand a large amount of firms can result in a reduced *freedom of design* because a multitude of subcontracts is needed to allocate and negotiate risks. Large firms can be expected to stimulate innovation (Qi et al., 2010) through their long term commitment to societal goals (trough political and social pressure). At the same time larger firms are often regarded as less creative being an inhibitor for innovation.

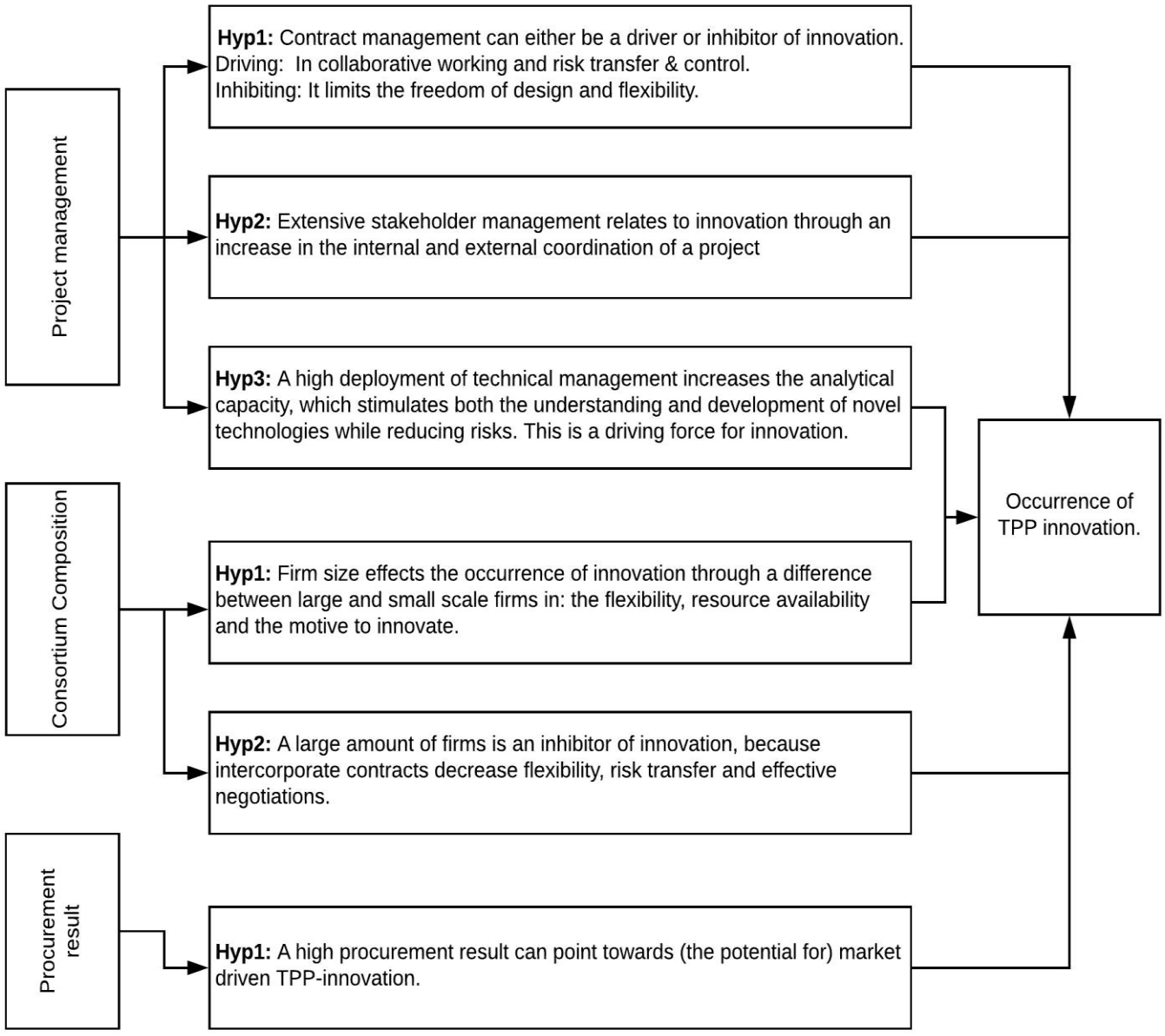
Conclusively a smaller amount of firms in a consortium is expected to have a positive relation to the occurrence of innovation, while hypothesizing the relation between firm size and innovation is more difficult. Still, when taking into account different types of innovation some expected results can be formulated. Small firms are expected to stimulate both outcome novelty innovation (through their creativity) and efficiency enhancing innovation (because of the direct economic driver). However, in the field of construction, the lack of resources for innovation at SME firms (Sexton & Barrett, 2003) and 'popularity' as driver of innovation at large companies (Qi et al., 2010) makes that a positive relation between small contracts and the occurrence of innovation is not necessarily expected. This while large firms are expected to drive outcome novelty innovation in their goal towards 'popularity' by addressing societal issues like congestion, sustainability and stakeholder appreciation.

Analyzing the consortia compositions is interesting for practice as well as academia, the academic duality is explained above. The practical implementation aligns with the current discussion on reducing the contract size. Reducing the contract size is a method for public clients to increase chances and responsibilities for smaller firms within consortia. So, if a positive relationship between smaller firms and innovation is found, reducing contract size can be a policy for public client to stimulate innovation.

2.5) Conceptual model

In the earlier paragraphs, theory and hypotheses on the relation between the input conditions (project management, consortium composition and procurement result) and the occurrence of innovation are made. Figure 2 shows a conceptual model, that integrates these hypotheses in the earlier presented research design (figure 1). The aim of this model is to provide readers with a schematic overview of the conditions and expectations that are part of the scope of this thesis.

Figure 2, a model of hypotheses



The model presented in figure 2 is also used in chapter 5, to provide structure to the conclusions drawn. In chapter 7, a reflection on the use of linear hypothesis and a configurational method is provided. As a reader, take into account that that these statements are hypotheses and not necessarily true. The rest of this thesis revolves around finding evidence for these statements, evidence that either affirm, support or oppose them.

2.6) Area of homogeneity

Area of homogeneity

In order to be able to conduct a systematic analysis of the independent conditions and their (combined) effects on the occurrence of innovation, an area of homogeneity is created. The area of homogeneity are the attributes that are kept stable throughout all researched cases. This is important for comparison because in order to compare cases, cases have to have some attributes in common. In this research the attributes that cases have in common are the type of contract, the project phase and 'infrastructure network' projects are part of.

DBFM(O)

As you can read in chapter one, PPP is defined as: organized cooperation through binding agreements (Koppenjan, 2005). Although PPP might also occur in a truer form of partnership, in infrastructure developments 'contractual forms' of partnership are more common (Klijn, 2009). A broad variety of contracts is used in public-private projects for infrastructure delivery. Examples vary from Design and Build (DB) to Design-Build-Finance-Maintain-Operate (DBFMO) contracts, but also Build-Operate-Transfer (BOT) or Build-Operate-Own (BOO) (Kwak *et al*., 2009; Lenferink, *et al*., 2013). When focussing on the Dutch context, Lenferink et al. (2013) identify the use of EC, DC, DBFM and to some extend DBFMO contracts in infrastructure projects.

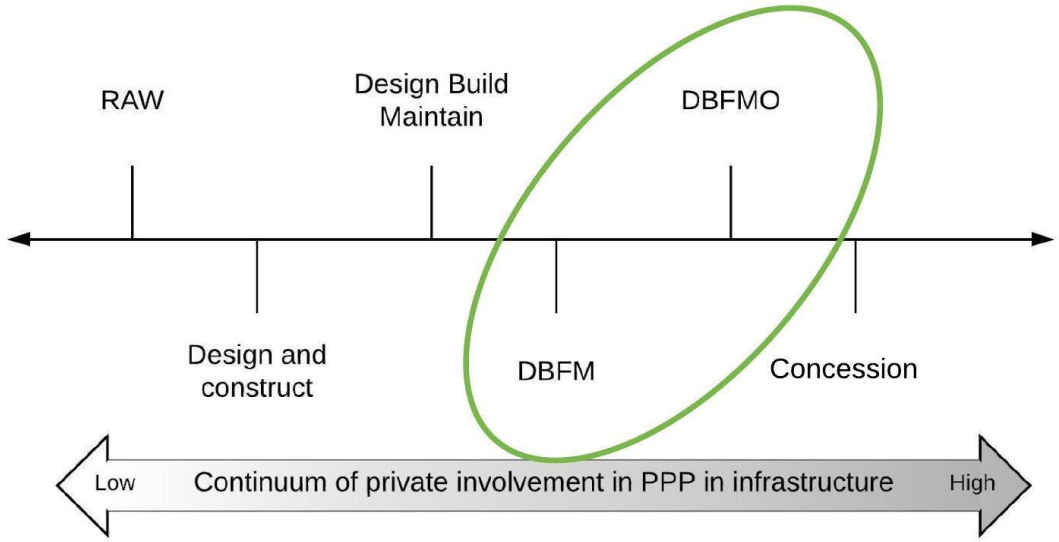
It is widely acknowledged that the type of contract can influence the occurrence of innovation in PPP (see for example: Hodge & Greve, 2007; Klijn, 2009; Kwak, Chih, and Ibbs, 2009). As explained in chapter one, this thesis only includes DBFM and DBFMO contracts. When assessing PPP, it is important to realise that all contracts fit on a spectrum from low to high public involvement. Figure 3 shows this spectrum and the contracts that are focused on in this thesis and where they are placed on the spectrum.

The choice for DBFM(O) contracts has several reasons. First of all, DBFM(O) contracts are the contract type preferred and promoted in (larger) Dutch PPP's in infrastructure development (Reynaers & Verweij, 2014). Secondly, DBFM(O) contracts and efficiency enhancing as well as outcome novelty innovation are closely connected. This, because DBFM(O) is expected to stimulate innovation (Ahadzi & Bowels 2004; Edler & Georghiou, 2007). Main arguments supporting the claim of increased occurrence of innovation are that of a larger *design freedom* and an increased financial stimulant for the contractor. However, because of (among other arguments) the allocation of risks, it is still disputed if DBFM(O) contracts truly stimulate innovation in practice (Kwak, Chih, Ibbs, 2009).

Another noticeable specification of DBFM(O) contracts is that it is not only privately financed (Hodge & Greve, 2007), but it often also contains a performance based reward system for the constructor. In these types of Performance Based Contracts (PBCs) payment is based on the generated outcome created, instead of the amount of input a contractor deploys (Selviaridis & Wynstra, 2015). This can, like private financing, cause inhibiting and driving forces to the occurrence of innovation. So, DBFM(O) contracts are an interesting contract type (in relation to the occurrence of innovation) and for that chosen as the scope of this research. Still, the relation that contracts in general and DBFM(O) contracts in particular have on stimulating innovation are an interesting topic for research but do not fit in the scope and purpose of this thesis.

In conclusion, DBFM(O) contracts are particularly interesting because these are not only PBCs, but they are also privately financed upfront with payments (including bonuses for performance) throughout the entire contract period (Siemiatycki, 2009). Academically DBFM(O) contracts are interesting, because literature is inconclusive whether the performance based and privately financed characteristics are inhibiting and driving innovation. This combined with the predominance of DBFM(O) contracts in practice, make it an interesting contract type for research for both academia and practice.

Figure 3, The contractual scope



Project phase

An second stable factor in the analysis will be the project phase. This is mainly done for methodological reasons. Defining a project phase is important to be able to calculate the public project management that is deployed. This, because the input is varying throughout different phases of the project. Within the project database of Rijkswaterstaat (source database RWS), data is updated every trimester throughout the entire duration of a project. In order to create a comparable sample it is important to analyze the same project phases for every project. In the data a division of different phases is found, ranging from the explorative phase, through the planning and realization phases, to the delivery of a project. As time frame the realization phase and the last year of the planning phase are chosen.

Network

The scope of this research is limited to projects within the main road and waterway network of The Netherlands. This is for reasons of both data availability and to assure projects are comparable. Although these networks are not necessarily more or less interesting than other networks, it does provide a suitable amount of comparable DBFM cases in the Dutch infrastructure network. Conclusively, for reasons mentioned above, the scope of samples in this thesis is limited to DBFM cases in the Dutch road and waterway infrastructure network, during the last year of the planning and the (first years of the) realization phase.

Now that the literature framework and expected relation between each of the conditions and TPP-innovation are clear, the next chapter will focus on the research methodology and operationalization of the in and output conditions. When operationalizing conditions, it is important to bridge the gap between the data and measurements used and the findings in the literature. The operationalization is the focus of the next chapter.

Chapter 3. Methodology and operationalization

In this chapter the methodology and operationalization towards the analysis are elaborated on. The QCA method is introduced and the outcome and explanatory conditions are operationalized to fit the method, furthermore the decision to use this method is justified.

3.1) Why QCA

QCA is an analytical method that identifies conditions and combinations of conditions that are necessary or sufficient in order to reach the outcome condition (Gerrits & Verweij, 2018). For this thesis, it means that QCA can be used to identify conditions or combinations of conditions in respectively project management, procurement result, and consortium composition that are necessary or sufficient for technical product or process innovation to manifest itself.

Within social science, there are two broadly used methodological branches, the 'small N' or 'case oriented methodology' and the 'large N statistical methodology'. Both have their obvious strengths and weaknesses. Small N research excels in examining motives and in examining predictive or causal relations. However, referring to subjects in more general sense is not possible. Large N statistical research can discover patterns that generally hold true, but are non-predictive as they lack in-depth insights of (social) processes (Ragin, 1998; Gerrits & Verweij, 2018). A QCA method finds middle ground here, it enables to assess causal logic within and between cases with regards to the outcome and input conditions, formulated in terms of necessity and sufficiency. A QCA method is also suitable to explain with a certain degree of generalization, at least for all projects that fit into the area of homogeneity (Gerrits & Verweij, 2018). The QCA method spans a N of between 5 and 50 cases and can therefore be seen as a middle N oriented methodology (Ragin, 1998).

The duality of possibilities of the QCA method helps to overcome a shortage of cases and enables towards at least some extent of generalization. At the same time, the QCA method provides the possibility to assess the configurational relation of different conditions. This can provide extra insight on the effect of (for example) project management in different contexts. The duality in possibilities is one of the main reasons for choosing this method. Another reason for the choice of the QCA method opposed to a small N method, is that it provides the ability to compare groups of cases, which is very useful in order to reach the main goal of this thesis.

3.2) QCA, a further introduction

Cases in the QCA method have a membership in sets of conditions, where cases can score as member (1) or non-member (0) of a condition (Ragin, 1998). The Boolean logic (scores of 1 and 0) the method uses has its limitations. Especially in social sciences, attributes often change along a gradient. Furthermore, research in social sciences often makes use of groups of categories or cases, which often contain more than two groups. In order to deal with these issues, *fuzzy sets* are introduced (Ragin 2008). The idea is that cases can be a full member of a set (score 1), a non-member of a set (score 0), but also obtain a score in between. When analyzing fuzzy sets, the membership of cases in sets is referred to in terms like a 'full', 'weak', or 'strong' membership. An example of this is seen in the article by Verweij et al. (2013). In their research on stakeholder satisfaction, they use scores for the input conditions ranging from 0 via 0,33 and 0,67 to 1.

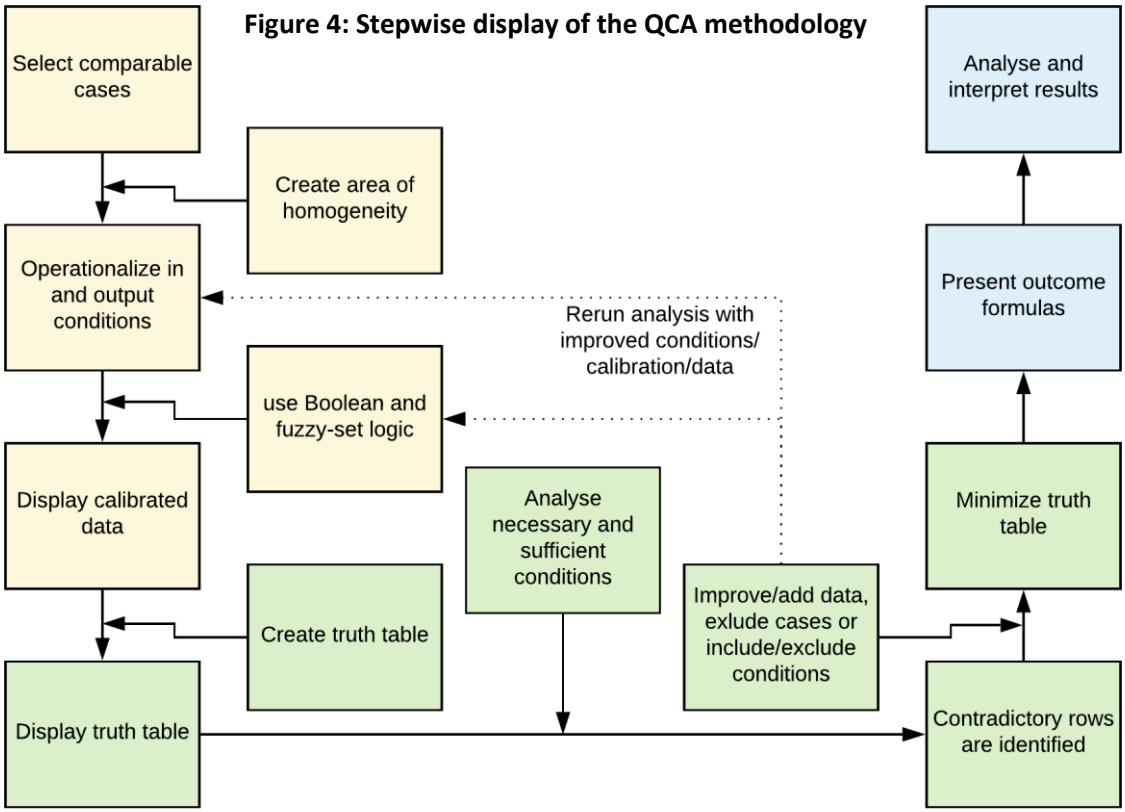
In this thesis, there are eight different possible configurations (2^3) of input conditions. The amount of possible configurations is immediately a downfall for the QCA method. The QCA method is not well equipped to deal with a large amount of input conditions, because the amount of configurations and thus the needed cases grow exponentially if the amount of conditions rise (Ragin 1998; Schneider & Wagemann, 2010).

Analyzing the results, which will be done in chapter four, is done in a truth table analysis. Minimizing the results will lead to the solution formula, which can be interpret in terms of necessary or sufficient conditions. Important is to account for the correct level of consistency and coverage when analyzing the results. In a solution formula, sets and the configuration of sets are expressed using the * sign for 'and', and the + sign for 'or'. Or, using the correct terminology, the + sign shows the equifinality, which means it shows different configurations leading to the same outcome. The * sign shows the configurational causality, or in other words, the causality of configurations of conditions that lead to a certain outcome. Examples of equifinal and causal relation can be found in chapter four. As second and third step of the analysis, it is important to return to the cases and theory when drawing conclusions.

As Ragin (1998) dictates, there are three phases of a QCA:

"(1) selecting cases and constructing the property space that defines kinds of cases (configurations), (2) testing the sufficiency of causal conditions, and (3) evaluating and interpreting the results." (Ragin, 1998, p121)

Figure 4: Stepwise display of the QCA methodology



For selecting the cases, an operationalization of the independent conditions is needed. This is done later in the chapter. Using the three steps described by Ragin (1998) and a standard on good practice of using QCA by Schneider and Wagemann (2010), a stepwise display of the research method is created and displayed in figure 4.

3.3) Case selection

The data used in this thesis was gathered at Rijkswaterstaat. Rijkswaterstaat allowed access to their project databases and next to these databases, Rijkswaterstaat experts and project management teams were consulted in data collection. All data is published anonymized on request of the parties involved.

Before further explaining the operationalization of the in -and -output conditions, it is important to select a comparable group of cases. This group is chosen for both empirical (quality, comparability and availability of data) and theoretical (as is explained in chapter 2.d "area of homogeneity) reasons. For reasons explained in chapter two, all cases will be DBFM cases. Furthermore, the cases are all infrastructure cases found in the database of Rijkswaterstaat. As stated earlier, all cases are projects in the road and waterway infrastructure networks. Also the period over which these cases are examined, is homogeneous. This is, as explained in chapter 2, the later phase of the planning period and the realization phase.

Using the criteria mentioned above, fourteen cases are found that fit the criteria. These are all DBFM contracts, which are projected to finish the realization phase before the end of 2020. Unfortunately, due to missing data, some cases have an incomplete dataset. This leaves 13 cases in the analysis, which have non or limited missing data. For reasons of anonymity, the cases are referred to with case ID's. As case ID's, letters are used, the letters A to M are randomly assigned to the cases.

3.4) Operationalization

Innovation

Innovation is operationalized as; innovation that is perceived through the 'eyes' of the public project management. This is done, because of the public perspective that is used in the thesis. Also a further assessment of innovation was not needed, in order to reach the aim the thesis. Within the scope of the thesis it is only interesting if the organization of a project provides opportunities for innovation (yes or no), so no in-depth analysis of the innovations themselves was done. Still, examples of the innovations are gathered, in order to get some feeling and familiarity with the cases and conditions that are part of the research.

In 2017, a baseline measurement on the occurrence of innovation at Rijkswaterstaat was done (personal correspondence with the department of Innovation and Market, RWS, 2018). This is used as a starting point for operationalizing innovation. The document uses a questionnaire that is answered by the technical manager of projects. It enquires about product and process novelties, the questions are included in appendix a. In the internal baseline document, some of the key questions are: does this project have an innovation requested by the client? Which innovations are brought forward by the market? And, are any of these innovations realized and if so, which ones? Next to the occurrence or absence of TPP innovation, another interesting distinction made in the baseline document, is the distinction between the market or the client as driver of innovation.

Different possibilities are explored for operationalization, options explored are a four-way fuzzy set, a three way fuzzy set and a crisp set. Eventually a three-way fuzzy set with the values of 0, 0.33, and 1 is chosen. This is done because a three-way fuzzy set best fits the data. In the data three groups are found, projects with innovation, projects without innovation and projects with 'little to none', or 'less than expected' innovation. The main goal of this thesis is to test which configurations of condition stimulates the occurrence of innovation, so all cases where innovation occurs score a one. The score of 0.33 is given to the third group in which the technical managers are disappointed by the innovation and a score of zero is given to the cases with no innovation.

In order to confirm the memberships of cases in the groups, information on the innovation in the projects is collected. Technical managers are for example asked to describe the innovation and to make a distinction between market driven and scope driven innovation. This extra information could have been used in order to create a four way fuzzy set. This is not done because in order to test each configuration of conditions for the presence of innovation (as is the aim of this thesis), it is important to discriminate between cases. A 'gap' in scores between positive and negative cases on the topic of innovation helps in doing that. For reasons of anonymity, cases and results are coded. Results are displayed, described and analyzed in chapter four.

The deployment of public project management

The deployment of public project management is operationalized through the hours or FTE's (FullTime-Equivalent, a measurement for the hours of deployments of employees) that are devoted to each of the project management roles. Both the management and the supporting function of each role are taken into account. Although only assessing the FTEs might surpass some qualitative aspect of project management, FTE deployment is a topic that is very interesting for practice. This because insight in the deployment of FTE can help plan and manage projects and project teams. Furthermore, FTEs are used because extensive data on the FTEs (or capacity) of each of the IPM roles is available.

In QCA, it is good practice to operationalize using standards, theory, or expected results. For this reason, information about the standard deployment of the FTEs for each capacity in DBFM contracts is sought. Standards values of the allocation of FTE in DBFM contracts are based on information provided by the NKA (Normering Kerntaken Aanleg) and gathered during a meeting with an expert of Rijkswaterstaat. Unfortunately, these norms are not specified per role, so in order to operationalize project management a benchmarking method needs to be used.

For each role a cluster analysis is conducted. The simple 'average linkage method' is used, as is supported by the QCA tool TOSMANA (Cronqvist, 2017). For each of the roles, the cases are divided into two clusters. The cluster with the higher relative deployment of FTE is scored with a 1, while the cluster with the lower FTE deployment scores a 0. The decision to make two clusters is in line with the Boolean logic that comes with QCA. This decision is supported by the fact that for each of the roles a clear cut-off point between two clusters is found, while this is not necessarily the case for four or six way fuzzy sets. A visualization of the clusters and the cut-off point is presented in appendix b. Ideally, the division of cases into these categories is based on empirical or theoretical input. However, as is described above, a shortage on information makes this impossible, so this benchmarking method is used as an alternative. Table 7 (chapter 4) provides an overview of the calibration, it also shows the minimum and maximum values of each of the clusters.

Procurement result

Procurement result is operationalized as relative procurement result as described in chapter 2:

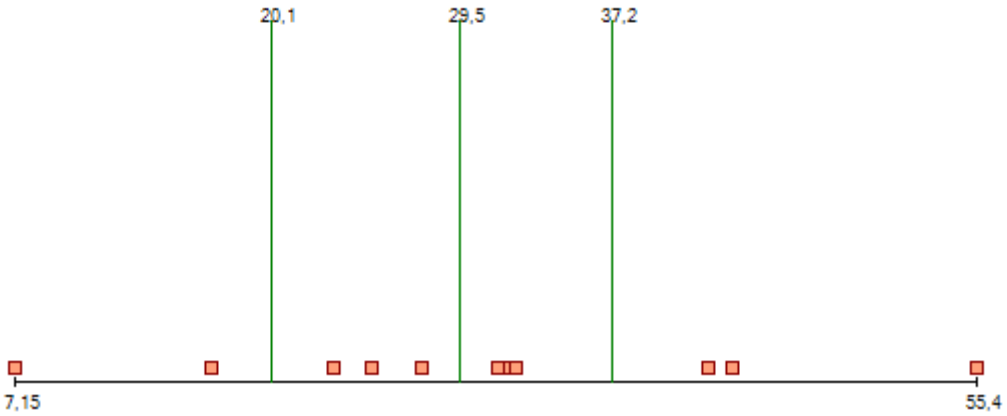
$$\frac{\text{(Procurement estimation – contract value)}}{\text{Procurement estimation}} = \text{Relative procurement result}$$

When operationalizing the procurement result, it is important that the procurement estimation and the contract value take the same phases of a project into account. However, after assessing the available data, it became clear that in the case of DBFM contracts, operationalizing the procurement result is not as straight forward as the equation above suggests. Because of the nature of DBFM contracts, there is not one single procurement estimation available, there are separate estimates for construction, maintenance and operating periods, and some estimations include fictive interest rates (in order to compensate for the long pay out period), while others did not. The same kind of variance was found at the contract values.

In this case, the 'BE-raaming' and the 'NCW gunningsbesluit' are used. Using the Netto Contante Waarde (NCW) (Net Present Value in English), is a way to correct for interest and time related variation in the value of the investment. The 'BE-raaming' is the estimated cost by the client, while the NPV at the tender decision (gunningsbesluit) is the eventual contract value. The data on the 'BE-raming' and the 'NCW gunningsbesluit' value are both gathered from the project database provided by Rijkswaterstaat.

For further operationalization, findings from earlier studies and a cluster analysis are used. It is expected that the higher the procurement result, the larger the potential for innovation. Furthermore, it is expected that the estimates made by Rijkswaterstaat are sound and bids by constructors are reasonable (Verweij et al., 2015), so extreme procurement results are not expected. Results from earlier studies show an expected average result of 24% (Verweij et al., 2015). Figure 5 displays a visualization of a cluster analysis with four cut-off points, a hierarchical clustering method is used (the average linkage method) together with TOSMANA software (Cronqvist, 2017). Each of the points in the figure represents one case (the procurement result was available for 11 cases) and the green lines show the cut-off point between the clusters.

Figure 5, Cluster analysis procurement result



The cluster with high values (cases A, K&M, the case ID's can be found in table 6) show a weak link with the other clusters and is awarded with a score of 1. The two middle clusters are positioned closer to each other, the cluster that consist of cases H,G and I consists of values around the expected result of 24%. While the cluster with cases E, J and L consist of slightly higher values. These two clusters with neither high nor low procurement results are scored with the scores 0,66 (for cluster EJL) and 0,33 (for cluster HGI). This way differentiation between the clusters is made, while taken into account that that clusters close to the 24% (based on an earlier study) should score close to the cut-off point of 0.5. The cluster with the lowest values is clearly distinguishable (B&F), these cases are scored with a score of 0.

Consortium composition

For the operationalization of the consortium composition, the framework presented in table 5 is converted into a four-way fuzzy set. A four-way fuzzy set is used in order to take both company size and the amount of companies in a consortium into account. According to QCA practice, cases which are most likely to lead to the outcome condition are given a score of 1, while the group which is least likely scores a 0. For this condition, it means that cases score 0 if a consortium exists of many large firms, because many large firms are least likely to stimulate innovation. Based on the literature presented in chapter two, the rest of the scores are as follows: 0.33 for many small firms, 0.66 for few large firms, and cases with few small firms score 1 (see table 5).

The terminology 'many', 'few' and 'small' and 'big' are of course not helpful for operationalization. With regards of the amount of firms, the first thing that is kept in mind is the amount of firms. Not only the absolute amount of firms is interesting, also the specialization or overlap in expertise is important (see chapter two and Heuckelum et al., 2007). A consortium is as a consortium with few firms if it consists of three or less firms. An exception is made if a consortium consists of more firms, but all the firms clearly have different areas of expertise. This exception is made because the theory in chapter two suggest that complementing each other's skills increases the innovative capabilities of a consortium. An example where this exception is used is at a consortium that consists of four firms, which are all specialized firms and all part the BAM (as a parent company). Despite the consortium consist of more than three firms, it is still coded as a consortium with few firms.

In DBFM infrastructure development, there are four differentiating fields of work found: asphalt related construction (roads), concrete related construction (bridges/tunnels), dredging and maritime construction, and financing. Therefore, a consortium consists of a few firms, if no more than three firms participate, or if all firms have different areas of expertise and/or operate in different.

With regard to the size of companies, financing/investment firms are not taken into account, because they do not directly relate to TPP innovation. And because the (financial) structure of these firms is different than that of consulting and construction firms (for example, is size measured by investment volume or revenue?), so it is decided to exclude these firms from the scope of the research. The role, type, and size of the investment or financing firms could be an interesting topic for future research, especially if the scope of the research is on financial and organizational innovations, which is not the case in this thesis.

The second aspect taken into account in the operationalization, is the size of the firms. In the Dutch standard categorization, the category of small infrastructure constructers consists of firms with a revenue of less than 15 million euros. The division between medium and large infrastructure constructers lies at 150 million yearly revenues (EIB, 2017). However, because of the nature and size of DBFM contracts, only large firms are represented in the data set. These "large" firms do differ in size (based on revenue), a basic cluster analysis is done. Again a hierarchical cluster analysis is used, figure 6 shows a visualization of the clusters, the green line represents a cut-off point (9688230*K) for the yearly revenue of firms. The orange squares are separate firms, the cluster with relatively small firms is composed of the cases left of the cut-off point, while the cluster of the largest firms is composed of the three cases right of the cut-off point, plus one outlier. The same method is used as in earlier cluster analyses, and a dendrogram of the hierarchical clustering is present in appendix b. Conclusively table 5 shows an overview of the operationalization of the consortium composition. A consortium is considered as consisting of large firms, if at least one firm with a revenue of more than 10.000 million is in it.

Figure 6, Cluster analysis firm size. Note one extreme case is excluded (revenue of around the 40.000.000*k)

Table 5, Operationalization consortium composition

	Many firms	Few firms
Large firms	- More than three firms with at least two in the same area of expertise. - At least one firm with a revenue larger than 10.000 million **Score: 0**	- The amount of firms in a consortium is ≤ 3, or all firms have specialized in different areas of expertise. - At least one firm with a revenue larger than 10.000 million **Score 0,66**
Smaller firms	- More than three firms with at least two in the same area of expertise. - All firms have a revenue smaller than 10.000 million **Score: 0,33**	- The amount of firms in a consortium is ≤ 3, or all firms have specialized in different areas of expertise. - All firms have a revenue smaller than 10.000 million **Score: 1**

In this chapter the methodology was introduced and the conditions operationalized. In other words, for each of the conditions, it is now clear what is measured and to which scores the measurements lead. This operationalization provides a scale for each condition, on which the cases can be placed. The scores of a case on all conditions combined lead to their membership in sets. In chapter four the data are discussed and descriptive analysis is conducted to provide further insights on the data. The truth tables are created and analyzed and the preliminary findings are presented. Discussions, conclusions, and reflections are presented in later chapters of the thesis.

Chapter 4. Data analysis and findings

4.1) Calibration of the cases and descriptive analysis.

In this paragraph, the collected data are described. An overview of the collected data is displayed in table 6. Furthermore, the calibration of the data is conducted following the 'rules' set in chapter 3. The data for all cases is converted to data that are ready for the truth table analysis. The calibrated data are displayed in table 8, it is used in order to conduct the truth table analysis in paragraph 4.2, 4.3, and 4.4. Furthermore, the results are interpreted. In the interpretation of the results, four steps are made. In the first two steps each analysis is interpreted separately, making use of the cases (step one) and comparing the different paths that form the solution formula (step two). Then, a cross comparison between the three analyses is made, and finally in paragraph 4.5, the findings are related to the theory and hypotheses presented in earlier chapters.

General description of cases

All cases selected are DBFM cases in the main road and waterway network in The Netherlands. The contract value varies from 250 million to 1.500 million euro, and Rijkswaterstaat is a key stakeholder in all the contracts. From a public perspective, the management of all projects is done using the IPM model. Market parties have, in most cases, formed consortia where the amount of firms varies between 2 and 7, while only in one occasion a single firm has obtained the contract. The cases are a mixture of tunnels, bridges, road and waterway renewal and often characterize as complex cases with different governmental and non-governmental stakeholders. Being DBFM contracts, the scope of the contracts extends into the exploitation phase, and the market parties are responsible for the maintenance. Table 6 shows the raw data. In this table and in the further analysis, the following abbreviations are used: Project Management (PM), Stakeholder Management (SM), Project Control (PC), Technical Management (TM) and Contract Management (CM).

Table 6	**Innovation**			**Project management (% to total)**					**Procurement result**	**Consortium Composition**	
Case	Occurs	Part scope	Market driven	CM	SM	PC	TM	PM	%	Amount of firms	Consisting of only 'smaller' firms
A	Yes	Yes	No	35,26	21,30	10,55	24,83	8,05	42,02	2	Yes
B	Yes	No	Yes	26,90	23,76	16,93	25,74	6,67	17,08	1	Yes
C	Yes	No	Yes	25,84	27,00	16,77	25,42	4,97		4	No
D	No	No	No	24,44	19,01	7,77	37,54	11,24		7	No
E									31,47	3	Yes
F	Yes	No	Yes	20,41	21,48	18,10	28,90	11,12	7,15	4	Yes
G				15,90	37,88	13,56	21,56	11,09	23,15	4	Yes
H	Yes	No	Yes	20,64	29,21	13,10	22,83	14,22	27,58	3	No
I	No	No	No	27,28	21,85	13,71	30,96	6,20	25,07	4	No
J	Yes	No	Yes	31,50	15,53	12,81	33,10	7,07	32,33	2	Yes
K	Yes	No	Yes	21,59	23,73	15,96	29,20	9,52	43,14	7	Yes
L	Partly	No	Yes	27,50	17,39	11,39	36,66	7,05	32,06	4	Yes
M	Yes	No	Yes	29,97	16,58	13,86	33,58	6,01	55,40	3	Yes

Innovation: data collection and calibration

With regard to innovation, most cases (8 out of 11) show TPP innovation. The first remark that has to be made, is that due to difficulties with the data collection, some information on the perception of innovation is obtained from the project manager and not the technical manager. Furthermore, in one case, information about innovation is obtained through interviews with others who are not currently part of the project team. However, most information is (in accordance with the 'rules' laid out in chapter three) obtained using questionnaires with the technical managers of the projects.

In accordance with the theoretical focus, the questionnaire focused on the product and process innovation. If the occurrence of technical innovation was claimed to be present, there is asked for examples. This is done in order to get insight in the innovations and how the managers interpreted the questions. For reasons of anonymity, an overview of the answers of the survey is not included, answers can too easily be traced to specific projects. In general, a case scores 1 if product or processes are described that are classified as innovative by technical mangers. One single case is given the score of 0.33, this because although multiple innovations were provided by the market, most of them are not realized and while some improved techniques were used to minimize nuisance during construction, they did not change the process of products used.

A variety of different innovations is described by the managers. Different categories can be made. A first category consists of innovations towards the energy neutral operation and production of infrastructure. Examples are an energy neutral operating lock, or the installation of solar panels as part of the infrastructure development. A second category, are innovations towards a circular economy. Examples are a circular fly-over, and recycling methods for concrete. A third type of innovation, is innovation that is found in the installation or maintenance of products. An example is removable lining on road in order to enhance the process of asphalt maintenance. Finally, some innovations revolve around pilots or try-outs of (measurement) tools that streamline processes in the infrastructure development, for example try outs with tools like Dubocal a calculation method for the environmental impact of concrete.

Interesting is that in most cases where innovation occurs, the innovation is driven by the market. A reason for this can be that one of the features of DBFM contract is to give the market a large freedom of design. Case A is the only exception, this because a pilot on circular design and environmental construction was part of the scope. In none of the other cases a pilot was a specific part of the assignment. Market parties did in this case come up with a design that fit the scope and so, innovation in environmental friendly construction methods became part of the project.

The deployment of public project management: data collection and description

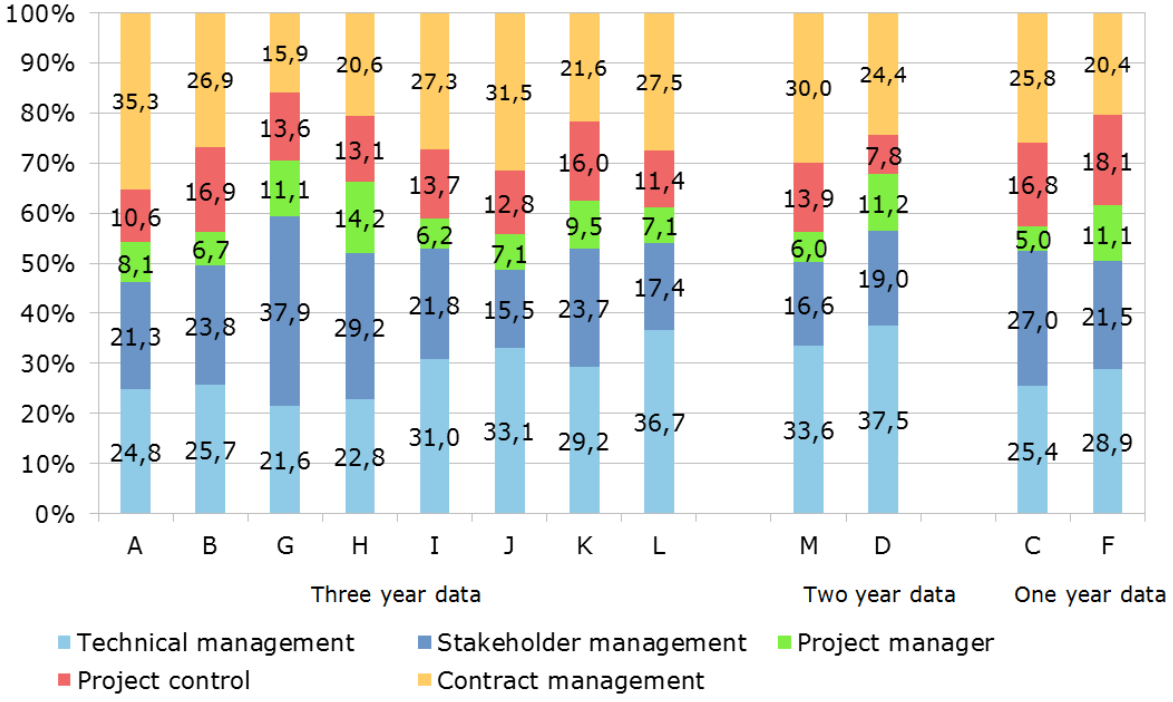
The data for public project management are composed of the average deployment of FTEs in the IPM roles during the first three years of the realization phase. The first three years are used, because all the cases have at least three years of realization phase, so data are often available. For each role the average deployment of FTE in the first three years of the realization phase is formulated as percentages of the total (of FTE of project management per project). This relative expression is used in order to be able to make a comparison between the cases, so for each row in table 6 the aggregated percentage on project management should be 100%. The data are composed of both the management roles, as

well as the supporting personnel for each role. A visual expression of the data is shown in figure 7. Before further analyzing the data, some comments on data collection have to be made.

In the cases C, D, F and M not all data were available, meaning that data on one or two (of the first three) years of the realization phase is missing. For these cases, the average of the available data is used. These cases all fit within existing clusters, so distortion because of this data irregularity are expected to be minimum. The fact that not all years of data were available, occurred because data collection had not started in the early stages of the realization phases of these projects jet. A second remark about the data gathering, is that for projects I and J only the combined data of a larger project cluster (or group) is available. These data are included in the analysis, if these cases show results that are not supported by other cases, the inconsistency has to be kept in mind. Figure 7 shows a visualization of the capacity deployment as it is displayed in the raw data matrix.

In order to test the hypotheses on technical, stakeholder and contract management, three separate analyses are done. Cases are grouped by their membership of the high or low cluster for each of the three roles. In table 7, the data calibration is displayed. Next to the data findings, the cut-off point of the clusters, and the score this results in are included. The rows labeled score are also included in the calibrated data matrix shown in table 8.

Figure 7 **Relative deployment IPM roles in DBFM projects during the first three years of the realization phase**



With regard to contract management, clustering the data resulted into two distinguishable groups that span cases between 15,9 till 21,6 and 24,4 till 35,3. For stakeholder management, one extreme case (case G) influenced the cluster analysis in such a way that it formed a cluster on its own. It was chosen to 'ignore' this extreme case in defining the clusters, the extreme case is added manually to the second cluster (cluster with the largest value). The cluster boundaries for stakeholder management are 15,53 till 23,76 and 27 till 37,88. Technical management again provided a clear distinction between two

clusters with 5 and 7 cases in it. The clusters span 21,56 till 25,74 and 28,9 till 37,54. The clusters are created using a hierarchical average linkage method, in the same way as is done in chapter three, both the TOSMANA visualization and the dendrograms are included in appendix b. As said, table 7 shows the score calibration, in 7b the cut-off points of the clusters that are used for benchmarking is included.

Table 7a, Score calibration for project management

	CM		SM		TM	
Case	**%**	**Score**	**%**	**Score**	**%**	**Score**
A	35,26	1	21,30	0	24,83	0
B	26,90	1	23,76	0	25,74	0
C	25,84	1	27,00	1	25,42	0
D	24,44	1	19,01	0	37,54	1
E						
F	20,41	0	21,48	0	28,90	1
G	15,90	0	37,88	1	21,56	0
H	20,64	0	29,21	1	22,83	0
I	27,28	1	21,85	0	30,96	1
J	31,50	1	15,53	0	33,10	1
K	21,59	0	23,73	0	29,20	1
L	27,50	1	17,39	0	36,66	1
M	29,97	1	16,58	0	33,58	1

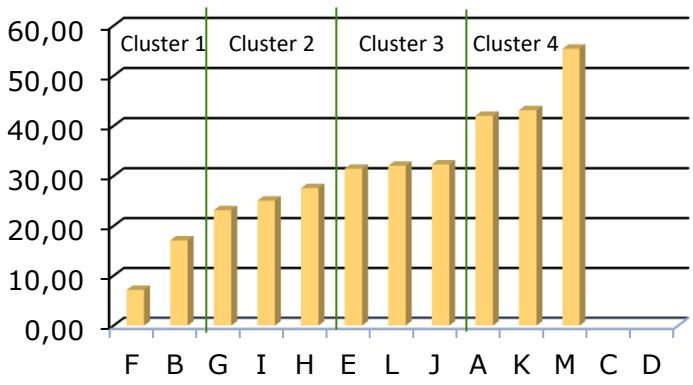
Table 7b, Clusters used for calibration

		Min	Max
CM,	Cluster 1	15,9	21,95
	Cluster 2	24,44	35,26
SM,	Cluster 1	15,53	23,76
	Cluster 2	27	37,88
TM,	Cluster 1	21,56	25,74
	Cluster 2	28,9	37,54

Procurement result: data collection and description.

A first glance at the data of the procurement results shows a variety of values. The average procurement result in the sample is 30,59%, meaning that on average the contract was 31% cheaper than the maximum price the ministry was willing to pay. Two cases stand out, because unfortunately no data was available The data unavailability occurred because there is no certainty on the estimate by Rijkswaterstaat (the BE-raming).

Figuur 8, Procurement result %



As said, the average procurement result is 30,59%. However, the deviation is high. The average deviation is 9,62 and the maximum and minimum values are 7,15% and 55,40%. Figure 8 shows an overview of the findings. The findings show a higher average than expected, based on an earlier study (24%) (Verweij et al., 2015). However, in the sample of the earlier study, both D&C and DBFM contracts are included, while in the present sample only DBFM contracts are included. An explanation of this can be in the measurement of the procurement result in DBFM project. Not the eventual contract value, but the 'NCW gunningsbesluit' (see chapter 3) is used in order to calculate the procurement result. This because of the different nature and duration of the contract. Two of the clusters (defined in chapter 3) are composed of values on or around the expected average result. All four clusters are clearly distinguishable, meaning that no cases in different clusters have

values close to each other. Next to the two cases with missing data, no further problems in data collation or calibration were experienced. The calibration (which is done in accordance with the 'set of rules' created in chapter three), is displayed in table 8.

Consortium composition: data collection and description

As one can see in the raw data matrix, up to as many as seven firms are responsible for the DBFM aspects of the contract and officially part of the consortia. Notable is that in some cases different specialized parts of one overarching firm take part in a consortium as "separate" firms. An example is the BAM, who operates in one consortium with BAM Infratechniek, BAM PPP, BAM Wegen, etc., all these (BAM) firms are accounted for as different specialized firms. This because such consortia do fit the bill regarding the hypothesis that the complementation of specialized firms stimulates innovation (as they complement each other skills). The calibration is done using the 'set of rules', presented in table 5 (chapter 3). The results of the calibration are shown in the calibrated data matrix (table 8).

The median of the amount of firms in the consortia is four, with a minimum and maximum of one and seven. In four out of thirteen cases at least one firm that is part of the consortium comes from the group of 'largest' firms.

Table 8, Calibrated data matrix

		Project management				
Cases	Innovation	CM	SM	TM	Procurement result	Consortium composition
A	1	1	0	0	1	1
B	1	1	0	0	0	1
C	1	1	1	0	-	0
D	0	1	0	0	-	0
E	-	-	-	-	0.66	1
F	1	0	0	1	0	1
G	-	0	1	0	0.33	1
H	1	0	1	0	0.33	0,66
I	0	1	0	1	0.33	0
J	1	1	0	1	0.66	1
K	1	0	0	1	1	0,33
L	0,33	1	0	1	0.66	0,33
M	1	1	0	1	1	1

In the rest of this chapter, the truth table analysis is presented. For each of the three analyses a truth table and a solution formula are created, in order to do the analysis, the fsQCA software of Ragin is used (Ragin & Sean, 2017). Innovation is set as the outcome condition, while the other conditions are set as input. The score of the outcome condition has to be entered manually, this score is based on the consistency threshold (Ragin, 2010) and on the data on innovation for the cases. The consistency threshold is based on the difference between configurations of conditions that are a consistent subsets of the outcome, and between configurations that are not. In QCA, the consistency of sets is reported in the raw consist, the PRI and the SYM columns of the truth table. In general, configurations (i.e., truth table rows) with a consistency score larger than 0.8 are considered as consistent and receive a score

of 1 as score for the outcome condition (in this case innovation). The general 'rule' for the consistency threshold is 0.8. However, if the division of consistency scores shows a logical cut-off point around the 0.8, this could be taken as constancy score instead.

Before each of the three separate analyses is done, an analysis of necessity is conducted using the fsQCA software (Ragin & Sean, 2017). The analysis of necessary conditions tests each condition separately, in relation to the occurrence of innovation. The results are presented in table 9, a condition is necessary if the conditions' consistency is higher than 0.9. In this case, the highest consistency found, is for the condition consortium composition with a score of 0.81.

Table 9, Analysis of necessary conditions	Consistency	Coverage
CM	0.590723	0.721667
SM	0.136426	1
TM	0.590723	0.721667
ProcuremntRes	0.589359	0.867470
ConsComp	0.817189	1

4.2) Innovation and contract management

Truth table analysis

As the first of the three analyses, the truth table analysis for innovation (as outcome) and contract management, procurement result and consortium composition (as input conditions), is done. The truth table and results are displayed in table 10. All configurations (i.e., truth table rows) that represent at least one case are considered as relevant and therefore displayed. Of the eight possible configuration (2^3), six of them have at least one case in it. The truth table (table 10) is sorted on raw constancy, because this is used to determine the score of the outcome condition.

When analyzing, the researcher has to decide if he wants to use the complex, the intermediate of the parsimonious solution. In this case, the complex solution is chosen, as is done in Verweij et al. (2013). The complex solution does not include configurations of conditions that are not present in the sample. A conservative method is needed when assumptions on the relation between in and output conditions are debated on, or inconclusive. As one can read in chapter two, these debates are found in the input conditions used in this research. For example, the relation between project management and innovation, as well as consortium composition and innovation are of interest, because hypotheses point in different directions. So, the complex solution is used.

The model that is tested, can be described as; innovation= f (Contract Management, Procurement Result, Consortium Composition), and results are calculated using a Quine-McCluskey algorithm (Ragin % Sean, 2017). The frequency cut-off (the amount of cases in a row before it is relevant) is set on 1 case, and the consistency cut-off is 0.8. In practice, the consistency cut-off turns out to be 1, because the first row to exceed the 0.8 has a consistency of 1. With these boundaries, the first four rows of table 10 are relevant and consistent, while the fifth and sixth row are relevant, but inconsistent. In table 10, the truth table is presented. Each row represents a configuration of conditions that is found in the data. The column 'number' represents the amount of cases that share this configuration, the letter for these specific cases are mentioned in the row 'cases'.

Table 10a, Truth table analysis with contract management as one of the input conditions

CM	ProcuremntRes	ConsComp	Innovation	Cases	Number	Raw consist.	PRI consist	SYM consist
0	0	1	1	H,F	2	1	1	1
1	1	1	1	M,A,J	3	1	1	1
0	1	0	1	K	1	1	1	1
1	0	1	1	B	1	1	1	1
1	1	0	0	L	1	0.3333	0	0
1	0	0	0	I	1	0.3267	0	0

As one can see in the results (table 10b), there are three different paths that lead to innovation. The solution has a coverage of 0.84 and a consistency of 1. Table 10b furthermore shows the coverage and consistency for each of the three paths that form the solution formula. Both the coverage and the consistence of the combined solution are high. The solutions' coverage tells something about the explanatory value of the solution. Or in other words, the percentage of cases in which the occurrence of innovation is explained by the solution.

Table 10b, Results	**Raw coverage**	**Unique coverage**	**consistency**	**Cases**
~ProcuremntRes*ConsComp	0.409277	0.181446	1	B, F, H
CM*ConsComp	0.545702	0.362892	1	M, A, J, B
~CM* ProcuremntRes*~ ConsComp	0.136426	0.0914052	1	K

Solution coverage	0.863574	
Solution consistency	1	

As explained in chapter 3, the results of a truth table can be interpreted as necessary or sufficient conditions. Necessary or sufficient conditions occur if a causal relation between a single condition and the outcome is found. As seen in table 9, no necessary conditions is found. Furthermore, the truth table shows no sufficient conditions. There are sufficient configurations of conditions, though. In this case, a equifinal causation is found. This means that there are multiple configurations of conditions that produce the outcome (Schneider & Wagemann, 2010). As seen in table 10b, three combinations lead to innovation. Furthermore, all the separate conditions that are found in these three paths are INUS condition. INUS stands for, Insufficient but Non-redundant parts of a configuration which is itself Unnecessary but Sufficient. In other words, all these conditions can be related to the occurrence of innovation, but only in combination with other conditions, while none of the conditions is present in all three paths.

Interpretation

Cases B, F, and H (that represent ~ProcuremntRes*ConsComp → innovation) are all found in the two lowest clusters of the procurement result (see figure 5). With regard to consortium composition, the cases score 0,66 or 1, meaning that the consortia consist of few firms, while the size of firms varies. So, if the procurement result is low, innovation is found in cases with consortia that consist of few firms, with both large and/or small firms in it.

Cases M, A, J and B score high in both contract management and consortium composition. All the consortia in these cases consist of 'a few smaller firms', while the deployment of contract management

is relatively high. Finally, case K shows that a low deployment of contract management and a low score on consortium composition can also relate to the occurrence of innovation, but only in a combination with a high procurement result. Case K is unique, because it is one of the only cases with a consortium consisting of many (seven) small firms. Case K proves that a low score on consortium composition is not an inhibitor for innovation, if it is part of the right configuration. Case K is interesting for discussion and is elaborated on in chapter 5.

The solution path ~ProcuremntRes*ConsComp → Innovation is compared to ~CM*ProcuremntRes*~ ConsComp → Innovation. In these paths, the scores for procurement result and consortium composition are opposing each other. Different possible explanations can be thought of. First of all, the conditions procurement result and consortium composition might be related to each other, where a high procurement result is more likely to occur in a consortium with many (large) firms and the other way around. Secondly, a variable which is not accounted for (as input condition or in area of homogeneity) might explain innovation, regardless of the scores for procurement result and consortium composition. Thirdly an explanation might be found in case K which is further discussed in the next chapter.

First conclusions

In this analysis, there is no single condition to explain the occurrence of innovation. The findings support evidence for the importance for a configurational approach towards the conditions, however. Due to the method used, this could have been expected. More interesting is that the hypothesis that both a high and a low deployment of contract management can lead to innovation is (to a certain extent) confirmed, but only within the right configuration of conditions. Furthermore, after comparing the solution paths amongst each other, a possible relation between the conditions procurement result and consortium composition is found. This is interesting for discussion and further research.

4.3) Innovation and stakeholder management

Truth table analysis for innovation and stakeholder management.

With regard to Stakeholder management, the model that is analyzed is: Innovation= f (Stakeholder Management, Procurement Result, Consortium Composition). Results are again calculated using the Quine-McCluskey algorithm (Ragin & Sean, 2017). The frequency cut-off is the same as in the earlier analysis, being 1. This leaves five out of the eight possible configurations occupied. The consistency cut-off is again placed on 0,8. The truth table is displayed in table 11a.

Table 11a, Truth table analysis with stakeholder management as one of the input conditions

SM	ProcuremntRes	ConsComp	Innovation	Cases	Raw consist.	Number	PRI consist	SYM consist
0	1	1	1	M,A,J	1	3	1	1
0	0	1	1	B,F	1	2	1	1
1	0	1	1	H,	1	1	1	1
0	1	0	0	K,L	0.60241	2	0.503759	0.503759
0	0	0	0	I	0.326733	1	0	0

Table 11b, Results	Raw coverage	Unique coverage	consistency	Cases
~ProcuremntRes*ConsComp	0.409277	0.0900409	1	F,B,H
~SM*ConsComp	0.727149	0.407913	1	F, B, J, A, M

Solution coverage	0.817189	
Solution consistency	1	

As seen in table 11b, the solutions coverage is 0.81 and the consistency is 1. Cases associated with the term a low procurement result in combination with a high score on consortium composition, are cases F,B, and H. Those associated with a relatively low deployment of stakeholder management in combination with a high score on the consortium composition, are F, B, J, A and M.

Again an equifinal causation is found in the analysis. A high score for consortium composition is part of both solution paths, an analysis of necessary conditions is done, but does not show any necessary conditions.

Interpretation

Cases F, B, and H, all score high for consortium composition, with scores of 1 and 0,66, meaning that the consortia of all these cases consist of few firms, while both large and small firms are included throughout the different cases. Cases F and B are the cases with the lowest procurement result, while H is in the second cluster. Also, for this solution formula, it is important to remember that only the combination of a high score on consortium composition in combination with the low score on procurement result lead to the occurrence of innovation.

A high score on consortium composition is present in both solutions paths. The importance of this variable is furthermore stressed, because of the high consistency in the analysis on necessary conditions (table 9). Still, a high score on consortium composition only leads to innovation in combination with other conditions. Again, the configurational characteristics of the relation between the input and output conditions is stressed.

The third step of the interpretation is comparing the different truth table analysis. In both the analysis that are done so far (in 4.2 and 4.3), the solution path ~ProcuremntRes*ConsComp → Innovation is found. These findings support each other, and are to some extend unexpected. This is further discussed in chapter 5.

First conclusions

This analysis again stresses the importance of the configuration of conditions. In this analysis, a high score on consortium composition plays a central role. More interesting is that both solution paths show surprising results. Both a low procurement result, as well as a low deployment of stakeholder management are part of configurations that can be related to the occurrence of innovation, while this was not expected. It are interesting topics of discussion, which are further elaborated on in chapter 5.

4.4) Innovation and technical management

Truth table analysis for innovation and stakeholder management.

The model analyzed with regard to technical management and innovation is: Innovation= f (Technical Management, Procurement Result, Consortium Composition). Again, the frequency cut-off is 1, and the consistency cut-off is 0.8. Table 12a shows the truth table analysis, six out of the eight possible configurations have at least one case in it.

Table 12a: Truth table analysis with technical management as one of the input conditions

TM	ProcuremntRes	ConsComp	Innovation	Cases	Number	Raw consist.	PRI consist	SYM consist
0	0	1	1	B,H	2	1	1	1
1	1	1	1	J,M	2	1	1	1
1	0	1	1	F	1	1	1	1
0	1	1	1	A	1	1	1	1
1	1	0	0	L,K	2	0.60241	0.503759	0.503759
1	0	0	0	I	1	0.326733	0	0

Table 12b Results	**Raw coverage**	**Unique coverage**	**consistency**	**Cases**
ConsComp	0.817189	0.817189	1	A, B, F, J, M, H

Solution coverage	0.817189	
Solution consistency	1	

This analysis shows a simple relation between the presence of a high score on consortium composition and the occurrence of innovation. A high score on consortium composition is, in this case, a sufficient condition. It was tested on necessity, however (as seen in table 9), none was found.

Interpretation

The interpretation of the results is in this case straight forward. All cases with a high score for consortium composition, have innovation present, while the scores on the deployment of technical management and the scores for the procurement result are mixed and inconclusive. Cases F, B, J, A, M and H are all represented by the solution formula, with a coverage of 0.81. For the conditions of technical management and procurement result, no relations with the occurrence of innovation are found. If the analysis is compared to the two earlier analyses, one can see that in most paths a high score on consortium composition plays an important role. The presence of this variable throughout the analyses strengthens conclusions drawn in relation to this condition.

First conclusions

Because consortium composition is a sufficient condition, the hypothesis that a consortium with relatively few and relatively small companies stimulates innovation is supported by the findings. However, no necessary relations are found, so, there might be other conditions or configurations of conditions (not included in this study) that relate to the occurrence of innovation. Still, a high score on consortium composition seems strongly related to the occurrence of innovation. A high score on consortium composition is not a necessary condition because a contradiction is found in case K. Innovation does occur in the case, while it has a low score on consortium composition. This contradiction is earlier noticed in paragraph 4.2 and case K is further elaborated on in chapter 5.

4.5) The relation between theory and the results.

In the previous paragraphs of chapter four, some first conclusions were drawn. A further analysis on the relation between theory and the results is conducted in this chapter and unexpected results are highlighted. In the next chapter these results are discussed.

The deployment of public project management

The hypotheses and research done on public project management is based on the deployment of IPM-roles in the project management teams of Rijkswaterstaat. Three roles, contract management, stakeholder management and technical management are of particular interest. An analysis was run and the result for the analyses are shown in chapter four. In none of the three roles, the deployment of FTE is an explanatory condition for the occurrence of TPP-innovation by itself. Still, contract and stakeholder management are part of configurations that point towards the occurrence of innovation.

A first interesting finding is that both a relatively high and low deployment of contract management can lead to the occurrence of innovation. The literature is inconclusive on the relation between contract management and innovation. The results of this thesis show otherwise. The relative amount of contract management that can be related to projects in which innovation occurs is not unknown, but dependent on the configuration of other (organizational) conditions.

With regards to the deployment of stakeholder management, unexpected results are found. The hypothesis suggested that a relative high deployment of stakeholder management could point towards the occurrence of innovation. However, this is not supported by the findings. Only the relative under-deployment of stakeholder management is part of a configuration of conditions that is related to the occurrence of innovation (~SM*ConsComp → innovation). Also, technical management does not react as expected. Again, according to the hypothesis, a high deployment of technical management is expected to point towards innovation in projects, while no results that support this hypothesis are found. Possible explanations for these, in some cases, unexpected findings are provided in the next chapter.

Procurement result

Researchers and professionals within the field of infrastructure development have been interested in the reasons for high procurement results (see for example Verweij et al 2015). In theory, one of the reasons for high procurement result is that market parties see potential for innovations that reduces costs. As part of this thesis evidence for this theory is sought. In all cases, a positive procurement result is found, meaning that market parties always operate for a price below the clients' procurement estimation. In order to assess the procurement result, clusters are made and clusters with a higher score are compared to clusters with a lower score. The results are mixed. The condition of a relative high procurement result in itself is not diversifying enough to be a necessary or sufficient condition. Still, both a high and a low procurement result are part of configurations of conditions as an INUS condition.

It is interesting that in two of the three analyses, a relatively low procurement result is part of the solution formula. This is not directly in line with the hypothesis made in chapter two and does not support the idea that a high procurement result is caused by the potential of innovation that is seen by the market. Possible mechanisms behind the result that a low procurement result in combination

with a high score on consortium composition lead to the occurrence of innovation are discussed in the next chapter.

Consortium composition

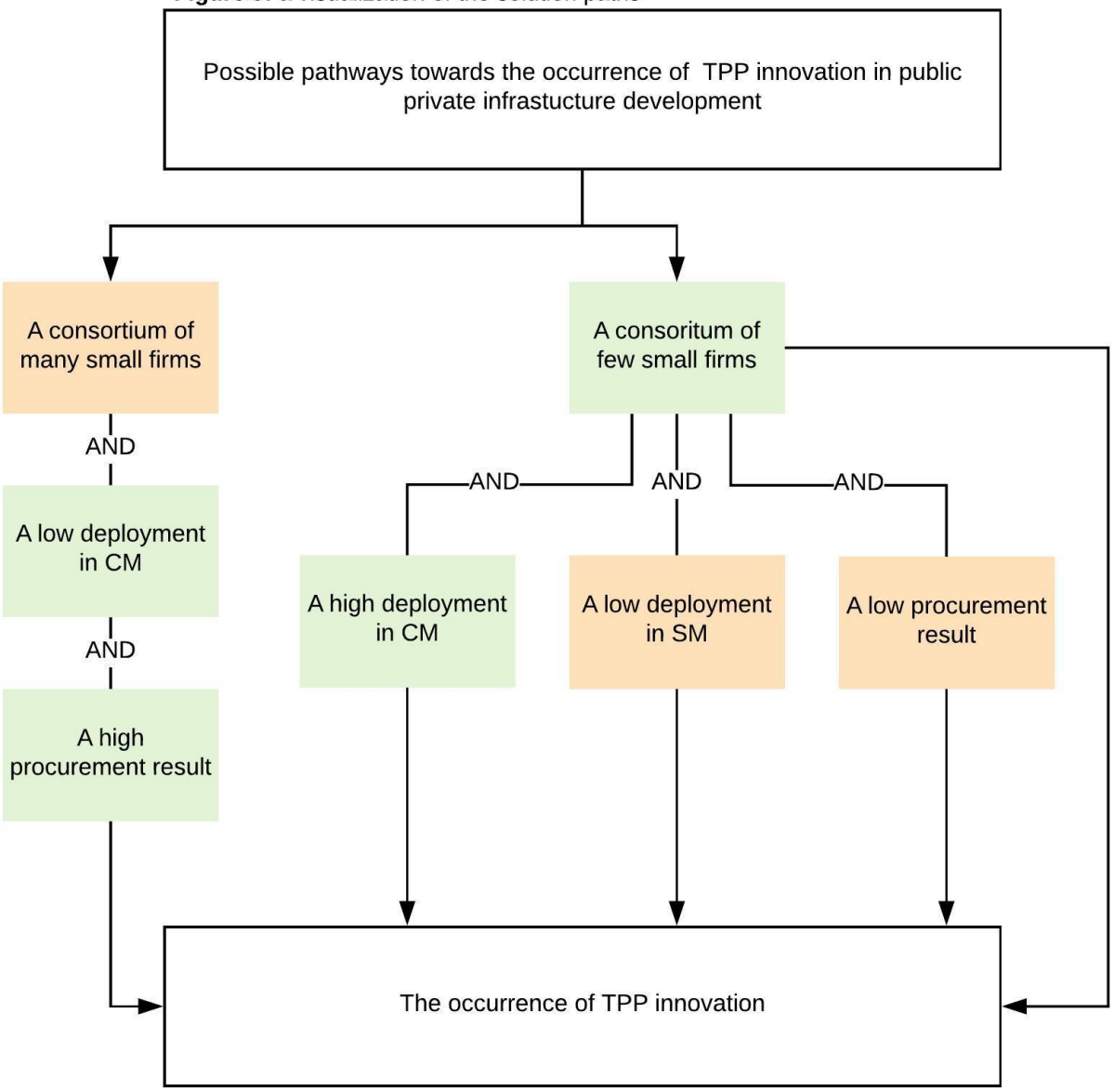
A high score on consortium composition is present in all the solution paths in two of the three analyses done. In the third analysis, only one case suggests a relation between a configuration composed of (among others) a low score on consortium composition and the occurrence of innovation. So, the majority of the evidence points towards a clear relation between consortia that consist of few (smaller) firms, to lead to the occurrence of innovation.

The findings in this thesis support the statement that fewer companies stimulate the occurrence of innovation. This is also expected from theory and part of the hypotheses displayed in chapter two. With regards to firm size, Spescha (2018) possess two possible lines of reasoning, one in favor of bigger firms to stimulate innovation, while the other (more classical argument) favors smaller firms. Although the result points towards smaller firms to stimulate innovation, this result is less distinctive than the findings on the amount of firms. Findings on this topic are less distinctive, because supporting cases almost unambiguously consist of few firms, while the data on firm size is more heterogeneous.

Chapter 5. Discussion

The relations between the conditions and the occurrence of innovation were presented in chapter four. In the coming chapters, how and why these relations occur, is discussed. Interesting findings and peculiar cases are highlighted in this chapter and explanations for some of the unexpected results are suggested. These explanations are based on the literature, but also on my own and experts' opinions. Figure 9 is a visualization of the findings in chapter four and shows the different combinations of conditions that lead to innovation. Unexpected results (results that do not align with the hypotheses shown in figure 2) are marked with an orange color, so if one of the conditions within a solution path is marked, unexpected mechanisms drive this solution which are relevant to discuss.

Figure 9: a visualization of the solution paths



5.1) Discussion

In general, project management does not react as expected and neither is it a necessary or sufficient condition. Still, if combined with other conditions, some unexpected relations are found. A couple of different reasons for these unexpected results are suggested. More reasons might exist, so this is an interesting point of discussion. With regard to project management, the following three findings are interesting to discuss:

- Both a high and a low deployment in contract management can lead to the occurrence of innovation, (as parts of different configurations of conditions).
- A relative low deployment of stakeholder management is part of a configuration that leads to the occurrence of innovation, while a high deployment is not.
- Neither high, nor low deployment of technical management is found to be a part of any configuration that leads to innovation.

As seen in chapter four, the relation between (the deployment of) contract management and innovation is dependent on a configuration of different conditions. So, the hypothesis that both a high and a low deployment of contract management can lead to innovation is proven. In theory innovation is on one hand related to an increase in contract management, because the novelty and the potential risks of innovations relate to contract negotiations or changes, while at the same time, the strict interpretation of contracts can also limit the flexibility within a project that is needed to innovate.

As shown in figure 9, an unexpected result is found with regard to stakeholder management. A possible explanation for this might be assumptions made on the cause-effect relation for the project management conditions. One of the main theoretical arguments is that over-deployment of technical and stakeholder management, would reduce complexity and risks, and through that stimulate innovation (see chapter 2). However, the other way around, a relative over-deployment of technical and stakeholder management could also be a sign of complex problems which are less suited for innovation to occur. In other words, it might not be the project management that stimulates innovation, it might be a matter of complexity.

A lower complexity can be beneficial for collaborative working, risk transfer and long term commitment, which can all increase the occurrence of innovation (see table 1). The complexity of projects can furthermore increase the risk profile and an increase in risk is a known inhibitor for innovation (Himmel & Siemiatycki, 2017 and Brinkerhoff & Brinkerhoff, 2011). Opposed to complex projects, well-coordinated projects are related to the occurrence of innovation (Himmel & Siemiatycki, 2017, and Rangel Galende, 2010). A new line of reasoning that emerges is that a high deployment of public stakeholder management occurs in complex projects, in an attempt to increase the (quality of) coordination of public-private projects. Including this matter of complexity can be interesting for future research. It can for example be interesting to assess if complex projects with a high deployment of coordinative project management roles, perform better on the subject of innovation than complex projects that have an average or low deployment of these roles.

Another possible explanation for the unexpected result for stakeholder management is a potential link between a (relatively) low deployment of stakeholder management and a high score on consortium composition. This, because a low deployment of stakeholder management only relates to innovation

in combination with a simple consortium. This relation is not academically tested in this research. It does however make sense that stakeholder coordination and building relationship is easier when fewer companies are part of the consortium. If this is the case, a low deployment of stakeholder managing could be related to a small consortium, without relating to innovation.

The results show no evidence that neither a high or a low deployment of technical management (from the public perspective) relate to the occurrence of innovation. This is caused by the inconsistent result that cases show on the condition of technical management. Why the deployment of technical managing shows inconsistent results, is not clear. Also, theory does not provide clear suggestions to help explain this peculiar result. So, it remains an open and interesting point of discussion.

There are three points of discussion regarding the condition of the deployment of contract management, discussed above. However, before the final conclusions are presented, there are two more findings that are interesting for discussion. These are the peculiar and inconstant results that are found in case K and the findings with regard to the condition procurement result.

The main interest of case K comes from the low score on consortium composition. It scores low on consortium composition, because as many as seven firms take part in the consortium. Besides this high amount of firms, the results are very much in line with the other cases (it shows no other extremes). It therefore clouds the results. Case K does prove that a consortium with a high amount of firms can create an innovative project. This contradictory result also means that a simple consortium is not a necessary condition. No reason to explain the ability of this consortium to still be innovative although it consists of many firms is found. However, there is only one case that supports this result so conclusions have to be drawn with care. Because it is only one case, and it is an interesting one, a future case study might be a suitable method for future research.

A final point of discussion is the unexpected relation between a relatively low procurement result (in combination with a high score on consortium composition) and the occurrence of innovation. A possible relation between risk and the procurement result could be an explanation of this unexpected result. A project with limited and well defined risks is often more suitable for innovation (see for example Himmel & Siemiatycki, 2017). At the same time, taking risks (in for example the planning and design) can increase the potential procurement result, because most procurement estimates (by the client) are rather conservative. So, the relation risk has with innovation on one hand and the procurement result on the other, can be a possible explanation for the unexpected findings.

Chapter 6. Conclusions and recommendations

6.1) Conclusions

Conclusion

As stated in chapter one, this thesis aims to:

"*..assess a configuration of conditions that stimulates innovation in public private infrastructure development. The conditions revolve around the organization of projects and the public and private perspectives on innovation."* (this document, p6)

Results generally do not support the hypothesis of single conditions to lead to innovation. An exception on this are consortia that consist of few firms, because this is a sufficient condition. The importance of consortium composition (compared to project management) in stimulating innovation, relates to a Schumpeter like saying that '*Entrepreneurs are innovators until they become managers'*. It supports statements by for example Hodge and Greve (2007), who stress the importance of competitive advantages for innovation to occur. So, this thesis adds strength to literature that recognizes the importance of market parties in stimulating innovation. The finding on the relation between the organization of a consortium and the occurrence of innovation, contribute to links theories and literature in the field of project management and public private partnership to general economic theories regarding stimulants for innovation.

Next to the importance of the consortium composition in stimulating innovation, the discussion and results show that it is interesting to assess conditions that drive or inhibit innovation as part of a broader configuration of conditions. This conclusion was expected to be found, because it is in line with the method used. However, it was also expected that the mechanisms that drive innovation for each separate condition (as hypothesized in chapter two), would also hold true if assessed in combinations of conditions. The results of this thesis show that this is not the case. An interesting conclusion is therefore not only the fact that configurations of conditions (opposed to single conditions) are often related to innovation, but also that mechanisms driving these configurations often deviate from what was expected, based on combining mechanisms that drive innovation for the single conditions.

Examples and discussions on (possible) mechanisms that drive innovation in the combination of conditions are presented in the previous chapter. In the rest of this chapter, the sub and main research question are answered systematically, before the generalization and recommendation are discussed. The first sub-question revolved around a theoretical assessment of the classification of and major factors that stimulate innovation in PPP. Innovation can be classified and interpreted in many ways. For this thesis there was decided to pragmatically define innovation as TPP-innovation. This is done, because in order to reach the aim of this thesis, data on the occurrence of innovation (yes or no), without a more profound analysis on the concept of innovation was found to be sufficient. Leiringer (2006) presented drivers for innovation in PPP. These are design freedom, collaborative working, risk transfer and long-term commitment.

After this theoretical assessment, three sub-questions on the conditions of 1) the deployment of public project management, 2) the effect of the consortium composition and 3) the effect of the procurement result and their relations to the occurrence of innovation were asked.

The deployment of public project management is assessed by the relative under or over deployment of IPM roles. The hypothesis that both a high and a low deployment of contract management can be related to innovation is confirmed (however only as a part of the right configurations of conditions). Stakeholder management shows surprising results, because a low deployment of stakeholder management in combination with a high score on consortium composition, relates to innovation. The initial hypothesis (chapter 2.5) took an opposing stand. This difference in hypothesis and result is discussed in chapter 5. The same is true for technical management, although a clear relation between the deployment of this IPM and the occurrence of innovation was hypothesized, none was found. In conclusion, the mechanisms behind two out of the three IPM roles react different than expected, during the assessment of configurations of condition these roles are part of.

The results for consortium composition are clear and discussed as one of the two main conclusions at the beginning of this paragraph. The hypothesis that a consortium that consists of few firms can stimulate innovation is confirmed. The third sub-question regards the effect of the procurement result and the relation to innovation. There is found that a low procurement result (as part of a configuration with a 'small' consortium) relates to the occurrence of innovation. This opposes the hypothesis that was formed. Possible explanations are sought in the risk profile of projects, these explanations are discussed in chapter five. These explanations are however not supported by academic findings, and remain an interesting topic for future research.

The main research question, as well as the final sub-question, both relate to the configuration of conditions that relate to the stimulation of innovation. The main research question is:

"*Which configuration of input conditions (deployment of public project management, the procurement result and the consortium composition) stimulates the presence of TPP innovation in DBFM infrastructure projects in the Netherlands?" (This document p13)*

All configurations of conditions that are found to lead to the occurrence of innovation are described in the findings (chapter 4). From these findings, three final conclusion are deducted, and explained and highlighted earlier in this chapter. First of all, there are public project management roles that can be related to innovation, however, only in combination with other conditions. Secondly, mechanisms that drive innovation in configurations of conditions show surprising results. And thirdly, the composition of consortia strongly relates to the occurrence of innovation. Where consortia that consist of few, relatively small firms are found when innovation occurs.

The generalization of the conclusions

It is important to keep in mind that from a methodological point of view, the conclusions only relate to projects that fit the scope of this thesis. However, in the recommendations and the impact that this thesis has for Rijkswaterstaat, academia and other practitioners, the conclusions presented above can be an interesting starting point for discussion and reflection, also if they operate outside of the scope. It can, for example, be expected that the importance of consortia in innovation at PPPs is not only true in the Dutch context, and might also be found in other sectors beside infrastructure. Furthermore, the

deviation of configurational and non-configurational mechanisms that drive innovation can be interesting for academia outside the scope of this thesis as well. So, the conclusions of this thesis can be useful outside the scope of the thesis, as leads for formulating research questions, further research and project assessments by professionals.

Recommendations and implication for Rijkswaterstaat.

Three statements are made as recommendation for Rijkswaterstaat. The first is: acknowledge the importance the consortium composition plays in the occurrence of innovation in public private partnership and potentially use this in the procurement procedure of projects. This, because consortia consisting of few firms turn out to be a sufficient condition that relates to innovation. A plausible explanation seems to be that the division of risks is easier with fewer partners in a consortium. If Rijkswaterstaat aims to organize projects in such a way to stimulate innovation, it could critically reflect on (potential) consortia and their performance in the field of technical innovations and include this in the tender of a project.

A second statement revolves around the procurement result. A high procurement result is not related to the occurrence of innovation, in fact, a low procurement result is more likely to relate to the occurrence of innovation (in combination with a simple consortium). Unfortunately, this result does not help to explain the high procurement results that is often experienced at Rijkswaterstaat, it implicates that there are other conditions related to a high procurement result.

The third statement is that in DBFM contracts TPP-innovation often occurs, which is in most cases initiated by the market parties. In this thesis, no comparison between different contract types is made, so it is unclear if DBFM project perform better than for example D&C projects. Still, theoretical arguments like the freedom of design for a consortium, and collaborative working between the public-private partners, are in line with the findings of TPP-innovation in DBFM contracts. On the other hand, DBFM contracts do potentially increase risk for the (private) consortium which is an inhibitor for innovation. Despite this there can be concluded that TPP-innovation is often occurring in DBFM projects, which is, in all but one of the cases, initiated by market parties. So, DBFM contracts seem to be a method to use the market her potential for innovation, without prescribing specific innovation in the projects assignment.

Recommendations and implications for academia.

For academia, the main implication lies in the importance of configurations of conditions when analyzing (organizational) drivers of innovation. As said, surprising results might be found in the mechanisms that drive innovation, when configurations are used. So, the main added value and first statement with regard to the recommendations for academia is that the focus in research on drivers for innovation, should not be on separate variables, but on configurations of conditions.

Other interesting findings are a suggested (stronger than expected) relation between stakeholder and contract management (does a relative increase in one relates to a relative decline of deployment in the other) and a possible interaction between a low procurement result and consortia that consist of a small number of firms. In general, there can be concluded that the relation between a project's organization and innovation remains interesting for future research.

Chapter 7. Limitation and reflection

In this chapter, a short reflection on the limitations of the research is written from the personal viewpoint of the author. First of all, the data availability and collection is discussed, after which, in short, the analysis, result and the process of writing this thesis is reflected upon.

The main point of reflection lies in the choice that was made to create linear hypotheses (displayed in paragraph 2.5), while a configurational method (QCA) was used. Linear hypotheses were made, based on literature regarding the mechanisms that drive and inhibit innovation for the separate conditions. For most of the cases, an elaborate basis of literature was available that discussed how the mechanisms driving innovation worked, with in some cases, interesting points of inconsistency or discussion. The linear hypotheses were thought to be useful, because there was expected that the mechanisms that drive innovation would work according to the same systematics, if assessed in a configurational manner. This turned out to be untrue. In the discrepancy between the linear hypotheses and the configurational results, also lies one of the main added values of this thesis. Being mechanisms that drive innovation change, when conditions are assessed in configurations of conditions opposed to being assessed as single conditions. Although the linear hypothesis helped to draw conclusions and discussion as is done above, one of the recommendations for future research is to hypothesize the mechanisms that lie behind combinations of conditions (opposed to single conditions). The findings in this thesis help in doing just that.

Other challenges of this research mostly occurred in data calibration and analysis. For the data collection, the database of Rijkswaterstaat was used. The ability to use this data kick-started this research and both the database and tips and extra information by Rijkswaterstaat experts who work with the database are greatly appreciated. In order to increase the reliability of the data, it was compared with other findings and knowledge that is available at Rijkswaterstaat, whenever possible. As in most databases, some cases showed missing data. Efforts were made to acquire this data through (short) interviews and questionnaires. Unfortunately (as seen in table 6), in some cases the data acquiring did not completely succeed. Still, the process of data gathering as a whole has been experienced as a relatively smooth process, while at the same time, the amount of missing data is higher, than it ideally would be.

With regard to data calibration, logical choices were made and substantiated as thoroughly as possible. Still, at some of the variables only benchmarking methods (cluster analysis) are used in order to calibrate the data, while according to good practice, calibration should take place through theoretical knowledge or expected result. Unfortunately, it was not always possible to do so, benchmarking methods were used instead. In this research, all three input conditions used (to at least some extend) benchmarking methods, although at two conditions, benchmarking is combined with theory and expected result in order to calibrate.

The amount of DBFM cases which fitted inside the scope of the research was small and, there were enough cases to still be able to use QCA, the inclusion of extra cases would have strengthened the conclusion though. Overall, the process of analyzing the calibrated data and drawing conclusion went well. The methodology used helped, because it leads to clear solution formulas from which conclusions are drawn.

Appendices

Appendix a) Questionnaire baseline measurement innovation in RWS projects.

The following questionnaire was used by the department of innovation and market of Rijkswaterstaat in order to create a baseline measurement for innovation in PGO projects. For reasons of anonymization the whole baseline measurement is not included.

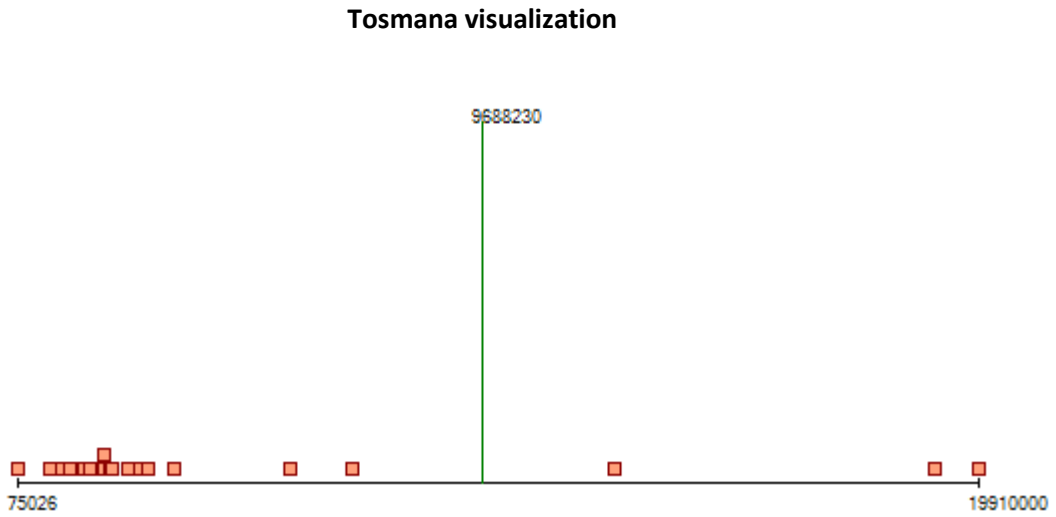
Questionnaire:

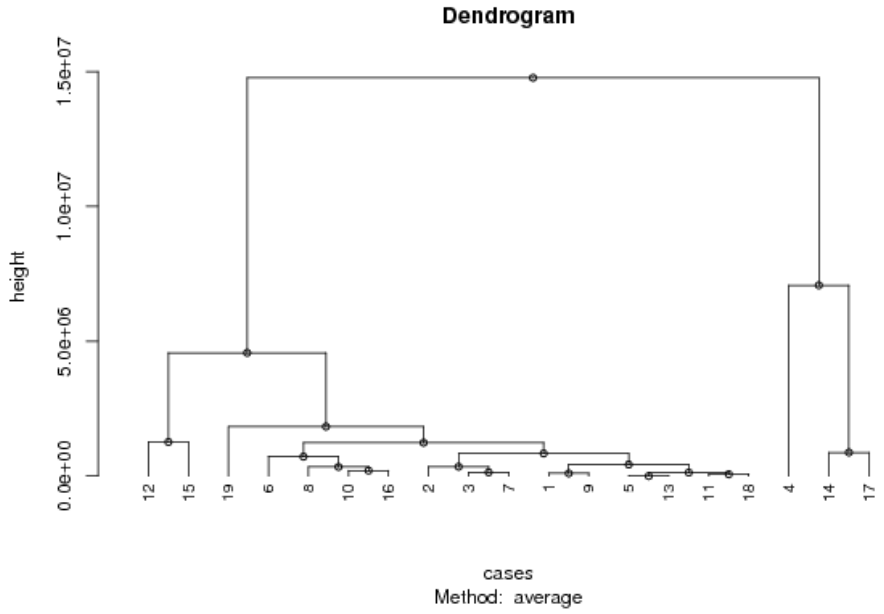
1. *Heeft dit project een (door RWS) benoemde innovatie opgave? Zo ja, benoem deze.*
2. *Zijn er bij dit project innovaties aangeboden door de markt? Zo ja, welke?*
3. *Wat is er met deze innovatie gedaan?*
4. *Zijn of worden er bij dit project innovaties gerealiseerd? Zo ja, welke?*
5. *Zo ja, zijn die ook gedeeld met andere projecten?*

Opmerkingen:

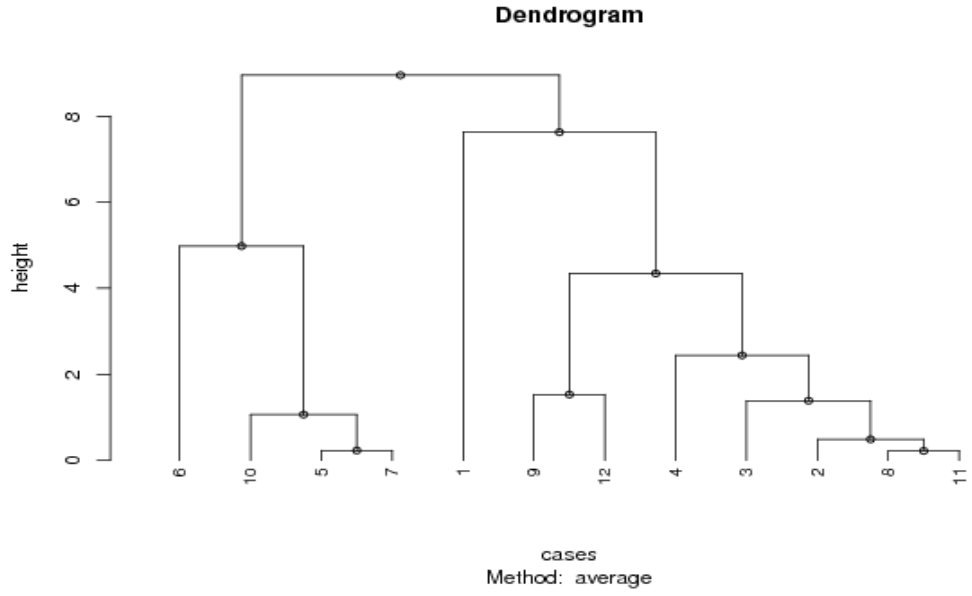
Appendix b) Dendrogram for the hierarchical cluster analyses

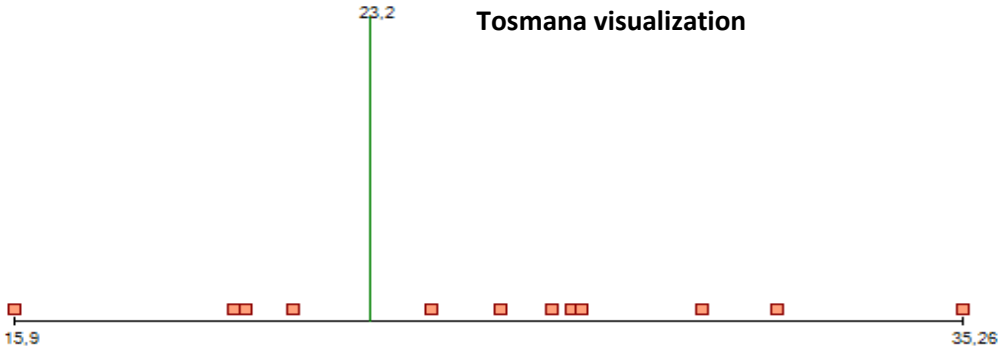
1: Cluster analysis for firm size, based on the average linking method (Wessa, 2017). Note: one extreme case is excluded and cases are anonymized using numbers (1 to 19) instead of firm names.



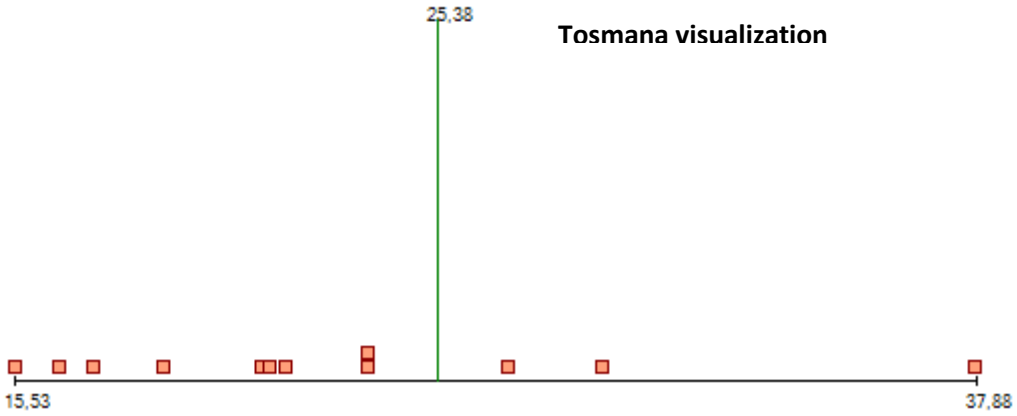


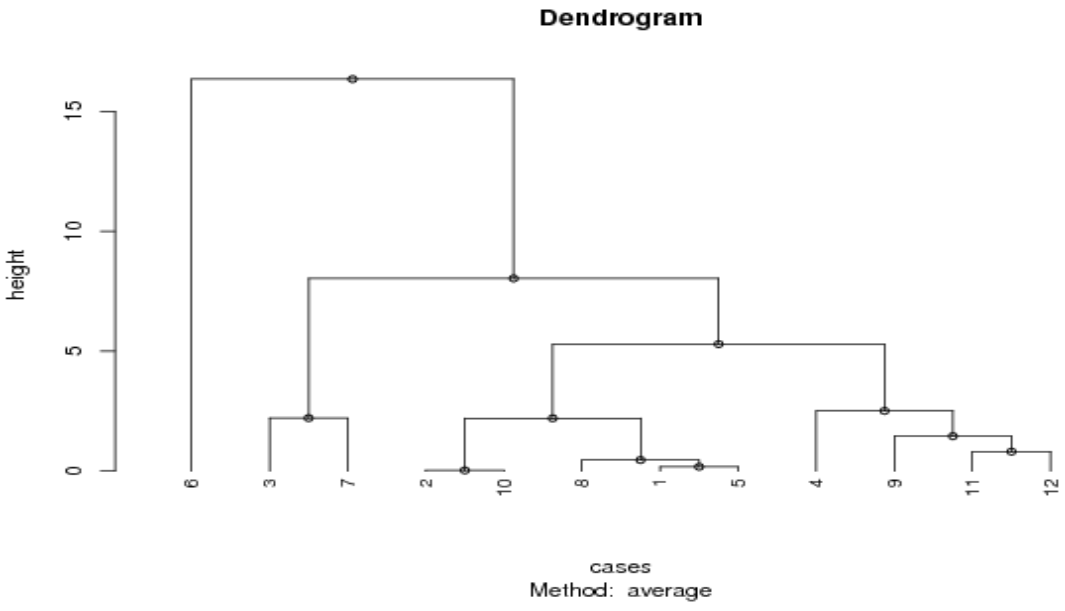
2: Cluster analysis for contract management, based on the average linking method (Wessa, 2017).
Note, case E is missing due to issues with data availability



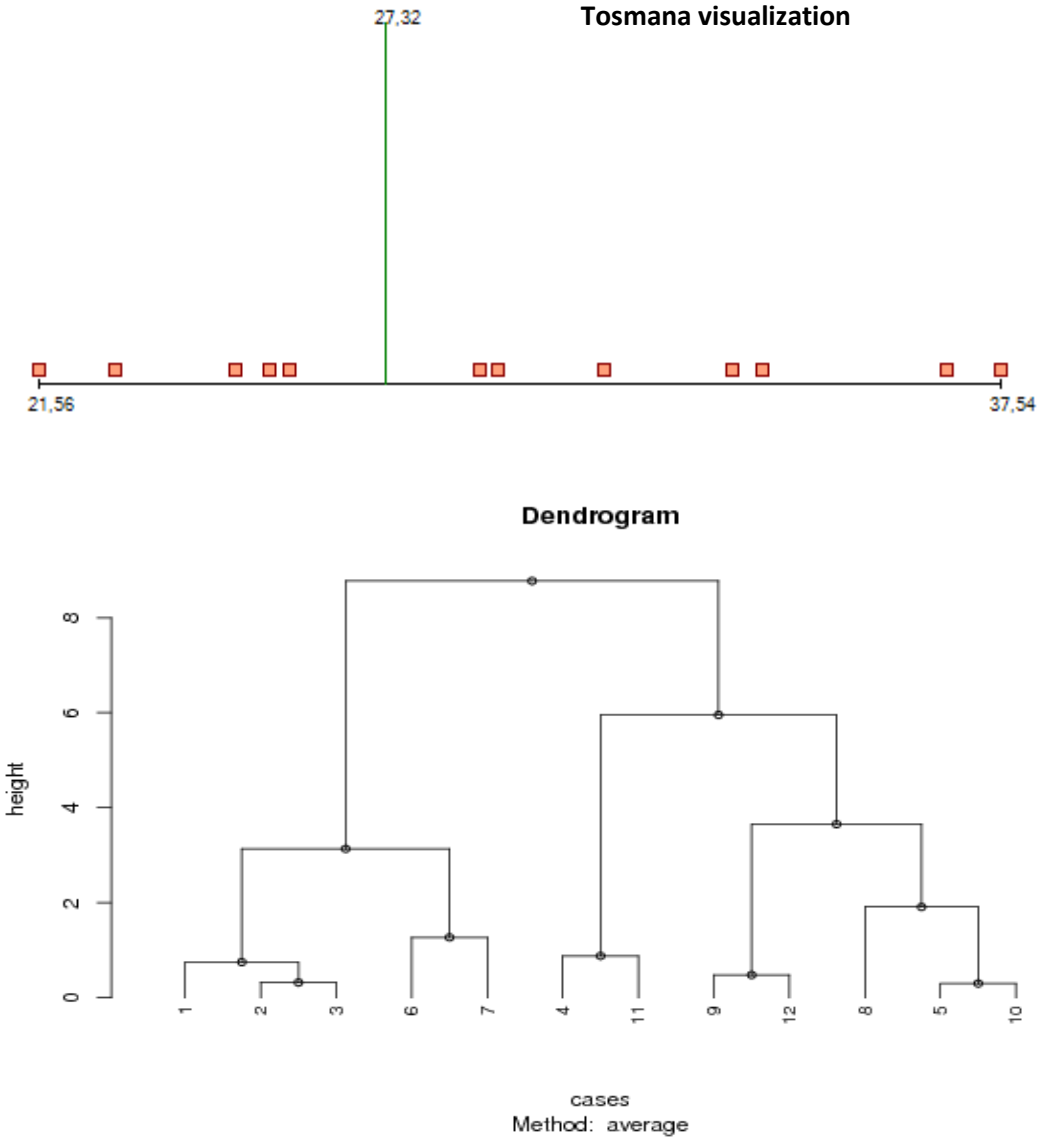


3: Cluster analysis for stakeholder management, based on the average linking method (Wessa, 2017). Note, case E is missing due to issues with data availability. Furthermore one extreme case is left out of the cluster analysis, this is a high extreme and it is given the score that coincides with a high deployment of stakeholder management.





4: Cluster analysis for technical management, based on the average linking method (Wessa, 2017).



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