

UNCONSCIOUS BIAS IN INFRASTRUCTURE PROJECT FINANCE DECISIONS



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1. Introduction

Investments into infrastructure assets are the key to maintaining Europe's competitiveness (Woetzel, Garemo, Mischke, Hjerpe, & Palter, 2017). According to the European Commission, by 2020 there are investment needs of 2 trillion Euros in European energy, transport, and information and communication technology infrastructures, to keep the European Union competitive (Scannella, 2012). Further, disruptive technologies change the user's needs for infrastructure and might increase this investment need e.g. drone delivery and autonomous driving (Woetzel et al., 2017).

However, all over the world, including Europe, there is a gap in infrastructure financing (Heath & Read, 2014). Main reasons for this gap are the constrained public budget and long-term funding from banks, as well as problems to match supply of private sector finance with investable projects (Woetzel et al., 2017).

There are different ways to close this gap. One way is to attract more banks and institutional investors to provide the funds needed (Woetzel et al., 2017). Another way to close the financing gap is to optimize public and corporate spending by e.g. prioritizing the right projects and improving the productivity of projects.

Many large construction projects face substantial cost and time overruns; therefore, investments are not efficient. A typical cause for this lies already in the planning phase of a project: A combination of delusion (unrealistically optimistic planning behavior of project planners due to inside view in forecasting) and deception (misrepresentation by project planners) often leads to artificially low costs expectation, exaggerated benefits, and underestimated risks (Flyvbjerg, Garbuio, & Lovallo, 2009).

Both public and private infrastructure spending can be optimized by using project finance (PF) in the project implementation. In the case of PF, investors and lenders do not only play

an important role in the provision of capital for projects, they also evaluate, monitor, and control risks (Alfen et al., 2009). Thus, PF is not only a way to finance a project, but also a project risk management tool. The implementation of public infrastructure projects as Public Private Partnership (PPP) PF can optimize public spending by transferring risks from the public to the private sector (Bundesministerium der Finanzen, 2016). Also, corporate projects can achieve efficiency gains from the risk transfer by using PF. However, PF does not only have the advantage of the risk transfer, it also is a project management tool that provides agency cost advantages (Müllner, 2017), reduces the risk of managerial mismanagement due to the monitoring of banks, and produces synergies (Esty, 2003).

However, PF, as a way to not only finance but also to manage a project, can only contribute to closing the infrastructure gap, if it is implemented efficiently. The risk management process and the risk transfer to the party that can best carry this risk play a vital role (Irimia-Diéguez, Sanchez-Cazorla, & Alfalla-Luque, 2014) in an efficient project implementation.

1.1 Overall problem definition and research gap

Although the risk management process is vital in large infrastructure construction projects, research in this area is not exhaustive. A vast set of specific risk factors for infrastructure construction projects has been identified in the megaproject literature. Several typologies exist and many researchers have focused on specific risk factors of construction projects. One characteristic all existing typologies have in common is that they neglect a detailed account of estimator related risks. Estimator related risks are risks the decision maker brings into the project by assessing risks too low or too high (Baloi & Price, 2003). Why do estimator related risks occur? The decision-making process of individuals changes if risk or uncertainty are involved in the decision. Kahneman and Tversky (1982) state that if faced with uncertainty decision makers more frequently apply heuristics and fall prey to cognitive biases in their decision-making-process.

An important challenge for lenders and investors in making decisions in the context of infrastructure PF is therefore to overcome own biases. While there is some literature on biases in the decision making of project planners in the initial financing of an infrastructure project (Flyvbjerg, 2009), little research in the field of financing projects focusses on other stakeholders in PF such as lenders. Further, until now in this area there is no research that takes the organizational perspective on biased information processing i.e. previous research did not determine what characterizes companies, whose decision makers are on average biased and bring a high degree of estimator related risk with them.

1.2 Objective and purpose

The overarching purpose of the dissertation effort is to analyze what causes individual decision makers and organizations to add estimator related risks to European infrastructure projects implemented with PF. To achieve this purpose, four key aspects will be covered:

RQ1: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?

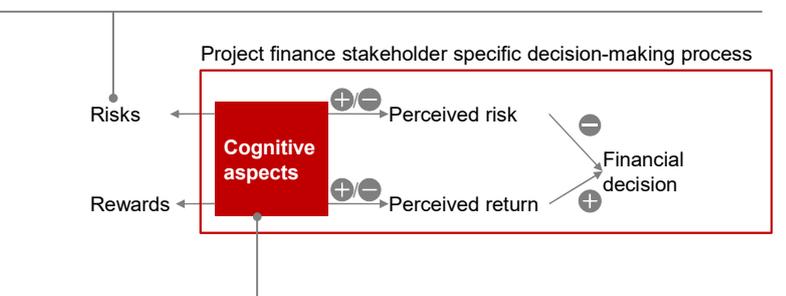
RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

RQ3: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?

Figure 1: Overview of research questions

RQ1: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?



RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

RQ3: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?

Source: Adapted from Hampl and Wüstenhagen (2012)

1.3 Relevant limitations

Overall, in this dissertation the rational planning view is to be taken in which successful projects are portrayed as a product of advanced planning and failures results from planning errors. Hence, accurate decisions in the planning phase contribute majorly to project success.

As stated above, the main purpose of this dissertation is to analyze the causes of estimator related risks regarding PF infrastructure projects. To focus the research, limitations are taken regarding the way estimator related risks are measured, as well as regarding the decision makers and projects in focus. Regarding estimator related risks, bias in decision making is not measured in real project decisions but is limited to laboratory like decision situations with relevant decision makers. This is a common method in empirical social science (Vetter, Benlian, & Hess, 2011). As relevant decision makers PF lenders and investors are defined due to their important risk management role in PF. With regard to the kind of projects studied, this

dissertation focusses on (1) large European infrastructure construction projects with (2) Fixed Price, Date-Certain Turnkey Construction Contracts financed with PF. In the following, a brief definition of these terms is presented, a more detailed description of the concepts follows in chapter 2.

1.3.1 Large European infrastructure construction projects

Weber, Staub-Bisang, and Alfen (2016) define infrastructure as: *“all physical assets, equipment and facilities of interrelated systems and the necessary service providers, together with its underlying structures, organizations, business models, and rules and regulations, offering related sector-specific commodities and services to individual economic entities or the wider public with the aim to enable, sustain or enhance social living condition”* (Weber et al., 2016, XXVI). This definition will be used in the following, infrastructure thus includes transport assets (roads, railways, bridges, tunnels, ports, and airports), public utilities (oil and gas networks, energy generation utilities including renewable energy, water supply, waste water, and waste disposal), as well as social infrastructure (schools, hospitals, administrative buildings, and social housing). An infrastructure construction project is any project in which an infrastructure asset is built. Infrastructure construction projects shall, in this dissertation, only be seen in the light of the European Union, with large projects costing more than 500 million US dollar, following Esty’s (2004b) definition of large infrastructure projects¹.

1.3.2 Fixed Price, Date-Certain Turnkey Construction Contracts financed with PF

In PF, lending funds is based on future cash flows of the project. The Basel Committee on Banking Supervision defines PF as: *“The lender is usually paid solely or almost exclusively out of the money generated by the contracts for the facility’s output [...]. The borrower is usually an SPE (Special Purpose Entity) that is not permitted to perform any function other*

¹ In the relevant literature there is no consistent definition of a “large construction project”, compare Kostka and Anzinger (2015).

than developing, owning, and operating the installation. The consequence is that repayment depends primarily on the project's cash flow and on the collateral value of the project's assets." (Basel Committee on Banking Supervision, 2004, p. 61).

Currently the most accepted delivery model in PF is the Fixed Price Date-Certain Turnkey Construction Contract (Böttcher & Blattner, 2013). A Turnkey Construction Contract is defined as *"the most extreme form of placing design and construction responsibility on the contractor, such that after completion the employer need only turn the key to commence operation of the constructed facility"* (Huse, 2002, p. 5).

1.4 Methodology

Overall this research takes a practical angle focusing on problems in the infrastructure industry the researcher has experienced in practice. As the researcher knows the relevant decision situations well, the approach is pragmatic, combining experience from infrastructure projects with theoretical modelling. In the following the research process and the structure of the dissertation are summarized.

1.4.1 Research process

RQ1: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?

In chapter 3 this research question is tackled in three steps. First, project risk factors are identified from relevant literature. In a second step, these findings are supplemented with own practical knowledge from three large scale infrastructure projects, publicized case examples stating main reasons why specific projects failed, a real project risk register, and eight explorative expert interviews, analyzed according to the process suggested by the Critical Incident Technique (CIT). Finally, the empirical findings are compared to the findings from

the literature review and used to create a typology of risks clustered by stakeholders that bear them typically.

RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

This research question is tackled in three steps. First, a review of the behavioral finance literature is conducted in chapter 4 leading to a theoretical causal bias model, which includes all biases applicable in the project financing of large infrastructure projects, as well as relevant influencing factors. Second, eight open interviews are conducted with lenders and investors from relevant companies to find out what impact biases had on their decision making in PF situations and which bias from the framework are most relevant. The framework is adapted and simplified according to these interviews. In a third step, presented in chapter 5, a survey among 102 lenders and investors is conducted and a regression is performed to test the framework.

RQ3: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

This research question is tackled in two steps. In chapter 4 hypotheses are developed from theory regarding the differences between lenders and investors. Second, in chapter 5, using the data from the causal model Anovas are performed to compare whether the different stakeholder groups are significantly different on the dependent variable “unrealistic optimism“. Also, an analysis of variance is performed for the enhancing and diminishing factors in the causal model to identify what causes the difference between the groups.

RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?

To answer this research question, a model identifying which characteristics best predict the tendency of a company to be biased is created in two steps. First, possible characteristics that differentiate biased and non-biased companies are researched from literature and presented in chapter 4. In a second step, the characteristics of biased and non-biased companies in terms of three classes of factors (objective company characteristics, overconfidence, and institutional characteristics) are compared through the analysis of variance in chapter 5 to identify factors that distinguish biased from non-biased companies.

1.4.2 Structure of the dissertation

In chapter 2, following this introduction, the concepts large infrastructure construction project and PF will be defined and explained in the European context. Additionally, a brief overview of recent literature in the field of large infrastructure PF will be given and gaps highlighted. In chapter 3, an overview of risk management in infrastructure PF projects is given. Further a typology of risks grouped by stakeholders that bear them typically will be derived (RQ1). In chapter 4, research on cognitive aspects, perceived risk, and decision making is discussed. Based on this a causal bias model will be developed for project financiers (RQ2), hypothesis about the difference between stakeholder groups will be developed in the light of the causal bias model (RQ3), and a model of company bias is developed (RQ4). In chapter 5 the causal bias model, the hypotheses about stakeholder group differences and the model of company bias will be tested empirically. In chapter 6 all findings will be summarized and discussed regarding theoretical and practical contribution. Additionally, an outlook will be provided.

Figure 2: Overview of structure

Part 1 Introduction
Part 2 Theoretical principals “Infrastructure Project Finance”
Part 3 Risks of large infrastructure construction projects <ul style="list-style-type: none">▪ RQ1: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?
Part 4 Cognitive aspects, perceived risk, and decision making in infrastructure PF – development of a theoretical framework <ul style="list-style-type: none">▪ RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?▪ RQ3: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?▪ RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?
Part 5 Empirical test of developed causal model and hypotheses
Part 6 Conclusion

2. Infrastructure PF – object of research, terminology, and fundamentals

In the following, (1) a brief overview of recent literature in the field of large infrastructure PF will be given to narrow down the object of research and provide the relevant terminology and fundamentals. Subsequently, (2) a market overview is conducted that discusses current problems in infrastructure project finance and highlights the importance of this research.

2.1 Status quo relevant literature infrastructure PF

Addressing the status quo of relevant literature, (1) the terminology mentioned in chapter 1 will be elaborated in more detail, followed by (2) an overview of relevant infrastructure PF research streams and gaps, as well as (3) a deep dive into the theoretical foundation of PF.

2.1.1 Terminology infrastructure PF

In this review the concepts (1) large infrastructure construction project and (2) PF that were named in chapter 1.3 will be defined and explained in the European context.

2.1.1.1 Large infrastructure construction projects

Projects in general are characterized by a limited lifespan with a defined start and end, a unique risk profile, a defined limited budget, and the production of a unique product, service, or process (Drees, Lang, & Schöps, 2010). In the following the term large infrastructure construction project will be defined in detail and the status of research summarized.

Esty (2004b) defines large projects as those costing more than 500 million US dollar. As this size seems common for large infrastructure construction projects in Europe, this definition will be used in the following. Why focus this study on large projects? First, the larger the project the more significant the financial, developmental, and social return it can provide when it succeeds and the higher the risk in case of distress (Esty, 2004a). Second, large projects are mostly more complex than small projects and involve more risks (Esty, 2004a). Third, large projects affect more stakeholders than small projects (Esty, 2004a, 2004b).

A construction project is any project in which an asset is built. Non-construction projects are for instance acquisitions. Within construction projects there are two different types: greenfield and brownfield projects. Greenfield projects are those where a new asset is created, brownfield are those where an existing asset with an existing revenue stream is improved, upgraded, or expanded² (Rossi & Stepic, 2015). Construction projects typically have four distinct phases: planning, construction, operation, and decommissioning (Ehlers, 2014). Risks differ between these phases (Ehlers, 2014). A typical risk in the planning phase is the design error risk i.e. the risk that the design as specified is not appropriate (Yescombe, 2013). In the construction phase however, a typical risk is the cost overrun risk i.e. the risk that the completion of the project will cost more than expected (Yescombe, 2013). Finally in the operating phase a typical risk is the market risk i.e. the risk that the demand for the asset is lower than expected (Yescombe, 2013).

Several different definitions of infrastructure are used in the relevant research field (Blanc-Brude & Makovsek, 2013). As noted in chapter 1, the definition of infrastructure in this study is based on the definition and examples Weber et al. (2016) provide and shall include transport assets (roads, railways, bridges, tunnels, ports, and airports), public utilities (oil and gas networks, energy generation utilities including renewable energy, water supply, waste water, and waste disposal), as well as social infrastructure (schools, hospitals, administrative buildings, and social housing).

Infrastructure projects such as power plants, wind parks, and airports have distinct characteristics that make their implementation and especially their financing particularly challenging. First, taking only direct payoffs into account a project's net present value (NPV) can be negative for infrastructure projects, making investments unattractive for the private sector. However, indirect benefits to communities may make even these seemingly

² Sometimes brownfield projects that require significant improvements, upgrades, or expansions are referred to as yellow field.

economically unprofitable projects worthwhile for the public sector (Ehlers, 2014). Second, the cash flow time profile of infrastructure projects is quite unattractive. The initial upfront investment is not only usually substantial e.g. 500 million Euro, but is also tied for many years. Cash flows that cover costs may be generated only in the last project phase (Ehlers, 2014; Sorge, 2004). Finally, infrastructure projects are very complex as often a large number of parties are involved (Ehlers, 2014; Sorge, 2004). The success of the projects depends on a joint effort of all parties. Coordination problems, conflicts of interest, and freeriding can lead to project failure (Sorge, 2004). Depending on the asset, governments may have a high interest to maintain complete control to prevent a company from abusing the monopoly power of the infrastructure.

On the other hand infrastructure investments can be financially attractive because often these projects offer long term predictable and stable cash flows³ that allow the projects to have a high leverage (Rossi & Stepic, 2015). Additionally many infrastructure projects protect against inflation, as payments, such as tolls, are connected to inflation security due to PPP arrangements (Rossi & Stepic, 2015; Weber et al., 2016).

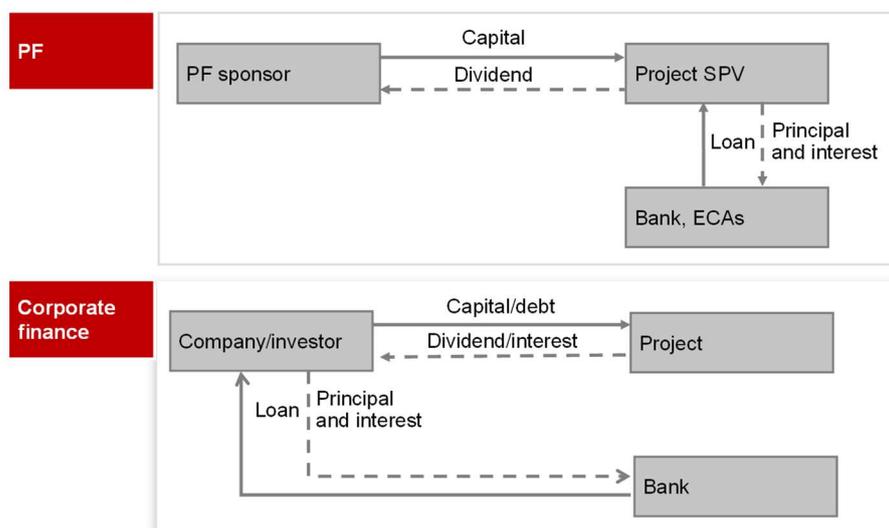
Large construction projects in infrastructure have popped up like mushrooms in recent years, regardless of the current economic developments worldwide. Particularly in emerging markets the demand for energy supply and other infrastructure is growing rapidly (Ladislaw, 2011). Even in the European Union an investment need into infrastructure of up to 2 trillion Euro until the year 2020 is estimated (Sauter, Illés, & Nunez Ferrer, 2014). Many infrastructure construction projects in Europe are implemented with PF (Project Finance International, 2017). The next chapter will introduce this concept.

³ Due to monopolistic characteristics of the infrastructure assets and in many cases concession agreements with governments.

2.1.1.2 Implementing projects with PF

Generally, there are three possible financing approaches for a project: corporate finance based on the creditworthiness of the company i.e. traditional lending, object finance based on the value of the asset, and PF based on future cash flows of the project. The main difference between PF and traditional lending is illustrated below in Figure 3. While in traditional lending the investor borrows money from banks to finance the project, in PF the project special purpose vehicle (SPV) takes the loan.

Figure 3: PF concept



Source: Own illustration

However, PF is more than just a means to finance a project. It is a project implementation form with several distinct features. First, PF usually relies on a SPV⁴ (Miller & Lessard, 2001; Scott-Quinn & Cano, 2015). All assets the SPV owns are the project's assets and all liabilities the project's liabilities. Typically, PF is off-balance sheet for sponsors (Daube, Vollrath, & Alfen, 2008). Second, in PF the capital investment focusses on a single purpose asset, which is operated by the SPV for a specific finite time (Scott-Quinn & Cano, 2015). Third, the future cash flow of the project serves as collateral for all debt (Daube et al., 2008). Loans are given

⁴ Also called SPE e.g. by Basel committee - the term SPV will be used for in the following.

on a non-recourse or limited recourse basis (Daube et al., 2008; Esty, 2004a). Non-recourse means that the borrower's financial liability for the loan is limited to the value of the collateral. If the borrower defaults and the collateral is worth less than the amount outstanding under the loan, the lender has no further recourse against the borrower and must absorb the loss (Miller & Lessard, 2001). Credit evaluations are based on the future cash flows, the value of the asset is only considered for collateral (Scott-Quinn & Cano, 2015). Fourth, the project is financed with high leverage: by up to 90% debt and only 10% equity (Daube et al., 2008). Debt capital is usually raised by a consortium of foreign and domestic banks. Equity is contributed by several sponsoring companies that have know-how in the specific area of the infrastructure project in question. Fifth, risk analysis and allocation i.e. risk sharing is a central element of project financing (Daube et al., 2008; Miller & Lessard, 2001): Risks should be identified, assessed and allocated to the party that can carry the risk at the least cost (Brealey, Cooper, & Habib, 1996; Esty, 2004a; Irimia-Diéguez et al., 2014; Miller & Lessard, 2001).

The Modigliani Miller proposition states that if a certain investment decision is given, the capital structure i.e. whether to use corporate finance or PF is irrelevant (Modigliani & Miller, 1959). So why use PF instead of other financing structures? Since several premises of the Modigliani Miller proposition (no transaction costs, no taxes, no cost of financial distress, no agency conflict, and no asymmetric information) do not hold in reality, capital structure can affect company value (Esty, 2004a; Yescombe, 2013). Esty (2004a) states that: "*a combination of a firm plus a project may be worth more when financing separately with nonrecourse debt*" (p. 5).

As for many financing means, PF only makes sense in certain situations. When deciding whether to use PF or traditional finance, advantages and drawbacks need to be considered. Companies typically compare risks and returns of different financing structures such as

corporate finance and PF and choose the alternative that generates the highest value or provides the lowest risk (Esty, 2004a).

The public sector uses private finance such as PF for projects implemented as PPP. The motivation to implement a project as PPP is manifold - arguments include efficiency gains through appropriate risk allocation to the private sector (Daube et al., 2008) and the gain of competences, resources, and funds that are not available in the public sector (Alfen et al., 2009). As owner of infrastructure the motivation for the public sector to use PF in a PPP project is threefold. First, by involving the private sector in financing the public sector can implement projects for which the necessary budget is not available (Böttcher & Blattner, 2013). Second, by involving the contractor as equity sponsor into infrastructure projects and allocating risks to the contractor, agency problems and misaligned incentives are reduced (Böttcher & Blattner, 2013) and equity is gained as additional security (Daube et al., 2008). Third, by involving lenders the public sector does not need to carry the financing risks and insolvency risks alone and gains a monitoring partner (Böttcher & Blattner, 2013) and an evaluator of the projects financial viability (Daube et al., 2008).

Also for commercial companies as project initiator the motivation to use PF has several important aspects. By using a SPV the sponsoring companies can reduce underinvestment in positive NPV projects due to the corporate debt capacity (Esty, 2004a; Pinto & Alves, 2016). In using PF, returns on investment can be achieved without any claim on the sponsor's balance sheet, since the financing is non-recourse. Therefore, corporate debt capacity is preserved and can be used for other projects. Also larger project volumes can be handled because of this (Böttcher & Blattner, 2013). Further, by using PF companies can reduce incentive conflicts between different projects within the company (Esty, 2004a). Additionally, underinvestment in profitable projects due to risk contamination and managerial risk aversion is reduced (Esty, 2003, 2004a). PF exposes the sponsor company only to potential losses of

their equity contribution. Further in implementing projects with PF the risk is shared with other sponsors and lenders, so that overall default losses are reduced. Also, according to the portfolio theory project financing can decrease risk for the sponsor when the combined cash flow variance of the project and the sponsor together is higher than that of the sponsor alone (Esty, 2003). Financing theory has been optimistic about agency cost advantages of PF as the SPV structure provides incentives for stakeholders (Müllner, 2017). Brealey et al. (1996) state: *“The dominant reason for the growing importance of project finance in funding infrastructure investment is that it addresses agency problems in a way that other forms of financing do not”* (Brealey et al., 1996, p. 27). PF may also enable sponsors to benefit from tax shields due to the high leverage and thus high interest payments (Gatti, 2012). Finally, by involving banks an additional monitoring takes place reducing the risk of managerial mismanagement (Esty, 2003).

However, there are also several drawbacks of PF. First, setting up the SPV is costly, complex, and takes a long time (Esty, 2003; Gatti, 2012; Müllner, 2017). Second, interest rates granted to a project are often higher than the ones that would be granted to public institutions or companies due to the non-recourse nature of the debt (Yescombe, 2013). Third, sponsors can to a certain extent lose control of the project to lenders (Yescombe, 2013). Lenders involvement can restrict managerial decision making due to extensive structure of contracts and monitoring requirements (Yescombe, 2013).

2.1.2 Overview relevant literature streams and gaps for infrastructure PF

Existing substreams in the field on PF literature, as highlighted by Müllner (2017) are finance research, management research, and international business research. The three streams cover numerous topics, however not all of them are relevant in the light of the overarching aim of this dissertation. As stated in chapter 1, this dissertation aims to determine if infrastructure PF can help to close the infrastructure finance gap through efficiency gains from synergies and

risk transfers, with a specific focus on estimator related risk and the role of lenders and investors. The international business literature stream however deals with the advantages of PF as an entry mode into high risk investment environments such as infrastructure investment in developing countries and thus does not contribute to the matter at hand. The other two streams (1) finance research and (2) management research touch upon relevant aspects of the defined research questions. These aspects will be highlighted in the following chapters.

In general, many authors state that further research is needed in the field of PF. According to Esty (2004a): *“the gap between theory and practice in the field of project finance has been growing over the last 25 years”* (Esty, 2004a, p. 13). This gap seems to still exist, as Pinto and Alves conclude in 2016: *“project finance is an economically significant growing financial market segment, but still largely understudied”* (Pinto & Alves, 2016, p. 3). Regarding the aim of this dissertation the most relevant gap in the existing research is that concerning benefits of PF, project valuation methods, risk management, and decision-making, estimator related risks are not studied with regard to lenders and investors.

2.1.2.1 Finance research

In finance research two streams are relevant concerning the aim of this dissertation.

One group of authors examine the factors underlying companies' choice between PF loans and corporate finance loans; i.e., between off-balance sheet and on-balance sheet funding, focusing on a-priori benefits of PF (Brealey et al., 1996; Esty, 2003; Pinto & Alves, 2016). This literature stream provides the basic argument for PF being able to contribute to closing the infrastructure investment gap. Theories that explain the superiority of PF in certain situations are capital structure theories such as the pecking-order theory of capital structure⁵ (Brealey et al., 1996; Myers, 1984), real options theory⁶ (Esty, 2003), and contracting theory⁷

⁵ Due to information asymmetries between borrowers and lenders, borrowers prefer debt in risky investments.

⁶ Non-recourse finance is said to give investors a *“walk-away-put option”* and thus managerial flexibility.

⁷ Contracts address and allocate risks before the initiation of the project and thus lead to active risk management.

(Blanc-Brude & Strange, 2007; Brealey et al., 1996). *“The overarching agreement is that the separation of a project to a separate entity reduces information asymmetry between lenders, allows for tailored capital structure and provides optimal incentives for all participants”*

(Müllner, 2017, p. 109). The findings of this research stream show the potential upside of PF and are summarized above in chapter 2.1.1.2: increased debt capacity, reduced incentive conflicts, reduced risk of managerial mismanagement, reduced agency cost, and optimized tax shields. However, while lenders and investors are named in terms of their monitoring role and their role as taking over risks in general, an advantage regarding estimator related risks is not mentioned in this literature stream.

The second relevant finance research stream evaluates project valuation methods. In PF the evaluation of the future cash flow is of high importance. Esty (2004a) states that many project financiers value cash flows using too simple tools such as the discounted cash flow method⁸. Gatti (2012) calls for using sophisticated methods such as Monte-Carlo simulations⁹. West (2015) even moves towards a more stakeholder-inclusive evaluation¹⁰ of project cash flows. This research stream highlights how much uncertainty is involved in the lender and investor decision situations. However, while different project valuation methods and thus also risk assessment methods are discussed, this stream does not touch upon the question which valuation method can help to reduce estimator related risks.

There are other finance research streams that touch upon PF but these are not relevant for the questions at hand. For instance one research stream examines the characteristics of PF as syndicated loan (Blanc-Brude & Strange, 2007; Sorge, 2004) e.g. host country environmental factors such as inflation were found to strongly affect credit risk and pricing (Dailami &

⁸ The discounted cash flow method is a valuation method discounting the free cash flows of future periods determined through costs and benefits by a suitable interest rate.

⁹ A Monte Carlo simulation is a simulation method that determines likely impact of risks and thus makes valuation more realistic.

¹⁰ A stakeholder-inclusive evaluation includes non-economic social and environmental benefits in valuation.

Leipziger, 1998) and PF loans were found to have lower credit spreads than comparable non PF loans, more likely to have a fixed rate loan pricing and have fewer loan covenants (Kleimeier & Megginson, 2000).

2.1.2.2 Management research

Three streams are relevant in the management research, concerning the research questions in this dissertation.

The first relevant management research stream evaluates the role of PF contractual structures in risk management and decision making (Blanc-Brude & Strange, 2007; Brealey et al., 1996; Gatti, 2012; Miller & Lessard, 2001). Contracts that address risks before the initiation of the project (Blanc-Brude & Strange, 2007) and allocate them to the parties that can best control them are recognized as risk management tools (Brealey et al., 1996; Miller & Lessard, 2001). Gatti (2012) further highlights the risk mitigating role of lenders such as lead arranging banks. Further specific risk typologies have been developed for different industries, also with regard to infrastructure construction projects. One characteristic all existing typologies have in common is that they neglect a detailed account of estimator related risks¹¹. Overall, this stream provides further indications for the benefits of PF, especially focusing on risks of infrastructure projects. But although lenders are mentioned with regard to risk mitigation, the mitigation of estimator related risks in specific is not mentioned.

The second relevant stream compares PPP, where PF is used often but not exclusively, and traditional public procurement. Authors found that PPP can generate value in certain settings but also comes at significant cost (Gatti, 2012). Also, authors of this research stream looked at questions from the above-mentioned streams in relation to PPP, such as pricing of loans and project risks e.g. Blanc-Brude and Strange (2007) analyze how loans are priced to PPP

¹¹ Risk the decision maker adds to the project by assessing other risks too high or too low, compare Baloi and Price (2003).

projects and find that only systematic risks determine pricing. This stream is important to show the potential downside of PF and highlights that only if the risk transfer is optimal, overall efficiency savings can be achieved. Again – estimator related risks are not studied.

Finally, authors also analyzed the disadvantages of PF in situations of project failure, taking into account agency problems, inter-partner complexities between the project stakeholders, and biases project managers are subject to (Flyvbjerg et al., 2009, 2014; Kostka & Anzinger, 2015). Here estimator related risks are mentioned for project planners regarding risk management, it is however not considered if lenders and investors take these risks over in PF or what can be done to manage this risk.

2.1.3 Theoretical foundation PF

Based on the existing finance and management literature presented above, in the following (1) the structure of PF projects, (2) PF stakeholders and their roles in PF, as well as (3) phases of PF are elaborated, to highlight the unique characteristics of this project implementation form.

2.1.3.1 Project structure of projects implemented with PF

With regard to the project structure of a project financed with PF, three areas are of importance: (1) organizational structure (project ownership and source of financing), (2) governance structure (capital structure), and (3) contractual structure (packaging of work, delivery models, and pricing scheme) (Esty, 2004a). In the following, all three structural aspects will be elaborated.

There are two ownership options for projects implemented with PF: public and private. Factors that determine which options are suitable for a specific infrastructure project are among others the strategic importance of the asset to the general public, the legislation, the ability of the private sector to manage the asset more efficiently, the financial resources of the public sector, and the ability of an asset's revenue to cover costs of operations and financing (Weber et al., 2016).

Private ownership requires private investors to provide substantial equity - this can be a single investor or a group of investors. An example for private infrastructure projects are power plants in Germany. Private projects typically have long term contracts for their output e.g. electricity and input e.g. coal, that enable the projects to have predictable profit streams (Scott-Quinn & Cano, 2015). This ownership option can only be taken when the infrastructure project is self-supported, i.e. the project revenues are able to fully fund operational costs in addition to all costs of financing.

In public ownership the state retains the entire ownership, or a large stake in the asset ownership. This is for instance the case for public schools in Germany (Weber et al., 2016). However, in the implementation the private sector may be involved. In PPP projects, in the UK also called Public Finance Initiative, the private sector typically constructs the assets and is allowed to operate and maintain it for 20-30 years, however the ownership of the asset remains public (Scott-Quinn & Cano, 2015). Examples for this are toll roads in Germany.

In terms of the governance structure, a project can generally be either financed with equity, a mix of equity and debt, or pure debt. Typically PF infrastructure projects have a debt to equity ratio of 80:20 (Yescombe, 2013). The high leverage allows equity investors, that profit from all upside risk of the project, to maximize their equity returns (Scannella, 2012) and transfer part of the downside project risk to lenders (Miller & Lessard, 2001). Banks on the other hand maximize their total fees at bearable risk level (Scannella, 2012). Certain project characteristics determine the suitable level of leverage. Determinants named in literature are the project phase, the ratio of tangible assets¹²(Miller & Lessard, 2001), operation risk¹³, taxes, regulations, and the stakeholders ability to bear risk (Miller & Lessard, 2001; Scannella, 2012). For PF long term financing instruments are needed i.e. for longer than one

¹² Tangible assets have a higher risk of expropriation than intangible assets, compare Miller and Lessard (2001).

¹³ Projects with low operation risk such as roads typically have higher leverage than e.g. nuclear plants with high operation risks, compare Miller and Lessard (2001).

year. Financial long term debt can be classified based on the seniority of the debt (Böttcher & Blattner, 2013). Senior debt is paid back first in terms of project default. Subordinate debt is only paid back after all senior debt and thus it is riskier and requires a higher return.

Financial instruments for debt are available in many forms. “*One of the most basic choices is between using bank loans or project bonds*” (Esty, 2004a, p. 11). Which form of debt instrument makes most sense for a specific infrastructure project depends on factors such as the kind of project, the amount of finance needed, and capital market conditions (Sorge, 2004). In the following focus is based purely on bank loans as this is today the most common project financing instrument (Project Finance International, 2017). However it should be noted that banks also created open ended funds as new asset class to attract a larger number of investors to infrastructure PF (Sorge, 2004).

Equity investment instruments are capital in form of cash or assets. Equity investors then become sponsors of the project company.

Mezzanine finance instruments such as coupon bonds¹⁴ or zero-coupon bonds¹⁵ are also used in PF - these are senior to equity and subordinate to debt instruments.

The contractual structure of a project is important in order to manage risks and thus reduce costly market imperfections (Esty, 2004a). In PF risks are ideally contractually allocated to the parties that can mitigate them best or that can carry them at the lowest cost (Brealey et al., 1996; Esty, 2004a; Irimia-Diéguez et al., 2014; Miller & Lessard, 2001). These contracts are necessary to align interests by providing incentives and preventing opportunistic behavior and free riding (Sorge, 2004). The main contracts govern construction, operation, input supply, and off-take of the project (Sorge, 2004). Additional contracts can concern government concessions, financial options, insurances etc. Inevitably long term contracts between the various parties end up being incomplete - thus in addition to contractual agreements,

¹⁴ Coupon bonds are debt obligations with interest payments.

¹⁵ Zero-coupon bonds are debt obligations without interest payments.

governance mechanisms need to be set up (Esty, 2004a). Three aspects determine the contractual structure: delivery models, package split, and pricing scheme.

As mentioned in chapter 1.3, the most common delivery model is the Date-Certain Turnkey Construction Contract where the completion date for the project is specified in the contract and legally binding for the contractor. Full contractor liability makes this the least risky delivery model for project financiers. Other delivery models generally used in infrastructure construction such as Design-Bid-Build¹⁶, or Construction Management¹⁷ do not make sense in the context of PF. The risks that remains with the project company and thus the amount of interest charged by lenders would be too high for these delivery models (Huse, 2002).

The package split of a project determines the number of distinct packages, a project is divided into. Under a Turnkey Contract a consortium of contractors, that was awarded the Turnkey Contract, splits the project into several packages as few contractors have the ability to handle very large packages (Huse, 2002). A higher number of packages however increases interface risks (Huse, 2002). Determining the right number of packages and the right package split is therefore critical.

The most common pricing schemes for construction projects are lump-sum (fixed-price), cost reimbursable, and unit price. *“The selection of a pricing method directly affects the distribution of certain risks, such as changes in the cost of labour and materials”* (Huse, 2002, p. 9). Lump-sum price means that the price of the project is fixed, regardless of the costs the contractor occurs (Huse, 2002). This pricing scheme is currently the most accepted one for PF (Böttcher & Blattner, 2013) due to the lower risks this pricing method holds for the project company and thus also for investors and lenders. In the cost reimbursable pricing scheme, the contractor is reimbursed for the actual costs he occurs plus an additional fee, thus

¹⁶ The project company is responsible for the design and the coordination of the project.

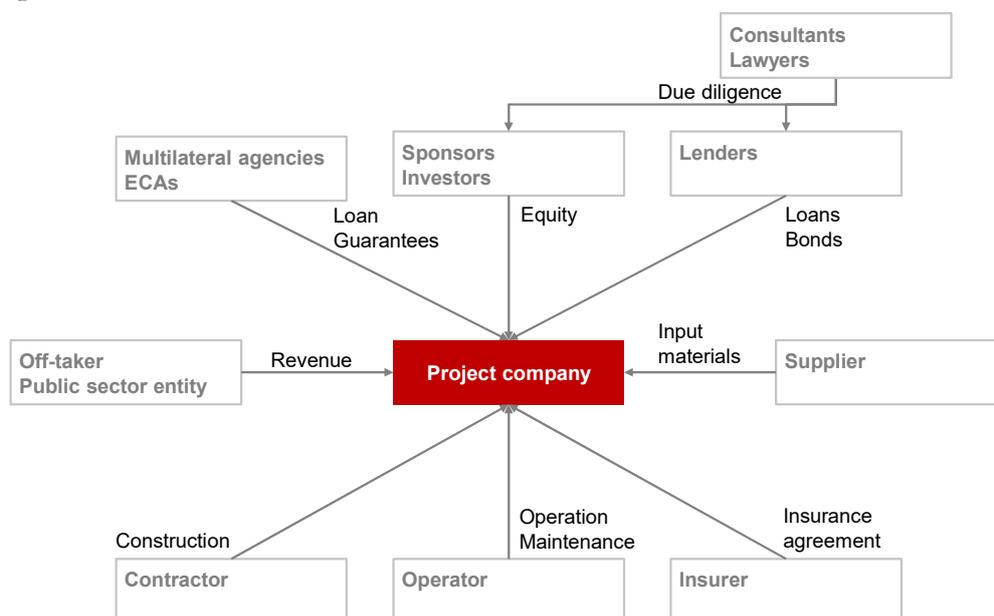
¹⁷ The contractor manages the project but liability for design and construction remains with the project company.

the contractor is not incentivized to keep costs at a minimum. Therefore, risk is high for investors and lenders. Unit price is a pricing scheme in which a fixed price is paid for each completed unit of work, here the contractor is not incentivized to finish the entire project in case completion costs are higher than payments for incomplete units.

2.1.3.2 PF stakeholders and their roles

Due to their important role in the provision of funds and the assessment of risks, the focus in this dissertation is placed solely on (1) lenders and (2) investors, as mentioned in chapter 1.3. However, to show the perspectives that are neglected in this dissertation, in the following also the other involved stakeholder groups illustrated in Figure 4 below will be briefly presented: (3) contractors, (4) operators, (5) insurers, (6) suppliers, (7) multilateral agencies, (8) consultants, and (9) lawyers.

Figure 4: Stakeholders involved in PF



Source: Adapted from Scott-Quinn and Deyber (2015)

Lenders typically form a consortium to provide debt to large projects as this allows the diversification of the risk of the project across a group of banks (Ehlers, 2014; Miller & Lessard, 2001). The consortium itself often plays a great role in forming the contractual

structure of the project including step-in rights and loan covenants (Blanc-Brude & Strange, 2007). The project company is typically not allowed to diversify debt sources – consortiums often require loan covenants that prohibit additional borrowing from different lenders (Blanc-Brude & Strange, 2007). Often, lenders do not give loans over the entire project lifetime, but restructure debt after the risky construction phase is completed (Scott-Quinn & Cano, 2015). In order to reduce the probability of default, lenders often require credit guarantees - these can be provided by multilateral public sector agencies (Ehlers, 2014).

In PF projects leverage is typically so high that lenders exert considerable control and fulfil the very important risk assessing and monitoring role during all phases of a project (Alfen et al., 2009; Asiedu, Frempong, & Alfen, 2017; Blanc-Brude & Strange, 2007). With entering into a PF contract, lenders provide a throughout analysis of the projects financial viability (Daube et al., 2008). Concentrated debt ownership makes monitoring easier, thus consortiums are formed rather than individual loans given (Sorge, 2004). The bank that acts as mandated lead arranger¹⁸ takes a leading role in the financing stage of the project, underwrites the financing, and handles syndication. Other banks in the consortium act as arrangers and structure the financing. Banks that act as participants provide funds to invest into the project. Further banks take advisory roles and consult sponsors (Blanc-Brude & Strange, 2007). Since interest rate charged by banks is low compared to the premium of investors, banks have to focus on avoiding credit losses rather than maximizing credit volume (Rad, 2017).

Project sponsors i.e. investors invest capital into the project in exchange for a share of ownership in the SPV. Hampl and Wüstenhagen (2013) define investors as “*project sponsors, financial or institutional (e.g. infrastructure funds, private equity funds, pension funds) and strategic (e.g. power companies) investors and other stakeholders that hold an equity stake in a project or SPV such as project developers or technology producers*” (Hampl

¹⁸ A lead arranger is a bank or firm that facilitates a syndicated loan.

& Wüstenhagen, 2013, p. 573). Many projects have a consortium of multiple sponsors generally including strategic investors such as the construction company, as well as sometimes suppliers and operators (Scott-Quinn & Cano, 2015). Additional equity finance is mostly provided by specialized financial investors, also called institutional investors, such as private equity companies, infrastructure funds, pension funds, insurance companies, government agencies, and the European Investment Bank (Scott-Quinn & Cano, 2015). Equity investors are typically contractually committed to the project in the long term, as a possible change of control would make debt risky and thus interest expensive (Scott-Quinn & Cano, 2015). Normally, equity investors have no guarantee of a return on their investment, thus they expect a high surplus on their investment in exchange for the risk they bear and therefore are motivated to focus on large projects and a high project volume (Ehlers, 2014).

Contractors are those companies that are responsible for the planning, design, and construction of the project. Typically, several contractors form a consortium to bid for an infrastructure project contract. The contractors then involve subcontractors and suppliers in the project. As mentioned above, it is also common for contractors to hold an equity stake in the project.

Operators are those that are responsible for maintaining and operating the infrastructure after completion. Also, operators commonly hold an equity stake in the project.

Insurers are those that provide risk insurances, which offer PF stakeholders an opportunity to mitigate risks they bear contractually at a certain cost (Esty, 2004a). This is specifically interesting for risks that cannot be controlled, such as the risk of earth quakes. Lenders for instance typically protect themselves from specific political risk events such as expropriation and changing regulation (Sorge, 2004). Also sponsors use insurances to decrease risk they cannot control e.g. currency devaluation (Esty, 2004a).

Suppliers provide materials and components of the infrastructure e.g. in a power plant project, fuel suppliers would be involved.

Further international financing institutions such as multilateral agencies or export credit agencies (ECAs) may be involved. Multilateral agencies such as the World Bank or regional development banks act as either lenders or provide loan guarantees for infrastructure projects. *“ECAs try to help domestic firms to export their goods and services to international markets”* (Esty, 2004a, p. 45).

Consultants provide due diligences and support in choosing project structure and bank consortium.

Lawyers set up the extensive contractual framework needed and support project initiators in choosing project structure and bank consortium. Further legal advisers aid in interpreting regulatory frameworks.

Public sector entities take different direct and indirect roles. Public sector entities can for instance be project initiators, take the role of project sponsor either in project finance or in public finance, or provide guarantees. Government agencies can also be suppliers in case the commodity needed for the project is something non-tangible such as a mining concession or the right-of-way. Additionally, regulations and policies of local governments can influence infrastructure projects greatly.

Public institutions that are involved in projects as sponsors have a different institutional structure than private sector investors such as infrastructure funds. The institutional structure of public entities is characterized by election periods e.g. in Germany 4 years, as well as the civil servant status (Bundesministerium der Finanzen, 2016). A complicating factor is that national and federal governments are often both involved and have different election periods, as well as different election results. While in investment funds, large projects are typically the responsibility of the top management, *“politicians are always*

happy to tout the success of completed projects, but if problems creep up in their construction, few are willing to take any responsibility” (Diekmann, Kröger, & Reimann, 2013) .

2.1.3.3 Phases of PF

After elaborating the typical structure of PF projects and the roles of PF stakeholders, in the following the typical phases of a PF project will be illustrated.

Project financing can be divided into successive stages: initiation, project analysis, risk analysis and distribution, as well as implementation of financing and monitoring of the project.

Project initiators, sponsors, consultants, and sometimes the public sector are involved in the initiating phase of PF. In this time consuming phase it is analyzed whether the project is financially viable (Alfen et al., 2009; Asiedu et al., 2017). If the result of this is that a project can be financed, lenders will be contacted with due diligence material (Scott-Quinn & Cano, 2015).

Then lenders and financial investors test the financial viability of the project and the prerequisites for PF with detailed due diligences (technical, environmental, legal, and economical) (Böttcher & Blattner, 2013). Valuing projects is complex as they are often exposed to unique risks and uncertain future cash flows (Esty, 2004a). Typically, complex cash flow models that also take real options into account are used for valuation. Credit rating agencies may be engaged in the process (Scott-Quinn & Cano, 2015). If the involved parties conclude that PF is an option, they will proceed with a risk analysis.

In the risk analysis risks are identified, classified, and allocated. The impact and likelihood of materialization is assessed for each risk. Together with the relevant stakeholders the risks are mitigated to the greatest extent possible, and allocated to the party that can best control them or bear them at lowest cost (Brealey et al., 1996; Esty, 2004a; Irimia-Diéguez et al., 2014;

Miller & Lessard, 2001). In this phase not only lenders and investors, but also consultants, and insurers are involved. Assessing the impact and likelihood of materialization is often done by simulations and sensitivity analysis (Esty, 2004a). Risk allocation is accomplished through contracts (Esty, 2004a).

The next step is implementing the PF by pricing the transaction and signing all documents. Contracts with lenders usually include step-in rights¹⁹ and extensive loan covenants²⁰. Lenders and investors will demand regular reports on project performance, milestones reached, and the status of credit covenants to monitor the project and manage risks continuously (Scott-Quinn & Cano, 2015; Yescombe, 2013).

2.2 Large infrastructure construction projects financed with PF in practice

After providing a brief overview of recent literature in chapter 2.1, including terminology (2.1.1), research streams and gaps (2.1.2), as well as the theoretical foundation of PF (2.1.3), in the following an overview of the PF market in general and specifically in Europe is given. Globally PF has experienced strong growth over the last years, the infrastructure field (including renewables) is expected to be the main growth area for PF in the future (Project Finance International, 2017), underlining the practical relevance of this dissertation. There is a consensus among scholars that PF will grow in importance due to budget constraints of governments both in developed and developing countries (Müllner, 2017). Pinto and Alves (2016) for instance conclude that PF “*represents a promising segment of global lending activity*” (Pinto & Alves, 2016, p. 3). According to Project Finance International (2017)²¹ the global project loans market was at 236.4 billion US dollar in 2016, which is slightly lower

¹⁹ A step-in right is the right to take over project company in case of a breach in contract.

²⁰ Loan covenants are promises the project company makes to lenders e.g. to fulfill specific information requirements with reporting and to keep specific financial ratios e.g. a certain debt service cover ratio.

²¹ According to Müllner (2017, p. 101): “*The most comprehensive sources of PF information are the databases maintained by Dealogic and Thomson Reuters.*”. Therefore, this effort uses the Thomson Reuters Project Finance International (PFI) annual league tables for the market overview.

than in 2015 due to a 40% decrease in PF activity in the US market (Project Finance International, 2017). The PF market in Europe 2016 remained at the same value as in 2015, sixty-five billion US dollar (Project Finance International, 2017). According to Project Finance International (2017) power was the single biggest PF loan sector globally and in EMEA in 2016, as can be seen in Figure 5. Growth in different sectors has been similar in recent years. The most relevant projects in Europe were in the offshore wind sector.

Figure 5: PF loans by sector 2016

Global loans by sector 2016		EMEA loans by sector 2016	
Sector	Volume USD M	Sector	Volume USD M
Power	110,915.8	Power	46,986.8
Oil & Gas	44,311.6	Oil & Gas	28,385.9
Transportation	43,278.6	Transportation	18,370.6
Petrochemicals	14,485.2	Petrochemicals	13,244.7
Leisure & Property	7,683.7	Industry	5,050.8
Industry	6,557.5	Leisure & Property	4,547.6
Mining	4,058.5	Mining	3,503.0
Water & Sewerage	3,371.1	Water & Sewerage	1,484.7
Telecommunications	942.7	Telecommunications	942.8
Waste & Recycling	851.1	Waste & Recycling	795.6
Total	236,455.8	Total	123,312.5

Source: Project Finance International (2017)

PF debt is mainly financed via loans, in Europe for instance loans made out 73% in 2014 (Scott-Quinn & Cano, 2015). Therefore, this dissertation focuses purely on loans as debt instrument, as mentioned in chapter 2.1.3.1. However, the importance of loans as PF instrument is slowly changing as according to Project Finance International (2017) “*activity in the bond market was up in 2016*” (Project Finance International, 2017, p. 50) while the loan market shrank. On the lender side banks remain the dominant lenders in Europe’s infrastructure financing. Increases in market share for the top ten players in recent years make

it more challenging for other players to land project deals²². As the largest players increase in size, they gain access to the increasing number of very large deals, effectively pushing smaller players to the side concurrently (Project Finance International, 2017). Some significant banks in recent years have now decreased their PF activity, focusing more on acquisition finance (Project Finance International, 2017). On the equity side institutional investors such as pension funds start to enter the PF markets on mostly brownfield but also occasionally greenfield investments (Heath & Read, 2014; Scott-Quinn & Cano, 2015).

Generally many large PF infrastructure projects face substantial cost and time overruns (Blanc-Brude & Makovsek, 2013). In 2014 the annual default rate in percent increased from 0.9 in 2013 to 1.3 (Gevero & Baker, 2016). However, *“the 10-year cumulative default rates for the PF study are consistent with the 10-year cumulative default rates for corporate issuers of low investment-grade (S&P Global Ratings Corporate Issuer Credit Rating of ‘BBB’)”* (Gevero & Baker, 2016, p. 3).

Currently the problem in the project financing industry is not the default rate, but rather the matching of finance from private investors with suitable projects (Ehlers, 2014). This (1) current challenge to finance infrastructure projects is explained in more detail in the following, further (2) the current political discussion is highlighted.

2.2.1 Current challenges to finance infrastructure projects and possible solutions

As mentioned in the introduction, there is a gap in infrastructure financing in Europe (Woetzel et al., 2017). It is vital to close this gap to keep the European Union competitive.

Main reasons for the gap are the three following. First, the public budget is constrained in developed countries like those in Europe (Müllner, 2017). One reason for this is the high level

²² The China Developing Bank was the only global top ten lead arranger in 2016 that was a newcomer in the top fifty ranking according to Project Finance International (2017). However, the ranking of China Development Bank was only due to one single big deal, while the other top banks in EMEA (Europe, Middle East, and Africa) arranged between thirty-five and fifty deals in 2016 according to Project Finance International (2017), therefore it is quite possible that this player will not appear in the ranking again next year.

of public in indebtedness in Europe (Woetzel et al., 2017). Therefore, important projects are hold up e.g. offshore wind farms in the North Sea were stalled for a long time. Second, long term funding from banks is constrained and expensive. Since the financial crisis of 2007, capital and liquidity requirement have become stricter for banks due to reforms like Basel II and III (Scannella, 2012). Thus banks will not be able to provide the amounts of debt that are required by large-scale infrastructure projects (Scannella, 2012). Additionally, the bank regulation Basel III has demanded higher capital requirements for banks that grant PF loans and has thus made interest more expensive (Chan & Worth, 2011). Third, since public resources and long-term debt by banks are constraint, there is the need to attract other sources of finance into the infrastructure sector. However, there are problems to match supply of private sector finance with investable projects. Europe's capital market has a current high level of liquidity while interest rates offered by government bonds are extremely low and investors look for investment opportunities with attractive rates of return (Woetzel et al., 2017). However, only few investors invest in infrastructure projects (Heath & Read, 2014). The reason for this is twofold. One the one hand, investors' appetite for low risk stable cash flow is not compatible with high risk greenfield projects and construction projects. Further disruptive technologies and changing users' needs increase uncertainty and risk (Woetzel et al., 2017). On the other hand, there is a lack of pipeline of properly structured projects. This is so because for some projects privatization is met with political skepticism. Often the early stages of project development are so complex and costly that many ideas do not move forward to an investable stage. Finally, many developers lack sufficient skill and resources for developing concepts into financeable well-structured projects.

As the infrastructure finance gap has many different reasons, different measures have been named to close the gap. One way to close the gap is to increase available funds by attracting more banks and institutional investors (Woetzel et al., 2017). This can be achieved by a combination of several measures. For instance, the pipeline of well-developed projects needs

to be improved. Further, changes to regulation and risk mitigation need to be made. Market facilitation and standardization need to be increased. Moreover, solid cross border investment principles need to be established and new investment assets such as the “Europe 2020 Project Bond Initiative” need to be developed (Scannella, 2012). Another way to close the financing gap could be to optimize the use of the funds already available today i.e. optimize public and corporate spending by e.g. prioritizing the right projects and improving the productivity of these projects.

Shifting more from asset, public, and corporate financing to PF in Europe can be a way to achieve optimized public and corporate spending.

As noted in chapter 2.1.1.2, using more PF for projects financed by corporates, this should lead to higher efficiency of projects due to agency cost advantages (Müllner, 2017) and reduced risk of managerial mismanagement due to the monitoring of banks (Esty, 2003).

As further mentioned in chapter 2.1.1.2, for the public sector as project initiator, by using PPP with PF agency problems and misaligned incentives might be reduced, financing risks shifted, project risks revealed, and shifted risks managed more effectively (Böttcher, Blattner 2013). According to Daube et al. (2008): *“PPP is not only a financing model, but an alternative, more profitable procurement method that involves a private contractor as well as private capital and know-how in realizing public infrastructure and services to reach value for money”* (Daube et al., 2008, p. 377). Moreover, public spending can be optimized by using PF on more PPP projects. In Europe PF is already a common financing form for PPP projects (Müllner, 2017). Yet, in the specific example of Germany another financing form is still dominant: the forfeiting model (Daube et al., 2008). Between 2002 and 2007 73% of PPP projects in Germany were financed by this method in which the private contractor sells the claims he has in the PPP project e.g. for the construction of the infrastructure asset to the bank, while the public entity declares a waiver of objection (Daube et al., 2008). The risks of the forfeiting model are that the public principal carries the insolvency risk, that the contractor

is less incentivized in case of bad performance, and finally that lenders do not evaluate, monitor, and control risks of the project (Daube et al., 2008). So while PF *"provides an all-embracing security instrument for public authorities"* (Daube et al., 2008, p. 381) the public principal carries more risks when using the forfaiting model. For all projects in which the risks of the forfaiting model are lower than the additional costs of PF, the forfaiting model optimizes the use of public spending. However, for many large projects this is not the case.

Besides optimizing the risk allocation for corporates and public institutions PF can help decreasing the investment gap. For corporate projects the financing gap is partly closed by reducing underinvestment due to corporate debt capacity and the risk of risk contamination (Esty, 2004a; Pinto & Alves, 2016). For public projects, by implementing PPP projects and by involving the private sector and lenders the public sector can implement projects for which the necessary budget is not available (Böttcher & Blattner, 2013). Nonetheless, it needs to be mentioned that PF does only solve this partially because long term lending capacity is limited and does not solve the problem to attract more investor funds into infrastructure. However, by introducing new financing models for PF private sector investors could be attracted to infrastructure finance e.g. debt finance through specific bond structures.

2.2.2 Current discussion about the use of PF for public infrastructure projects

Since several years there is the discussion, if private capital should be used in public infrastructure (Bundesministerium der Finanzen, 2016). There is infrastructure that is historically public in Europe, either because of its characteristics as for instance a monopoly²³, or because the private sector would not provide it sufficiently²⁴ (Heath & Read, 2014).

However, *"although governments in many countries have historically played a dominant role in the construction, ownership and operation of key economic and social infrastructure, more recent decades have seen a shift towards greater involvement of the private sector, not just as*

²³ E.g. citywide public transportation.

²⁴ E.g. healthcare, education.

builders, but also as operators, financiers and owners of what would otherwise be considered 'public infrastructure' assets and services" (Heath & Read, 2014, p. 100).

Opponents of private investment in public infrastructure question whether the complexity and high cost of PPP with PF (Bundesministerium der Finanzen, 2016; Yescombe, 2013) is worth it for the taxpayer. For public infrastructure, interest rates granted to privately financed SPVs are typically higher than the historically low ones that would be granted to public institutions (Bundesministerium der Finanzen, 2016; Yescombe, 2013). Yescombe (2007) estimates this premium to be as much as 200–300 basic points²⁵. Given the capital cost premium there is the concern, that the efficiency savings of PPPs and savings due to risk transfer overall might not manage to outweigh these costs (Hodge & Greve, 2007). However, when discussing this concern, currently savings from efficient risk allocation are not regarded, as their calculation is complex (Daube et al., 2008). Additionally, like public debt, PPP with PF pushes public investment obligations into future election periods (Bundesministerium der Finanzen, 2016; Daube et al., 2008) not being visible in the budget. Thus in times of the debt break, project finance/PPP might be used for public projects, even if it is not suitable for the individual project (Bundesministerium der Finanzen, 2016). Finally opponents view the level of profit that private investors make unreasonable, compared to the risks they take on (Heath & Read, 2014; Vecchi, Hellowell, & Gatti, 2013).

Proponents see private capital as the only way to close the infrastructure gap. Governmental intervention has the drawback that it can create inefficiencies (Engel, Fischer, & Galetovic, 2010; Gatti, 2012). In spite of the complex calculation of savings from efficient risk allocation there seems to be a consensus that private financing *"can lead to efficiency benefits by harnessing the skills and know-how of private partners combined with commercial incentives"* (Heath & Read, 2014, p. 106).

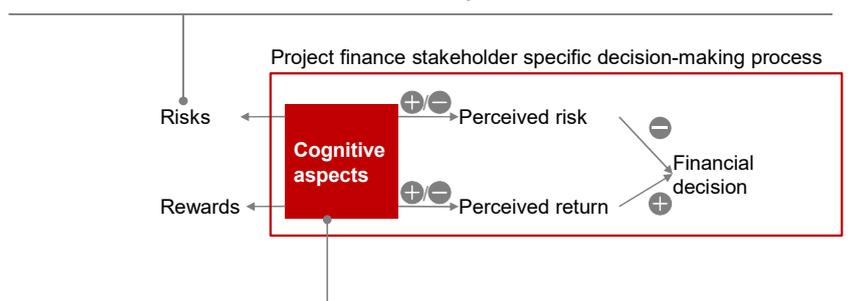
²⁵ According to other authors, however, there is no general PPP premium, compare Heath and Read (2014).

2.3 Synopsis - problem definition and addressed gap

Investments into infrastructure assets are the key to maintaining Europe's competitiveness, but all over the world, including Europe, there is a gap in infrastructure financing. Optimized use of available funds by e.g. prioritizing suitable projects and improving the productivity of projects seems to be one way to close this gap. Implementing projects with PF can help to achieve this if efficiency gains from synergies and the risk transfer to the party that can best carry the risk are higher than the costs of PF. For this, risks need to be understood far better than it is the case today. Especially estimator related risk i.e. the use of cognitive bias, triggered by high uncertainty of large infrastructure projects, is not accounted for sufficiently. Thus, in terms of the literature a gap exists regarding the benefits of PF, project valuation methods, risk management, and decision-making in the context of estimator related risks. Therefore, the aim of this study is to examine which estimator related risks are applicable in infrastructure PF in Europe, what fuels these risks, who can best carry them, and how they can be avoided. The relevant research questions can be reviewed in Figure 6.

Figure 6: Overview of research question

RQ1: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?



RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under "unrealistic optimism"?

RQ3: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?

3. Risk management in infrastructure PF

3.1 Problem statement

Infrastructure projects are becoming bigger and more complex (Baloi & Price, 2003; Flyvbjerg, 2014). Thus, managing risks becomes increasingly vital to ensure not only the project success (Baloi & Price, 2003), but also the success of the stakeholders involved (Flyvbjerg, 2014). Due to their size, failed projects can lead to corporate bankruptcy, as well as downswings in national economy (Flyvbjerg, 2014).

The implementation of projects as PF does not only feed “fresh” money to large infrastructure projects but simultaneously entails that risks are transferred from the public institution and corporates to contractors, lenders, and investors, as well as other PF stakeholders such as consultants. Risks are transferred optimally to the party that can bear the risk best at the lowest cost (Brealey et al., 1996; Esty, 2004a; Irimia-Diéguez et al., 2014; Miller & Lessard, 2001).

If this optimal risk transfer succeeds at a fair cost, shifting from asset, public, and corporate finance to PF as main financing method can be a way to achieve optimized public and corporate spending in Europe. At the same time, optimized spending can contribute to closing the infrastructure finance gap that was mentioned in the previous chapter.

To start with, a reliable risk assessment and handling can only be achieved with a profound knowledge of the risks and uncertainties large infrastructural projects typically face, and to whom these are typically transferred to.

3.1.1 Practical relevance

As mentioned in chapter 2, PF is only better than other financing options if the costs of PF are less than the costs the risk transfer generates for the corporate or public institution.

Understanding these risks is an essential foundation to assess this trade off properly.

3.1.2 Theoretical relevance

A vast set of specific risk factors for infrastructure construction projects have been identified in the project management literature. Many researchers have focused on specific risk factors of construction projects. Blanc-Brude and Makovsek (2013) for instance examine the systematic nature of cost overruns as a planning or estimation problem.

However as can be seen in Table 1 no typology of the risks has been defined for infrastructure projects financed through PF that shows exactly which risks are taken over by lenders and private investors. This is surprising, because as described in chapter 2, the risks of infrastructure projects implemented with PF are different to risks of other project types, and PF is growing as an implementation form. Further lenders and investors take over specific roles in this implementation form, so the risks these stakeholders carry are vital and should be investigated. Additionally to the missing focus on PF, apart from Baloi and Price (2003), previous research omits estimator related risks, such as those caused by cognitive bias, from their risk taxonomies and typologies.

Table 1: Selected previous studies on risks in infrastructure construction projects

Author	Type of project		Allocation of risk			Risks		
	Infra-structure projects	PF	Public and private sector	Stakeholder groups	Includes lenders and investors	Risk factor categorization	Specific risks factors	Estimator related risks
This paper	x	x		x	x	x	x	x
Irimia-Diéguez et al. (2014)	x			x	x	x		
Marques and Berg (2011)	x		x			x	x	
Ibrahim, Price, and Dainty (2006)	x		x			x	x	
Bing, Akintoye, Edwards, and Hardcastle (2005)	x		x			x	x	
Baloi and Price (2003)	x					x	x	x
Girmscheid and Busch (2003)						x	x	
Grimsey and Lewis (2002)	x					x		
Miller and Lessard (2001)	x					x	x	
Akintoye and MacLeod (1997)	x					x		

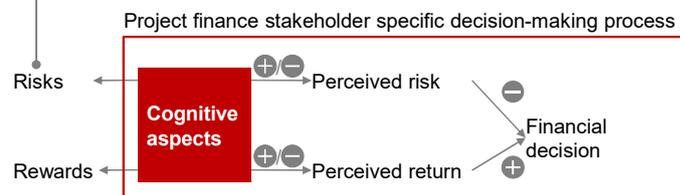
3.2 Goal and approach

In the risk management literature, it was proposed to transfer risks of large infrastructure construction projects to private sector stakeholders because they have a higher motivation to avoid and diversify these risks (Flyvbjerg, 2013). However, it is not clearly defined which risks typically transferred to private parties. Already 14 years ago Sorge (2004) called for "*a deeper understanding of risks involved in PF*" (Sorge, 2004, p. 101), yet, still in recent years authors call for further research (Irimia-Diéguez et al., 2014; Müllner, 2017).

The risk categorization of Irimia-Diéguez et al. (2014) is the latest typology in previous research. Therefore, goal of this chapter is to build on this typology and show which infrastructure stakeholder typically bears which risks, answering the research question highlighted in Figure 7 below.

Figure 7: Research question relevant in this chapter

RQ1: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?



Source: Adapted from Hampl and Wüstenhagen (2012)

To derive an answer to this research question, the approach is threefold.

First, a comprehensive literature review of existing research on risk factors of infrastructure projects financed through a SPV is conducted to gain an overview of the concepts themselves (presented in chapter 3.3). A specific focus during the literature review is laid upon the typical allocation of these risk factors to project stakeholders and the project phases the risks occurred.

Second, because risks are discussed in previous literature on a high level rather than detailed and are typically not defined for estimator related risks, an explorative approach was taken (presented in chapter 3.4). Following a qualitative research design, internal project documents of three projects (risk registers), publicized case examples stating main reasons why specific projects failed, and eight semi-structured interviews with PF decision makers are analyzed according to the process suggested by the CIT.

Finally, the empirical findings are compared to the findings from the literature review and used to create a typology of risks clustered by stakeholder that bears them typically (presented in chapter 3.5).

3.3 Status quo relevant literature on risk management in infrastructure PF

In the following (1) the terms decision under risk and decision under uncertainty are defined, (2) an overview of the relevant literature streams is provided, and (3) the typical risks present for large infrastructure projects are named.

3.3.1 Terminology - decisions under risk and decisions under uncertainty

Decision making situations are usually defined as either deterministic i.e. the outcome is known with certainty, decisions with risk involved, and decisions under uncertainty (Baloi & Price, 2003). In the following the term risk and uncertainty are defined for the course of a decision-making process.

Infrastructure projects are full of risks for their stakeholders. But what is risk in this context? "*Risks are parameters which can affect any venture either positively or negatively*" (Ibrahim et al., 2006, p. 151), it is the chance of any outcome to be different than expected (Heath & Read, 2014). In a decision under risk a probability, objective or subjective, can be assigned to the materialization of the risk (Baloi & Price, 2003). Objective probabilities are those that are determined statistically e.g. based on historic data (Aven, 2016). Subjective probabilities are those that are based on personal experience, beliefs, or intuition (Aven, 2016).

In decision making, uncertainties are those parameters that are simply unknown and therefore no probability can be assigned to them (Baloi & Price, 2003). In infrastructure projects this can be e.g. completely unforeseen events, or errors (Baloi & Price, 2003).

3.3.2 Overview of literature streams and gaps

The following table gives a brief overview over the relevant research streams regarding the questions which the typical risks and uncertainties of large infrastructure construction projects are, as well as which stakeholder they are typically transferred to. Overall, a gap exists regarding the exact risks, including estimator related risks that are taken over by lenders and investors in infrastructure PF. This is surprising, because as was described in chapter 2, PF is growing as an implementation form with very specific risks, and understanding the risk transfer is vital to decide if PF can contribute to closing the infrastructure finance gap.

Table 2: Overview of relevant literature streams for RQ1

Literature stream	Most relevant journal	Latest review	Aspects relevant for RQ1	Other aspects covered
Risk management literature	various	Aven (2016)	Development of concepts and tools for risk management, applicability of risk management to decrease risks of specific activities in practice	
PF literature	International Journal of Project Management	Müllner (2017)	Management research (role PF in risk management, reasons for project failures)	Financial research (benefits PF, project valuation methods, characteristics PF loans), management research (comparison and traditional procurement), international business research (benefits of PF in high risk investments)
Megaprojects literature	International Journal of Project Management, Project Management Journal	Irimia-Diéguez et al. (2014)	Risk analysis and management (risk typologies)	Organization/stakeholder management, scope/procurement management, cost/schedule management, construction/site management megaproject management as new profession, central project monitoring/control, complex project management, information technology

The overarching literature stream that contributes to the question at hand is the risk management literature. *"The number of papers in this field has been increasing in recent years; consistent with the importance that this topic has assumed"* (Irimia-Diéguez et al., 2014, p. 415). This stream describes the risk identification, allocation, and response process in

detail. Regarding risk identification, findings were transferred to different literature fields and e.g. risk typologies and taxonomies exist for different kind of decision situations. Relevant for the research question at hand are decision situations discussed in the literature streams of PF and megaprojects. For these individual literature streams specific gaps of the existing risk typologies and taxonomies are highlighted in the next paragraphs.

The PF management stream presented in chapter 2 is relevant for the research question at hand, as it evaluates the role of PF contractual structures in risk management and decision making, highlighting the risk mitigating role of lenders, and providing specific risk typologies. In the PF literature Müllner (2017) states: "*IB research would benefit greatly from sharpening its perspective to differentiate between very broad uncertainty and specific sources of risks that are both measurable and manageable*" (Müllner, 2017, p. 126).

However, as mentioned in chapter 2, all existing typologies neglect a detailed account of estimator related risks, although they are investigated with regards to project planners.

Also in the megaprojects literature a vast set of specific risk factors has been identified.

Already Akintoye and MacLeod (1997) acknowledge "*the construction industry and its clients are widely associated with a high degree of risk due to the nature of construction business activities*" (Akintoye & MacLeod, 1997, p. 31). Many researchers have focused on

specific risk factors in the construction phase of construction projects. Blanc-Brude and Makovsek (2013) for instance examine the systematic nature of cost overruns as a planning or estimation problem e.g. due to scope changes and design related errors and omission.

However Irimia-Diéguez et al. (2014) state: "*Further research into how these risks are managed in megaprojects is called for, in an effort to recognize risk mitigations and coverage measures*" (Irimia-Diéguez et al., 2014, p. 416) and specifically highlight that in the infrastructure area there is only little research on labor risks and force majeure. However, not only labor risks and force majeure are understudied. Apart from Baloi and Price (2003), who

mention estimator related risk without providing further details, previous research omits this risk category completely in their risk taxonomies and typologies.

Based on the existing risk management, PF, and megaproject literature above, in the following a summary of the status quo in (1) risks on infrastructure projects and (2) risk management is presented.

3.3.3 Theoretical foundation - risks of infrastructure construction projects

To see how risks are managed a first step should be to identify which specific risks are relevant in the context of infrastructure projects financed through a SPV. This will be done in the following.

The desirable outcome for any infrastructure project is delivery according to specifications, as well as on-time and within the budget completion (Blanc-Brude & Makovsek, 2013).

However, cost and schedule overruns happen frequently, e.g. according to Flyvbjerg, Skamris Holm, and Buhl (2003) in 90% of transport infrastructure projects. This phenomenon is global and seems to have persisted over time (Flyvbjerg, Skamris Holm, & Buhl, 2004). How risks are evaluated affects the financial viability of the cash flow analysis (Irimia-Diéguez et al., 2014). Risk management is necessary on any kind of project, however in megaprojects it is especially relevant due to the large impact megaprojects have on companies and societies (Irimia-Diéguez et al., 2014). Grimsey and Lewis (2002) state that one of the greatest risks in any PF infrastructure project is, that the initially predicted revenues do not materialize. Other authors argue that the failure to meet construction cost, completion time, and quality targets is one of the main risks (Baloi & Price, 2003).

The general risk of not achieving project targets, can be classified in more detailed risk categories. *"The classification of risks constitutes a basic element in this process since not only does it help in the process of risk identification, but also in the subsequent steps, including how these risks should be managed"* (Irimia-Diéguez et al., 2014, p. 413). Up to

today, no consistent classification of risks in infrastructure projects exists. Some authors classify risks in terms of influenceability by project management, others focus on impacted project areas, or originating sources (Baloi & Price, 2003). In Table 3 examples of different classifications are presented.

Table 3: Selected risk categorizations

Author	Categories	Categorization factor
United Nations Industrial Development Organization (1996)	General/country specific risks (political, country commercial, and country legal risks) and project specific risks	Originating source
Akintoye and MacLeod (1997)	Physical, environmental, design, logistics, financial, legal, political, construction, and operation risks	Originating source
Miller, R. and Lessard (2001)	Market related risks (due to revenue risks and financial markets), completion risks (related to construction and operation), and institutional risks (result of laws, regulations, public pressure)	Originating source
Grimsey and Lewis (2002)	Global (not controllable by project participants) and elemental (controllable) risks	Influenceability by project management
Girmscheid and Busch (2003)	Legal, financial, technical, and schedule related risks	Impact area
Baloi and Price (2003)	Estimator related (cognitive biases), design related, level of competition related, fraudulent practices related, economic related, and political related risks	Originating source
Bing et al. (2005)	Macro, meso, and micro levels of risks	Influenceability by project management
Ibrahim et al. (2006)	Exogenous risks (political & governmental policy, macroeconomic, legal and legislative, social factors, natural factors) and endogenous risks (project selection, project finance, residual risk, design factors, construction risk, operation risk, relationship risk, third party risk)	Influenceability by project management
Marques and Berg (2011)	Production, commercial, and contextual risks	Originating source
Irimia-Diéguez et al. (2014)	Design, legal/political, contractual, construction, operation and maintenance, labor, clients/user/society, financial/economic, and force majeure	Impact area

As mentioned above, this research will use the categorization Irimia-Diéguez et al. (2014) proposed, as this seems to be not only the latest attempt to achieve an exhaustive and mutually exclusive classification, but as well considers most researched risks. However, estimator related risks i.e. the risk to assess risks incorrectly, is not included in the typology of Irimia-Diéguez et al. (2014) but needs to be considered as an additional risk factor category.

According to Flyvbjerg (2006): "*a major source of risk in project management is inaccurate forecasts of project costs, demand, and other impacts*" (Flyvbjerg, 2006, p. 5). Table 4 below shows this extended, full risk categorization used in the following and provides definitions of each of the risk factor categories.

Table 4: Risk categorization used in the following

Risk factor category	Explanation
Clients/user/society	<i>"Include: (a) demand risks such as inflation, price trends, price range; (b) market risks, such as variations in the client's requirement, existence of the market; (c) social profitability risk which puts into question if the project provides the expected benefits to society; (d) impact on local groups' risk arises when the inhabitants of an area are a source of risk due to not being managed correctly; (e) environmental risks, which are usually called environmental impact assessments (EIAs); and (f) reputational risks, including media and marketing control"</i> (Irimia-Diéguez et al., 2014, p. 414)
Construction	<i>"Cost overruns (or cost escalation), project schedule, coordination problems, an inappropriate design or accident during the construction are examples classified within this section"</i> (Irimia-Diéguez et al., 2014, p. 414)
Contractual	<i>"Those derived from the renegotiation of the contract, such as midstream change of project scope, and issues caused by imprecision and vagueness in the contract"</i> (Irimia-Diéguez et al., 2014, p. 413)
Design	<i>"Those related with the planning phase of the megaproject, such as delivery method, contract formation, and scope control"</i> (Irimia-Diéguez et al., 2014, p. 413)
Estimator related	<i>"Cognitive biases: availability, representative adjustment and anchoring, and motivational bias"</i> (Baloi & Price, 2003, p. 264)
Financial/economic	<i>"Encompass a variety of events related with the financing and performance of the megaproject. These are composed of: (a) economic risks related with the investment or economic structure of the megaproject, such as lower-than-expected profitability, and inappropriate metrics about the project; (b) financial risks due to the high level of leverage which exerts an impact on the megaproject solvency; (c) liquidity risks, such as financial restrictions, availability of funds, and downgrading of credit ratings; and (d) foreign-exchange and interest-rate risk derived basically from long-term interest rates and foreign exchange rate"</i> (Irimia-Diéguez et al., 2014, p. 414)
Force majeure	<i>"War, natural disasters, extreme weather conditions, terrorism"</i> (Irimia-Diéguez et al., 2014, p. 414)
Labor	<i>"Related with the workers linked to training, language, accident cost, and culture"</i> (Irimia-Diéguez et al., 2014, p. 414)
Legal/political	<i>Derived from changes in the governing policy of the country where the megaproject is developed i.e. authorization criteria, political actors, changing government regulations, cancellation of a concession</i> (Irimia-Diéguez et al., 2014, p. 413)
Operation and maintenance	<i>Those related with the operational phase that can affect the operation cost, operation capacity or quality, such as economic viability issues, unnecessarily high operations costs, poor construction quality, and operator incompetence</i> (Irimia-Diéguez et al., 2014, p. 414)

Infrastructure construction projects have distinct characteristics as named in chapter 2. They are capital intensive, long term, and have an unattractive cash flow time profile (Ehlers, 2014; Sorge, 2004). Therefore, certain risks e.g. regulatory risks in the risk factor category clients/user/society are more relevant for these kind of projects than for other project types (Baloi & Price, 2003). The high uncertainty leaves room for estimator related bias (Flyvbjerg, 2006). Furthermore, for infrastructure projects construction activities are customarily needed, and *"construction cost overruns are generally considered to be one of the greatest risks faced in infrastructure project development"* (Blanc-Brude & Makovsek, 2013, p. 3), with *"the construction industry and its clients are widely associated with a high degree of risk due to the nature of construction business activities"* (Akintoye & MacLeod, 1997, p. 31).

Infrastructure projects are further typically very complex as often a large number of parties are involved (Ehlers, 2014; Sorge, 2004). The success of the projects depends on a joint effort

of all parties. Coordination problems, conflicts of interest, and freeriding can lead to project failure (Sorge, 2004). Naturally design risks related to scope and construction risks such as coordination problems are high in infrastructure projects (Blanc-Brude & Makovsek, 2013).

Table 4 above shows a categorization for general risks a large infrastructure project faces. However, different (1) infrastructure project types and different (2) project phases carry different additional risks. These will be elaborated in the following.

3.3.3.1 Specific risks of different infrastructure project types

As this research uses the infrastructure definition of Weber et al. (2016) comprising transport assets, public utilities, and social infrastructure, in the following examples of specific risk factors for one specific project type in each of the mentioned infrastructure categories will be given, to highlight the difference between subsectors. However, although differences exist, the similarities prevail, so the overall focus of this work will be placed on large infrastructure construction projects in general.

Transport assets comprise roads, railways, bridges, tunnels, ports, and airports (Weber et al., 2016). For projects in the road sector for instance, an important risk factor belonging to the risk factor category clients/user/society is risk of changing customer demand, as it is often hard to predict traffic in the long run because alternative transport connections can be opened in parallel. Further political risks play a role such as the risk of a concession cancellation (Irimia-Diéguez et al., 2014).

Public utilities are oil and gas networks, energy generation utilities including renewable energy, water supply, waste water, and waste disposal utilities (Weber et al., 2016). Risks for public utilities are partly different than those for transport assets. To highlight this, in the following specific risks for the wind energy sector will be named, as this is currently the most important project type in European infrastructure project finance, as pointed out in chapter 2.2. In wind energy projects legal/political risks arise inside and outside the national

boundaries especially from the potential change in laws and provisions in Europe e.g. change in feed-in tariff (Lüthi & Wüstenhagen, 2012). In the risk category clients/user/society, community acceptance risk is quite specific for wind parks (Hampl & Wüstenhagen, 2013) as local resistance, frequently supported by activists from other regions and even other countries, might develop against installation of wind turbines. Protests or attempts to declare areas environmentally protected, can increase the project's planning and construction phase (Horbaty & Huber, 2010). In addition, especially offshore wind projects have high construction risk due to the harsh sea conditions, which make construction projects hard to implement.

Social infrastructure, classified as schools, hospitals, administrative buildings, and social housing (Weber et al., 2016), has also a partly unique risk profile. In the following specific risks for the education sector will be named, in order to highlight the difference to transport and public utility projects. As education provides a guarantee for social security (Poole, Toohey, & Harris, 2014), privatization is seen more critical by society than in most other infrastructure subsectors. At the same time e.g. education projects have a closer long term involvement with local communities than other project types (Jefferies & McGeorge, 2009). Thus, if implemented as PF with private sector involvement, in the risk factor category clients/user/society there is a high risk of public opposition to the project. Further, changing education systems, and thus new requirements play a big role (Irimia-Diéguez et al., 2014). At universities for instance many students use online lectures today – thus university buildings do not need lecture halls in the same dimension as in the past. Further, in German highschools for instance there has been a recent change from morning only lectures to all-day schools, requiring lunch facilities that were not needed in the past.

3.3.3.2 Specific risks of different infrastructure project phases

“Risks change as an infrastructure asset passes through the planning, construction, operation and decommissioning phases” (Poole et al., 2014, p. 14). Therefore, exemplary differences in specific risk factors between the project phases planning, construction, and operation (as highlighted in chapter 2.1.3.3) will be named in the following.

"It must be emphasized that risks are present in a megaproject from the beginning, even in the very early planning stage" (Irimia-Diéguez et al., 2014, p. 413). A major risk in the planning phase is the so called optimism bias: often in the planning phase forecasts are too optimistic (Blanc-Brude & Strange, 2007; Flyvbjerg et al., 2009). Further risks associated with the bidding, planning, and approval processes are characteristic of this phase e.g. land acquisition risks (Alfen et al., 2009).

"It is commonly acknowledged that cost estimates become more accurate through the project as a project's scope becomes better defined" (Blanc-Brude & Makovsek, 2013, p. 5), thus often cost associated risks become smaller as the construction phase evolves. Specific risks in the construction phase are for instance changes in the design, unforeseen construction site costs, health and safety on construction sites, project schedule overruns, and coordination problems (Irimia-Diéguez et al., 2014; Poole et al., 2014). Overarching the risks can also be summarized as construction cost and time overrun (Alfen et al., 2009).

Risks in general decrease dramatically as operations start. This becomes visible indirectly in a decreasing finance cost after the completion of the construction (Blanc-Brude, 2013). Specific risks in this phase are risk of expansion and major upgrading costs, increasing operation costs, and risk of inappropriate maintenance measures (Irimia-Diéguez et al., 2014), as well as demand risk (Alfen et al., 2009).

Not all infrastructure construction projects have a decommissioning phase (Poole et al., 2014). For those that do, e.g. nuclear power plants, risks are still present in this phase, for instance environmental risks (Poole et al., 2014).

3.3.4 Theoretical foundation - risk management process

Risks are typically managed by a formal risk management process, which runs continuously on a project (Alfen et al., 2009; Mills, 2001). The key to effective risk management in infrastructure projects is to allocate risks through contracting to the stakeholder that can carry the risks at the lowest cost (Brealey et al., 1996; Esty, 2004a; Irimia-Diéguez et al., 2014; Miller & Lessard, 2001). In practice due to a lack of knowledge and time constraints, risk management is often not done unprejudiced but based on "*individual intuition, judgement and experience gained from previous contracts*" (Akintoye & MacLeod, 1997, p. 37).

The first step in the risk management process is risk identification and qualitative/quantitative risk assessment, followed by allocation to the relevant project stakeholder, and finally risk mitigation/response including risk monitoring and controlling (Baloi & Price, 2003; Irimia-Diéguez et al., 2014; Marques & Berg, 2011). In the following these steps are shortly explained.

Risk identification is vital, because only those risks that are identified can be managed (Mills, 2001). Typically projects identify risks by using different methods like check lists, brainstorming, and site visits (Alfen et al., 2009; Eid, 2008).

Once a potential risk is identified, a risk assessment is carried out in which the likelihood of the occurrence and the consequence of the risk materialization are analyzed (Alfen et al., 2009). The assessment is typically either qualitatively or quantitatively, depending on the data available (Eid, 2008).

Different stakeholders can carry risks at different costs, therefore in construction contracts it is vital to assign risks to the stakeholder that can carry the risks at the lowest cost (Brealey et al., 1996; Esty, 2004a; Irimia-Diéguez et al., 2014; Miller & Lessard, 2001). This is not always straightforward (Poole et al., 2014), therefore typical allocation and problems in practice are presented in the following. While many researchers just discuss the allocation of risks between owners and contractors, or in case of PPP between the public and the private sector, Irimia-Diéguez et al. (2014) describe to which stakeholder groups relevant for PF risks (excluding estimator relate risks) are typically contractually allocated. From this allocation, that can be seen in Table 5, it can be derived which risks are relevant for the stakeholders in a Fixed Price Date-Certain Turnkey European infrastructure PF.

Table 5: Typical allocation of risks

Risk factor category	Public sector	SPV	Contractor	Consultants	Private investor	Lender
Clients/user/society	x	x				
Construction			x			
Contractual	x	x			x	
Design	x	x		x	x	
Estimator related	?	?	?	?	?	?
Financial/economic		x		x	x	x
Force majeure	x	x	x		x ²⁶	
Labor		x	x			
Legal/political	x	x		x	x	
Operation and maintenance		x	x			

While the ideal risk allocation looks straightforward in theory, in practice there are numerous problems with contractual risk allocation. Contracts between different stakeholders and especially between the SPV and the contractor are complicated to design, as risks are highly project specific. Contracting itself is thus a central risk in large infrastructure PF (Poole et al., 2014). Further, when transferring risks, problems due to incentives for opportunistic behavior in contracts (principal agent, hidden intention, hidden action, cognitive bias) can appear (Flyvbjerg et al., 2009). Another important factor when transferring risks is, that a risk transfer always includes costs (Poole et al., 2014). Stakeholders therefore need to assess if

²⁶ Adding to the allocation of Irimia-Diéguez et al. (2014), other authors also argue that investors additionally carry force majeure in fixed price contracts, as contractors can default, compare Blanc-Brude (2014).

transferring a specific risk away from them is worth the cost they pay to be freed from that risk. However, in practice a complete transfer of a certain risk is often not possible, as e.g. sponsors often contractually transfer construction related risks to contractors, but these can default contracts and go bankrupt, leaving the sponsor with a degree of risk (Blanc-Brude, 2014; Grimsey & Lewis, 2002).

After risk identification, assessment, and allocation the final step of the risk management process is risk mitigation/response. The stakeholder that carries and monitors a certain risk can take two different actions, when responding to it. Either the risk can be controlled or ways have to be found to finance losses from this risk (Alfen et al., 2009). To control risks, the relevant stakeholders can use elimination, transfer, or reduction of the risk (Ibrahim et al., 2006). In order to e.g. control force majeure, insurances can be purchased that transfer the risk to insurance companies (Eid, 2008).

3.4 Explorative approach - qualitative research design

In the previous chapter the status quo of relevant literature was provided as foundation to answer the research question at hand, including terminology (3.3.1), description of relevant research streams and gaps (3.3.2), as well as the theoretical foundation of risks on infrastructure construction projects (3.3.3), and the risk management process (3.3.4). In the following, the general aim of the study design, the data collection method, and data analyzing method are explained.

3.4.1 General aims

The research question of this chapter is: Which are the typical risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?

In the literature review, provided in chapter 3.3.2, it became visible, that existing typologies do not fully fit to the specific decision situation this research concerns itself with. Further, in all but one paper, estimator related risks are not examined. Therefore, data collection following a qualitative research design is necessary to adapt existing risk typologies to the specific decision situation this effort is concerned with.

3.4.2 Data collection method

The first step to answer the research question was to gain an overview of existing concepts for risk allocation and monitoring with a focus on project stakeholders and project phases the risks occur in. This was provided in chapter 3.3.3. Now following is a qualitative research design, analyzing internal project documents of three projects (risk registers) and semi-structured interviews with eight PF decision makers according to the process suggested by the CIT.

The interview method to collect data was chosen because it allows to access expert knowledge not only at factual but also at meaning levels (Kvale, 2007) and to get information that is not explicitly asked for. In risk management studies interviews are a commonly used method (Rad, 2017). Both semi-structured interviews and a focus group is used.

Semi-structured interviews were chosen because they allow the experts being interviewed to steer the interview and provide enough room for the experts to share their specific individual expertise and perspective, as suggested by Silverman (2006). Finally interviews also offer the interviewer enough flexibility to discover hidden facets of human behavior such as perceptions.

A focus group interview, where three experts discussed their perceptions of risks simultaneously, was conducted to supplement the semi structured interviews. Main aim was to gain a broader understanding of the matter at hand, as suggested by Williams and Katz (2001).

The interviews were conducted over a period of three months. Each interview lasted between 30 and 60 minutes. Whenever the experts allowed, taped recordings were made to ensure a thorough analysis of the collected data. Afterwards recordings were transcribed to prepare them for analysis. In two interviews experts did not want to be recorded – during these interviews detailed notes were taken.

Interviewees were chosen both due to experience in the field of infrastructure PF, as well as due to their current position as either consultant active in the infrastructure sector, or investor and lender active in infrastructure PF. In Table 6, a description of the sample is provided.

Table 6: Overview of experts interviewed

Expert	Anonymized description of expert
Consultant I	Head of consultancy company for capital projects, having also > ten years of experience as project owner and contractor (male)
Consultant II	Expert at global consultancy firm with extensive experience as project owner and > twenty years' experience in the infrastructure sector (male)
Consultant III	Consultant with two years of consulting experience in the infrastructure sector (female)
Investor I	Investor with > twenty years of experience with different investment funds in the infrastructure industry (male)
Investor II	Investor with > twenty years' experience as consultant and owner in infrastructure industry (male)
Lender I	Lending officer in market department focused on infrastructure financing (male)
Lender II	Head of bank branch with department focused on infrastructure finance and > ten years' experience in infrastructure financing (male)
Lender III	Head of PF department at a European bank with > twenty years of PF experience with focus on the transportation sector and PPP projects (male)

During the process of interviewing, risk categories and typical risk allocation were identified and noted until no new themes emerged, as proposed by Kutsch and Hall (2005). Relevant quotes from the experts can be found in the Appendix. Theoretical saturation seemed to be reached after analyzing three risk registers, and conducting interviews with eight experts.

3.4.3 Method used for analysis

Following a qualitative research design, the internal project documents of three projects (risk registers) and the interviews with eight PF decision makers were analyzed according to the process suggested by the CIT. The CIT was chosen, as it allows researchers to analyze data about human behavior such as risk management process (Butterfield, Borgen, Amundsen, &

Maglio, 2016; Flanagan, 1954). The method is flexible, it consists of a set of rules and guiding principles and can be adapted to various research fields and topics (Butterfield et al., 2016). Focus of the method is to identify critical events.

To ensure a systematic approach of the data analysis, the interviews were analyzed by first grouping the collected statements of each interviewee according to the risks involved in the projects and the stakeholder that carried the risk they described. The grouped statements were then compared across interviews together with the data from internal project documents of three projects (risk registers) and the existing typologies from previous literature, especially the risk categorizing framework of Irimia-Diéguez et al. (2014).

In order to achieve reliability in the data analysis, suggestions for reality checks from Butterfield et al. (2016) were followed. One additional researcher familiar with the CIT method was used to extract several critical incidents from the transcriptions as well as to place a few critical incidents in the categories formed. This did not yield any other results.

Further, with some interviewees a second interview or a follow up mail was used to check if the derived results were interpreted correctly. Finally, the list of risk factors and risk factor categories was viewed by two industry experts to enhance the lists credibility.

3.5 Findings - generating a risk typology for PF infrastructure projects

In the following, the main results are presented, with a focus on similarities and differences to previous literature. The full typology derived can be found in the Appendix.

Building on the categorization of Irimia-Diéguez et al. (2014), who named nine risk factor categories and two to four exemplary risk factors per category, the mixed qualitative method resulted in a risk typology with ten risk factor categories and 175 detailed risk factors.

Naturally not all identified risk factors have the same importance, likelihood, and impact, however it is still remarkable that more than 20% of risk factors can be classified

financial/economic and about 16,5% construction related, while only about 2% of risk factors are estimator related.

The SPV itself carries the majority of the risk factors, as can be seen in Table 7, however most of these risk factors are shared with other stakeholders. Contractors are the only risk owner for construction risk.

Table 7: Distribution of risk among stakeholders

Risk factor category	Number of identified risk factors per stakeholder that typically carries the risk						Number of identified risk factors per category
	Public sector ²⁷	SPV	Contractor	Investor	Lenders	Consultants	
Clients/user/society	13	13					13
Construction			29				29
Contractual	19	19		19			19
Design	11	11	1	11		11	11
Estimator related risks		1	2	1	1		3
Financial/economic		38		38	38	38	38
Force majeure	7	7	7				7
Labor		13	13				13
Legal/political	22	22		22		22	22
Operation and maintenance		20	20				20
Total	72	144	72	91	39	71	175

Expert interviews, as well as risk registers showed that the allocation of typical stakeholder responsibility for risks made by Irimia-Diéguez et al. (2014), see Table 5, holds in general. The public sector (in case of public projects or PPP) carries risk factors included in the risk factor categories design, legal/political, contractual, clients/user/society, and force majeure. The SPV carries risk factors included in the risk factor categories design, legal/political, contractual, operation, labor, clients/user/society, financial/economic, and force majeure. The contractor carries risk factors included in the risk factor categories construction, operation, labor, and force majeure. Consultants carry risk factors included in the risk factor categories design, legal/political, and financial/economic. The private investor carries risk factors included in the risk factor categories design, legal/political, contractual, and financial/economic. And finally, the lender carries risk factors included in the risk factor category financial/economic.

A difference to the allocation of Irimia-Diéguez et al. (2014) is that design related risks are also allocated to contractors in this typology, because an interviewed expert described, that often contractors themselves must take on design risks in case projects are greenfield.

Results regarding the gap of estimator related risks are that this risk category is threefold: construction costs can be over- or underestimated, as well as construction time, and future revenues from the project. The typical allocation of these risks can be seen in Table 8. In a Turnkey Contract the risk to under- or overevaluate construction costs is carried by the contractor. In Date-Certain Turnkey Contracts, the risk of time overruns is also carried by contractors, however, since future revenues are delayed if this risk materialized, the SPV, investor, and lenders also carry this risk. The risk of misevaluating future revenues is carried by the SPV (who needs the revenues to break even), investors (whose investment profit depends on revenues), and lenders (SPV's ability to amortize the loan depends on revenue stream).

Table 8: Estimator related risks in PF infrastructure projects

Risk factor category	Risk factor	Stakeholder that typically carries risk					Consultants
		Public sector ²⁷	SPV	Contractor	Investor	Lenders	
Estimator related risks	Risk of under- or overevaluating future revenue		x		x	x	
	Risk of under- or overevaluating construction cost			x			
	Risk of under- or overevaluating construction time			x	x	x	

3.6 Discussion risk management in infrastructure PF

The goal of this chapter was to build on the risk categorization of Irimia-Diéguez et al. (2014) and show which infrastructure stakeholder typically bears risks answering the following research question: Which are the risks and uncertainties of large infrastructure construction projects that need to be evaluated, and which stakeholder are they typically transferred to in

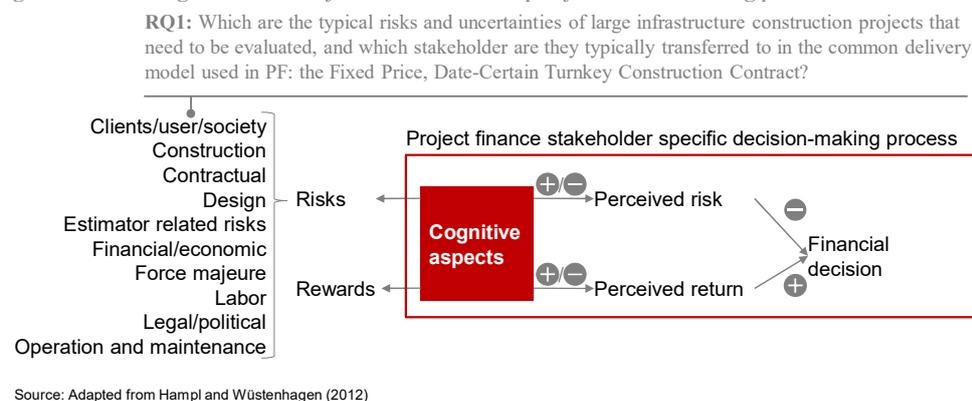
²⁷ Here not in their role as investor/sponsor but as project initiator and supplier of e.g. concessions

the common delivery model used in PF: the Fixed Price, Date-Certain Turnkey Construction Contract?

To derive an answer to the research question, a comprehensive literature review was conducted, internal project documents of three projects and semi-structured interviews with eight PF decision makers were analyzed according to the process suggested by the CIT, and finally a typology of risks clustered by stakeholder that bears them typically was created.

The full risk typology that answers the research question above can be found in the Appendix, risk categories can be seen in Figure 8 below.

Figure 8: Risk categories relevant for PF stakeholder specific decision-making process



The typology revealed (1) a comparably high percentage of financial/economic risks and (2) the fact that estimator related risks are carried also by project outsiders.

The highest percentage of risk factors mentioned in the literature and by PF decision makers can be classified as financial/economic while the lowest percentage are estimator related. The high percentage of financial/economic risk factors underlines the high uncertainty in infrastructure PF. According to Kahneman and Tversky (1982) high uncertainty often leads to heuristics and cognitive biases in the decision-making process. Thus, it can be said that the high uncertainty in infrastructure PF provides room for estimator related risks, namely the risks of under- or overevaluating future revenues, construction costs, and construction time. While the risk category estimator related risks only contains these three different risk factors,

these might have a very large impact on the final project outcome (Flyvbjerg et al., 2014).

Unrealistic optimism, which is directly related to these three risk factors, can lead investors to do less critical analysis (Baker & Nofsinger, 2002) and invest in unprofitable projects (Heaton, 2002).

The risks to under- or overevaluate construction costs is carried by the contractor in a Turnkey Contract, while the risk of miscalculating future revenues is carried by the SPV, investors, and lenders. The fact that lenders and investors as project outsiders carry estimator related risks means, that banks and funds do not only provide money needed to close the infrastructure finance gap, but also take over risks attached to the risk management process. This is an interesting finding as so far, literature in the area of infrastructure projects usually emphasizes how an outside perspective prevent cognitive bias in risk assessment (Flyvbjerg et al., 2009). Our findings, however, suggest that outsiders might be impaired by cognitive bias themselves. In the following the (1) theoretical and (2) practical contribution are presented, (3) limitations are named, and finally (4) a brief outlook is given.

3.6.1 Theoretical contributions

A vast set of specific risk factors for infrastructure construction projects have been identified in the PF management and megaprojects literature stream. However, as can be seen in Table 1 in chapter 3.1.2 no typology of risks has been defined for infrastructure projects financed through PF that shows exactly which risks are taken over by lenders and private investors. By developing a typology of risks involved in infrastructure PF and by deriving which risks are carried by which stakeholder, this research study attempts to close this inherent gap in the literature. Filling this gap is important, because knowing the specific risks for infrastructure PF, which is growing as project implementation form, is an essential foundation to assess if costs of PF are less than the costs the risk transfer generates for the corporate or public institution. However, as shown in chapter 2 the risks of PF are different than risks of other

project types and lenders, as well as investors have specific roles, so the risks these stakeholders carry are also specific.

The second gap the typology addresses is that estimator related risks were not included in existing typologies and taxonomies. Closing this gap is important, because creating the awareness of these risks lays the foundation to manage them. While Baloi and Price (2003) mentioned estimator risks years ago, they did not elaborate on the importance of this risk category sufficiently to establish it as a relevant category in typologies and taxonomies published afterwards. By including this risk category it was further shown how vital it is to move beyond a theoretical discussion of risks towards a practice based view and an integration of different literature streams. The rational view in risk management will never be able to explain certain decisions in certain situations, therefore it is important to connect the risk management literature and the behavioral decision-making literature. Using the CIT, important insights could be gained from practitioners, that were not found in previous literature. The latest relevant typologies, e.g. Irimia-Diéguez et al. (2014) and Marques and Berg (2011) are based on a review of previous literature. Conducting interviews with relevant practitioners using the CIT should be used by future research to ensure including not only a theoretical but also a practical perspective in their typologies.

3.6.2 Practical contributions

Project finance is better than other project implementation options, if the costs of PF are less than the efficiency gains from the risk transfer. Knowing the relevant risks is an essential foundation to assess this tradeoff properly. The detailed risk typology in the Appendix can serve all infrastructure PF stakeholders as a checklist, when evaluating risks and returns, as well as in the process of transferring these.

The main lesson learned is that estimator related risks, as an additional risk factor category should be considered, carried not only by the SPV and contractors, but also by lenders and

investors. These stakeholders should be aware of these risks and include them in their models and frameworks.

3.6.3 Limitation

The developed typology has the limitation that risk categories and risk factors are presented, however not how much impact the risks typically have. However, numerous studies concerning finding the reason for project failures and thus analyzing risk impact have been published already in the relevant literature, compare e.g. Flyvbjerg et al. (2004).

One limitation of the qualitative research conducted is that the number of interviews conducted, or incidents discussed, is below the number of 50 incidents recommended by Flanagan (1954). However, saturation was already achieved after the conducted interviews. This was not surprising, as extensive research already exists regarding risk typologies and the gap concerning estimator related risks was very specific.

3.6.4 Outlook

It should be researched to what degree lenders and private investors are subject to estimator related risks. Are lenders on average less prone to cognitive biases because they get involved in projects later and thus view the project as an outsider as described by Flyvbjerg et al. (2014)? How can estimator related risks be best managed and controlled? Further, research should focus on the next stages of the risk management process to see how stakeholders handle risks when projects evolve.

4. Cognitive aspects, perceived risk, and decision making in infrastructure PF – development of a theoretical framework

4.1. Problem statement

One way to close the infrastructure financing gap is to optimize public and corporate spending. As introduced in chapter 2, PF might provide a solution to this gap. However, PF can only be better than other financing options if costs of PF are less than the costs of the risks that are transferred away from the corporate or public institution.

In chapter 3 a typology of risks has been defined for infrastructure projects that also reveals how these risks are typically allocated to different actors. It was shown that most authors do not incorporate estimator related risks decision makers adds to the equation. Estimator related risks, typically carried by the SPV, contractors, lenders, and investors are threefold: construction costs, construction time, and future revenues from the project can be over- or underestimated.

Investors and lenders along with other stakeholders in PF, typically make decisions based on a process of carefully weighting the risks and returns described in previous chapters. For this they use frameworks and models that have been developed to support the decision-making process (Hampl & Wüstenhagen, 2013). However, the use of models does not guarantee objective decision making - inputs decision makers put into the models are often far from accurate when risk or uncertainty are involved in the decision. Kahneman and Tversky (1982) state that in situations of uncertainty, decision makers more frequently apply heuristics and fall prey to cognitive biases in their decision-making-process.

Heuristics and cognitive bias can lead decision makers on both the lender and the investor side to under- and overvalue risks and rewards. According to Hampl and Wüstenhagen (2013) the situational perception of risks and rewards, not actual or objective statistically weighted risks and rewards, can become significant barriers to investment. Thus, an important

challenge for individual lenders and investors in making decisions in the context of PF is to overcome own unconscious biases, specifically those related to the perception of risks and rewards like unrealistic optimism. Companies involved in infrastructure PF lending and investing activities in turn face the challenge to provide an institutional environment that prevents biased decision making. To examine and possibly explain these influencing factors on both individual and company level a theoretical framework must be established.

4.1.1 Practical relevance

Estimator related risks can cause project failure (Flyvbjerg et al., 2014). Thus, it is vital to create awareness of this risk. As a first step it is important to highlight that also project outsiders such as investors and lenders can be subject to this risk category. Further, it is relevant to identify what causes estimator related risks in this industry, to provide possible counter measures. It might be small changes that make PF in infrastructure projects more profitable, and given the need to finance a growing amount of large infrastructure projects through PK, these can have a considerable impact on the pending financing gap. Thus, this work is highlight relevant.

The implementation of public and corporate projects as PF can optimize public and corporate spending, if high costs of setting up the SPV are outweighed by the benefits of it i.e. efficiency savings through risk transfer to parties that can best carry them (Irimia-Diéguez et al., 2014). When assessing which organizational structure (private or public project ownership; project, corporate/public, or asset finance) is applicable for a certain project, the benefit of PF i.e. concrete savings due to the risk transfer is often hard to grasp. For most risk categories insights about who can best bear the risk exist in previous literature. However, while the typical allocation of estimator related risk was analyzed in chapter 3, it is not yet clear which stakeholder can best bear this risk. By shedding light on differences in unrealistic optimism between stakeholder groups such as public and private investors as well as lenders

in this sector, this dissertation provides a guideline to both the transfer of risk and reward assessment to groups less subject to estimator related risks and to learn best practices from each other.

Further, when involving private sector companies, it is important to know what type of companies to involve. Companies can also be generally better or worse in carrying estimator related risk. To identify a pattern that allows to predict which kind of companies provide an institutional setting that fuels decision maker unrealistic optimism, characteristics of companies that tend to be above average and below average unrealistically optimistic need to be identified. These characteristics can further show companies what they can do to prevent bias rather than fuel them.

4.1.2 Theoretical relevance

Optimism bias, the focus of this work, is a well-researched topic in behavioral finance. However, it has not yet been studied in the context of infrastructure PF, with a focus on credit assessment and investment decisions, as the Table 9 highlights on the next page.

Applying the learning of behavioral finance to this new context, this work is the only one that develops a causal model (RQ2) that differentiates between personal factors, organizational factors, and other bias/heuristics as enhancing/diminishing factors of individual unrealistic optimism in this specific industry, and tests the model empirically with the relevant decision makers.

Until now research has been done that focusses on lenders unrealistic optimism in infrastructure PF credit allocation. However, this work is not only a contribution to close the wide gap in examining lenders biases in risk and reward assessment of large infrastructure projects. It also compares lenders to investors regarding their unrealistic optimism in risk and reward assessment (RQ3) to identify stakeholder group specific biases and enable learning from industry specific best practice.

Further, already 15 years ago Durand (2003) demanded: “*The possibility that organizations might also condition forecasting ability needs to be investigated*” (Durand, 2003, p. 821).

However, despite the number of articles published on risk management since, Müllner (2017) called for focusing on this aspect with regard to PF last year. This stresses the importance to not only focus on individual decision makers but also on companies. No comparable work on infrastructure projects exists as can be seen in Table 9. Therefore, this work will also provide a company perspective (RQ4).

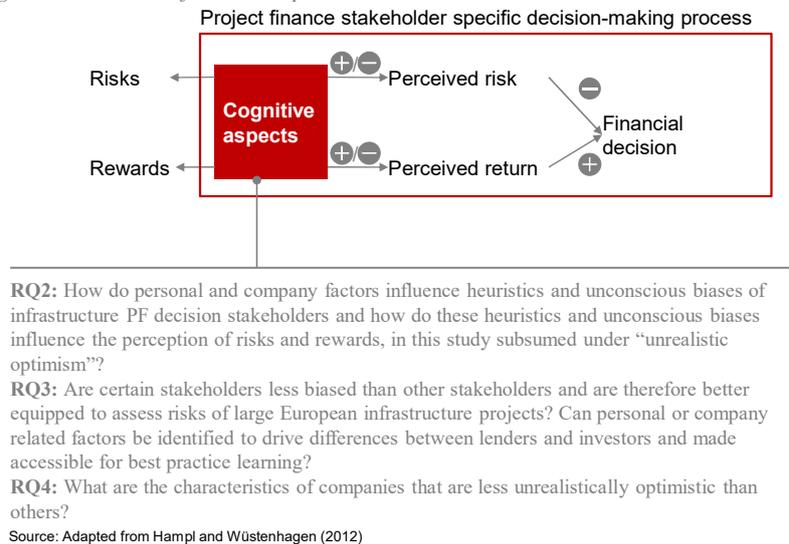
Table 9: Selected previous studies on unrealistic optimism from behavioral finance literature

Author	Industry focus		Decision situation			Empirical test w. industry decision makers	Drivers of unrealistic optimism of the individual				Drivers of company unrealistic optimism		
	Large Projects	Infrastructure sector	Credit PF	assessment	Investment decision		Personal factors	Organizational factors	Other Bias	Heuristics	Institutional factors	Organizational factors	Bias
This paper	x	x	x	x	x	x	x	x	x	x	x	x	x
Stingl and Gerald (2017)	x												
Flyvbjerg et al. (2014)	x	x											
Shepperd, Klein, Waters, and Weinstein (2013)									x	x			
Vaaler and McNamara (2011)				x				x					
Flyvbjerg et al. (2009)	x	x							x	x			
Vaaler and McNamara (2004)				x								x	
Durand (2003)				x								x	x
Lovall and Kahneman (2003)	x				x								
Baker and Nofsinger (2002)					x								
Heaton (2002)	x				x								
McNamara, Moon, and Bromiley (2002)				x								x	x
Shepperd, Carroll, Grace, and Terry (2002)									x	x			
Helweg-Larsen and Shepperd (2001)							x	x					
McNamara and Vaaler (2000)				x								x	x
McNamara and Bromiley (1997)				x								x	
Shepperd, Fernandez, and Ouellette (1996)								x					
Weinstein (1980)							x						

4.2 Goal and approach

The goal of this section is to develop a theoretical framework that can serve as a basis to answer the three research questions displayed in the figure below.

Figure 9: Overview of research questions



The theoretical framework for RQ2 is tackled in two steps. First a review of the behavioral finance literature is conducted to create a theoretical causal bias model, including all biases applicable in the project financing of infrastructure projects, as well as relevant influencing factors. Second, comments from five of the eight experts interviewed for the previous chapter of this study are used to adapt and simplify the framework, to tackle only the most relevant biases and heuristics²⁸.

To provide the theoretical framework for answering RQ3, a review of the behavioral finance literature is conducted to create hypotheses concerning differences between lenders and investors on dimensions of the causal bias model tested in the previous part. If lenders are identified as a stakeholder group being less affected by estimator related risk it would mean that PF in fact has an advantage over public or corporate finance since by involving lenders

²⁸ The other three experts did not make explicit statements about previous biases they had.

not only a monitoring partner is gained, but estimator related risks would be controlled by a stakeholder that can manage it better (contracting theory, resource based view of the firm).

To provide a theoretical framework for RQ4, possible factors that can be characteristics for unrealistic optimistic companies are researched from literature. In addition, findings from the individual level are examined regarding transferability to company level.

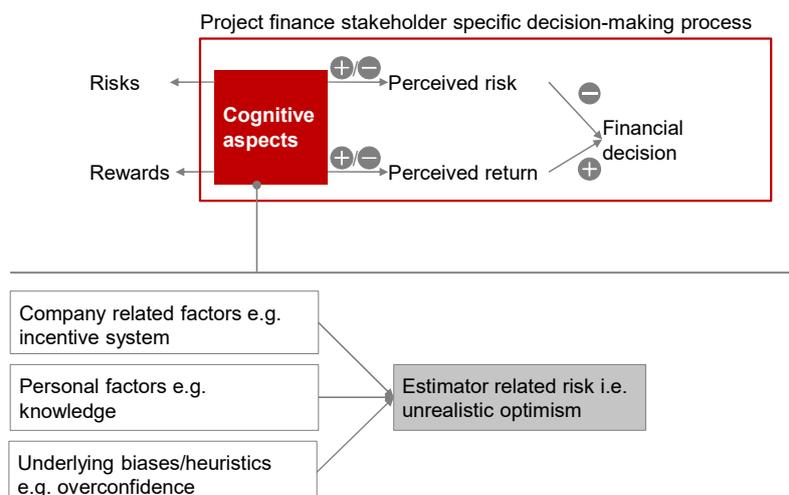
4.3 Status quo relevant literature

In the following the terminology of (1) cognitive aspects, perceived risks, and decision making in infrastructure PF is presented. Then, (2) an overview of the relevant literature streams is given and gaps are highlighted. Finally, (3) the theoretical foundation of causal biases on infrastructure projects is provided.

4.3.1 Terminology - cognitive aspects, perceived risks, and decision making in infrastructure PF

As can be seen in Figure 10, lenders and investors make financial decisions in which they weigh the risks described in chapter 3. Cognitive aspects influence the perception of risks in decisions under uncertainty (Kahneman & Tversky, 1974). One important cognitive aspect is unrealistic optimism, also described as estimator related risk in chapter 3.

Figure 10: Unrealistic optimism in PF can lead to over- and underevaluating risks/rewards



Source: Adapted from Hampl and Wüstenhagen (2012)

In the following (1) the relevant decision situation for lenders and investor will be highlighted in which cognitive aspects and perceived risks play a role. This is followed by (2) a definition of what exactly cognitive aspects and perceived risk mean in terms of decision making.

4.3.1.1 Infrastructure PF decision situations of lenders and investors

In PF many decisions i.e. “*the most proper assessment among the alternatives*“ (Özen, 2016, p. 1744) need to be taken by lenders and investors. After an initial decision to invest in a project or grant a project company a loan, a continuous cycle of new decisions follows until the project is complete. In the following a brief description of (1) lenders and (2) investors decision situations is presented that was derived from expert interviews as well as relevant literature in order to show the extend of uncertainty involved and the room for cognitive aspects in the decision-making process.

“Risk assessments of commercial borrowers are critical decisions for banks since they determine approval of new loans, renewal of existing lines of credit, the interest rate charged, which section of the bank manages the loans, and the level of loan loss reserves that will maintain it” (McNamara & Bromiley, 1997, p. 1066). Thus, the initial decision of lenders in a PF situation is if they, mostly in conglomerates, should grant a specific project company a loan, and if yes, to which conditions. Early in the development of a project, developers will typically contact lead arranging banks to provide letters of intent. However, many banks issue these letters without going through a normal credit approval procedure. For the actual credit approval procedure, the decision situation this dissertation focusses on, these banks typically have two departments dealing with credits: the market department and the risk department. The market department will look at due diligence documents attached to the proposal e.g. legal, environmental, financial, technical due diligence that are made by a third party. *“Here, due diligence is specifically understood as an evaluation of the costs and benefits deriving from investing in a given project, and especially whether the estimated costs and benefits for*

that project are likely to materialize” (Flyvbjerg, 2013, p. 762). Values from these due diligences as well as qualitative factors such as the location of the project are used in complex cash flow models, including a sensitivity analysis with at least three cases (normal case, client case, base case). For the different cases factors such as the debt service cover ratio are measured²⁹. Using a bank specific model, a rating is made, including quantitative and qualitative factors³⁰. The rating grade will then determine if the loan is viable and which financing conditions such as interest rate, duration, and amount apply. Typically banks rather focus on avoiding credit losses than rating borrowers non-creditworthy (Rad, 2017). Normally sensitivities and all factors put into the model are controlled by employees of the risk side. Results from this review are then discussed with the lender responsible for the model from the market side, to arrive at a result agreeable to both. Especially qualitative factors are often rather subjective and need to be agreed on by the risk department. In the end, granting a loan is a group decision taken by teams and normally even several banks together based on perceived risks and rewards of a project, involving top managers for high loan amounts (Rad, 2017). However, the decision of each individual involved is important as all subsequent decisions may underlie anchoring effects³¹. Further there are interdependencies between individual decision bias and bias in group decision making (Kerr, Kramer, & MacCoun, 1996). Therefore, it makes sense to look at the decision situation of the individual lender. The initial decision of investors is if they should invest into a specific project company. Usually the developer of a project contacts the investor with a project proposal. The developer presents the potential value and the concept of the deal to get a budget for a due diligence. After reviewing the initial proposal which has a high degree of uncertainty concerning e.g. involved stakeholders, the investor might grant an initial budget to develop the business plans,

²⁹ Depending on the kind of project this typically must be larger than 1,3.

³⁰ Confidence in project overall, location, and cost control management quality.

³¹ According to Zaiane (2015) the tendency to rely too heavily on a piece of information such as a proposed decision of a college when making decisions.

the execution model, and the contracting strategy further, as well as to engage third parties to conduct due diligences. After reviewing final plans for the project including which contestants are awarded the construction, supplier, and operation contracts the investment decision is made based on perceived risks and rewards using frameworks and models that include subjective as well as objective factors (Hampl & Wüstenhagen, 2013). Typically, uncertainty is still quite high, because at that stage contracts might be planned but not awarded yet. After the initial decision to invest in a project, more decisions involving uncertainty follow e.g. the decision if additional capital should be invested when needed. However, focus in this dissertation is the initial decision to invest into a project, as this provides the foundation for the decisions to follow.

4.3.1.2 Cognitive aspects, perceived risks, and decision making

Classical finance theory and classical decision theory assume that decision makers are risk adverse and rational, thriving to maximize profit. Rational decision making by investors means that investors always update their beliefs correctly (Bayes' law) and based on their beliefs make the optimal choice (expected utility theory) (Barberis & Thaler, 2003). At the same time that the Bayes' law and the expected utility theory were published, other authors questioned, if this is really the case in reality (Baker & Nofsinger, 2002; Barberis & Huang, 2001; Barberis & Thaler, 2003; Heaton, 2002).

In behavioral finance³² it is acknowledged that not actual risks play a role in decision making, but rather perceived risks. A perceived risk is the subjective judgement the decision maker makes about the severity, likelihood, and other characteristics of the risk. The study of perceived risks, coming primarily from the field of natural hazards and greenfield

³² According to Constantin and Popovici (2010), the modern theory of behavioral finance differs from classical finance theory as it focuses on various aspects of decision making such as psychological bias and does not only assume rationality and profit maximization as premise.

technologies, has however also been used by Hampl and Wüstenhagen (2013) to describe investors decision making in the context of infrastructure projects. Already Lichtenstein and Fischhoff (1977) acknowledged that the quality of peoples' perceived risk judgements limits the quality of sophisticated risk assessment techniques such as cost benefit analysis. One theory that explains why perceived risks might differ from actual risks, is the psychological approach of heuristics and cognitive biases i.e. systematic deviations from rationality in individual decision making. As illustrated in Figure 10, heuristics and cognitive biases can lead decision makers to under- or overvalue risks and rewards. Subjective risk perception, which can be negatively or positively skewed, then directly mediates decision making on individual and team level (Houghton, Simon, Aquino, & Goldberg, 2000).

Many different cognitive biases and heuristics are known to influence risk perception and decision making. Most them can be explained by a variety of different psychological theories e.g. cumulative prospect theory (Kahneman & Tversky, 1992) or expected utility theory (Bernoulli, 1954). In addition to specific theories, most psychological biases can be explained by heuristic simplification like affective short-circuiting, and self-deception (Hirshleifer, 2015). Heuristics are short cuts e.g. rules of thumb people use consciously or unconsciously in order to simplify their decision making in specific situations (Hirshleifer, 2015). The study of cognitive biases and heuristics together with understanding underlying theories can be used to explain a certain decision in a certain situation (Mitroi, 2014).

4.3.2 Literature overview of cognitive aspects and perceived risk in PF decisions

After explaining the terminology, in the following a brief literature overview is presented to highlight gaps and the current status quo. Four literature streams are relevant regarding cognitive aspects, perceived risk, and decision making in PF: (1) literature about behavioral decision making in projects, (2) PF literature in general as described in chapter 2, (3) literature about factors affecting risk assessment, and (4) literature about behavioral decision making

concerning bias management. Table 10 below gives a brief overview of main journals, relevant reviews, and perspectives.

Table 10: Overview of relevant literature streams

Literature stream	Most relevant Journal	Latest review	Relevant aspects for research question	Other aspects covered
Behavioral decision making in projects	International Journal of Project Management, Project Management Journal	Stingl and Geraldi (2017)	Reductionist school of thought (cognitive limitation-errors)	Pluralist school of thought (political behavior) and contextualist school of thought (social and organizational sense making)
PF	International Journal of Project Management	Müllner (2017)	Management research perspective	International business perspective and financial research perspective
Factors affecting risk assessment	Academy of Management Journal	Vaaler and McNamara (2011)	Individual decision maker effects on risk assessment (especially behavioral decision making in credit risk assessment) and organizational effects on risk assessment	Competitive effects on risk assessment
Behavioral decision-making bias management	various	Montibeller and Winterfeldt (2015)	Methods to prevent bias: influencing the individual decision-making process	Methods to prevent bias: debiasing individuals and accounting for bias

Although the megaprojects literature also mentions estimator related risks in the risk typology of Baloi and Price (2003), this literature stream will be neglected in this review, as risk typologies do not provide a relevant contribution in the light of the research questions at hand.

In the following a more detailed review of the relevant four streams is provided.

4.3.2.1 Literature about behavioral decision making in projects

In the light of the three research questions, the relevant substream this research focuses on is the reductionist school of thought. This stream analyzes deviations from rational decisions that stem from biases and mistakes, the causes of these deviations, and the impact these deviations have (Stingl & Geraldi, 2017). As mentioned in chapter 4.3.1.2, the decision-making process of individuals changes if risk or uncertainty are involved in the decision, providing room for biases and heuristics (Kahneman & Tversky, 1982). Detailed research on cognitive biases such as unrealistic optimism exists, but empirical tests were conducted mostly with students e.g. (Houghton et al., 2000; Shepperd et al., 1996; Weinstein, 1980), and not industry relevant decision makers such as lenders and investors. Thus, findings must be

tested in specific decision situations such as PF to show if findings are fully transferable to these decision situations.

As shown in Table 10, the other two substreams are not regarded in this work as they are not commensurable with the reductionist school of thought. The pluralist school of thought for instance deals with deviations from rational decisions due to political behavior, while the contextualist school of thought focusses on social and organizational sense making (Stingl & Geraldi, 2017).

4.3.2.2 PF literature

An overview of the PF literature stream was already given in chapter 2. As presented in Table 10, out of the three existent substreams in this field, only the management substream that deals with psychological fallacies of managers including cognitive limitations, political behavior, and deception, covers aspects relevant for the three research questions in this chapter. As this dissertation takes the reductionist view, only findings concerning cognitive limitations such as unrealistic optimism are relevant for the research questions at hand, political behavior and deception are neglected. Within this substream cognitive limitations were mentioned, but not empirically tested with the relevant decision makers. The term “psychological fallacies of managers” in this literature stream stands currently only for PF project planners and project owners. No study was conducted on psychological fallacies of PF lenders. The importance of broadening the focus from only planners and sponsors also to lenders is underlined by Müllner (2017), who states regarding PF: “*Future IB and Management research need to address the important role of the liabilities side as strategic complement to equity based strategies*” (Müllner, 2017, p. 127). Further, previous literature in the field has not shown who can bear estimator related risks best, and how to control these risks. Müllner (2017) also states: “*IB should put more emphasis on important firm-specific*

advantages in terms of risk management and finance" (Müllner, 2017, p. 126). This stresses the importance to not only focus on individual decision makers but also on companies.

4.3.2.3 Literature about factors affecting risk assessment

With a focus on individual and organizational effects of risk assessment, biases on company level and institutional characteristics were covered as influencing factors on risk assessment by researchers. Competitive effects on risks assessment were also researched but are disregarded in the following, as they do not aid in answering the research questions at hand.

Regarding organizational effects of risk assessment research has concluded that cognitive biases e.g. organizational illusion of control can occur on company level (Durand, 2003).

Some institutional processes such as standardization of decision processes were found to lead to less biased risk assessment (McNamara & Bromiley, 1997). However, other actions taken by companies e.g. tournaments as incentive lead to an increase in biases (McNamara et al., 2002), hinting that institutions are not fully aware of the impact they can have on their employees' biases. Overall, literature shows that the institutional environment does affect the risk assessment of individuals and entire institutions, however institutions are often unaware of the exact institutional environment they need to create to allow for best possible risk assessment. Although this problem has been described in previous literature, up to now no company model of factors influencing risk assessment on company level was created.

Addressing the individual effects on risk assessment, the table below shows clearly that no study was conducted with PF lending officers focusing on the PF credit decision situation.

There have been studies testing behavioral biases on commercial loan officers, however PF provides a completely different decision situation than commercial bank loans to companies or private people especially with regard to risk and uncertainty. McNamara and Bromiley (1997) state *"Further research should address additional cognitive and organizational effects in additional business environments"* (McNamara & Bromiley, 1997, p. 1085).

Table 11: Overview of previous studies with lending officers

Author	Methodology	Finding
McNamara and Bromiley (1997)	Interviews with commercial lending officers in large US banks and analysis of lending decisions at one bank	Industry excitement triggers under-assessment of risks
Sutcliffe and McNamara (2001)	Analysis of 900 borrower risk rating decisions through interviews with commercial lending officers at large US banks	Decision standardization increases likelihood of risk rating errors
McNamara et al. (2002)	Analysis of risk and return data from 386 annual borrower evaluations made in community banking division of an US bank	Escalation of commitment leads lenders to underassess risks in defaulting loans
Wilson (2016)	Interviews and focus group discussion with 35 loan officers in four branches of one bank	Gender of loan applicant or lender does not influence the lending decision

Filling this gap is important, as highlighted by Vaaler and McNamara (2011), that called already 7 years ago for research on: *“how behavioral and political model factors can affect prudential credit assessment... Future research should seek a broader understanding of their [risk assessing companies] expertise and vulnerability to bias”* (Vaaler & McNamara, 2011, p. 32).

4.3.2.4 Bias management literature

Recent literature focusing on how companies can prevent biased decision making, i.e. how estimator related risks can be controlled, identified three levers: influencing individual decision making, debiasing individuals, and accounting for biases in decisions.

A company’s institutional structure can influence an individual’s decision-making process for instance by incentive systems (McNamara & Bromiley, 1997), feedback systems (Shepperd et al., 1996), and standardized decision processes (McNamara & Bromiley, 1997), as well as team composition (Montibeller & Winterfeldt, 2015). However, often the influence of these institutional pillars is not completely known and unintended consequences are possible (McNamara & Bromiley, 1997). Some researchers have even found that processes installed to prevent biases, fuel biased decision making instead (McNamara et al., 2002). Often also certain elements of institutional processes decrease a bias, but other elements unintentionally increase it e.g. while incentive systems are said to in general reduce biases, tournaments as tool to incentivize employees may lead to biased decision making (Heaton, 2002). Therefore,

more research in this field is needed, in order to provide more knowledge and avoid unintended effects.

The other two methods (debiasing individuals and accounting for bias in decisions) are not relevant to answer RQ2, RQ3, and RQ4. However, since they show additional tools companies can make use of to reduce the influence of biases on decision making in their company, these methods are important to derive practical implications. Thus, important findings are presented briefly in the following, without elaborating on gaps.

Debiasing individuals is one way to prevent biased decision making (Clemen & Lichtendahl, 2002; Montibeller & Winterfeldt, 2015). Different debiasing techniques exist e.g. training, framing, and explicit warning/instructions (Montibeller & Winterfeldt, 2015). Training is the most prominent debiasing technique, although there are mixed empirical results on the impact of training on cognitive biases (Arkes, 1991; Clemen & Lichtendahl, 2002). Through training decision makers can understand the psychological processes underlying their biases (Schoemaker & Tetlock, 2016) and can therefore work on consciously avoiding it.

Specifically, on the overconfidence bias it is reported that lectures on investor psychology with relevant examples helped to debias overconfidence (Kaustia & Perttula, 2009). However, training does not manage to eliminate biases completely (Clemen & Lichtendahl, 2002).

Especially for biased experts a better calibration can be achieved by framing assessment questions in terms of relative frequencies (Clemen & Lichtendahl, 2002). Warning people and giving them specific instructions to avoid specific biases can also help to reduce these biases (Arkes, 1991). Explicit warnings did for instance reduce the better-than-average facet of overconfidence in an experiment (Kaustia & Perttula, 2009). However, when tested for overconfidence in general and especially the facet miscalibration, this technique did not yield overarching positive results (Kaustia & Perttula, 2009; Plous, 1995).

A final method to control biases is to perform ex-post debiasing by adjusting for possible biases through e.g. a Bayesian calibration model based on past performance data (Clemen & Lichtendahl, 2002). For this the individual expert's specific biases tendency needs to be known and thus this method requires as much historic decision data as possible (Clemen & Lichtendahl, 2002).

4.3.3 Cognitive biases and infrastructure projects – theoretical foundation

Based on the existing literature on PF (4.3.2.1), behavioral decision making in projects (4.3.2.2), factors affecting risk assessment (4.3.2.3), and bias management (4.3.2.4), in the following a summary of the status quo on cognitive biases in the context of infrastructure projects is presented.

It is important to note that the decision-making process of individuals changes if risk or uncertainty are involved in the decision, heuristics and cognitive biases are applied more frequently (Kahneman & Tversky, 1982).

Large infrastructure construction projects are highly complex and underlie high uncertainty (Meyer, 2016) – future cash flows as well as exact construction cost are not easy to determine accurately up front (Asiedu et al., 2017). So, it is no surprise that researchers found evidence of cognitive biases in different stages of infrastructure project decision making. Cognitive biases exist for instance in planning and reporting on the side of the project planners (typically project sponsors) and managers (Flyvbjerg et al., 2009, 2014).

To focus the literature review on industry relevant biases, the expert interviews conducted on estimator related risks as described in chapter 3 were analyzed with the CIT. Relevant statements can be found in the Appendix. Overall three specific cognitive biases were identified to be most relevant in infrastructure project financing: unrealistic optimism, representative heuristic, and overconfidence. Unrealistic optimism was seen by nearly all stakeholders in retrospect concerning future cash flows of projects, e.g. concerning the use of

toll roads or the traffic of a commercial harbor. Especially lenders voiced the concern that project developers are extremely unrealistically optimistic. Several lenders said that in hindsight they realize having been victims of the representative heuristics. When an infrastructure PF credit defaulted in a certain industry, geography, or with a certain project sponsor, lenders often generalized that experience and were extremely pessimistic about new credits of that kind. It did not play a role whether they themselves made this negative experience, or whether they just heard about it from colleagues or in the media. Nearly all experts seemed overconfident about their individual ability to assess risks and learn from past mistakes.

In the following recent literature from the three literature streams behavioral decision making in projects, PF, and factors affecting risk assessment is presented concerning (1) unrealistic optimism, (2) representative heuristic, and (3) overconfidence. The biases are defined in detail, consequences of the biases are named, the fields in which the biases were identified are pointed out, and occurrence in the field of infrastructure projects is discussed. Finally, comments for further research are included for each bias if applicable and moderating factors are named.

4.3.3.1 Unrealistic optimism

Weinstein (1980) focused on the fact that people are often not objective when predicting future events and coined the term unrealistic optimism³³. This cognitive phenomenon has been demonstrated by researchers in various countries (Shepperd et al., 2013) and in various fields³⁴. Optimistic bias, over optimism, delusional optimism, and unrealistic optimism (Shepperd et al., 2013) are used to describe the phenomenon that reflects the difference

³³ His paper “*unrealistic optimism about future life events*” has been cited 4573 times as of January 2017.

³⁴ However, it should be mentioned that A. J. L. Harris and Hahn (2011) raise questions about the existence of the unrealistic optimism bias in reality, because according to the authors, evidence is overstated in most previous studies. Shepperd et al. (2002) investigate these allegations in detail and refute the statement that unrealistic optimism is merely “*a methodological artifact of the sample*”, compare Shepperd et al. (2002, p. 75).

between personal and target risk and reward estimates (Helweg-Larsen & Shepperd, 2001). Recent literature calls for a more precise definition of the phenomenon unrealistic optimism³⁵ as it can occur in four different forms: absolute³⁶ at individual level, absolute at group level, comparative³⁷ at individual level, and comparative at group level (Shepperd et al., 2013). So far comparative optimism at group level seems to be the most commonly used method (Helweg-Larsen & Shepperd, 2001; Shepperd et al., 2002; Shepperd et al., 2013; Weinstein, 1980). Thus, in the following when referring to unrealistic optimism, the kind that is comparative at group level is referred to. It is important to note that this definition of optimism includes only the non-intentional deviations from reality³⁸.

Shepperd et al. (2013) define this unrealistic optimism as: “*a favorable difference between the risk estimate a person makes for him- or herself and the risk estimate suggested by a relevant, objective standard [...] It may reflect a distortion in personal risk estimates, a distortion in the perceived risk of the comparison target, or both*” (Shepperd et al., 2013, p. 396). In an infrastructure project this situation can mean that the decision maker believes that a project is less affected by a certain risk than comparable projects. This kind of unrealistic optimism is explained by two theories: the downward comparison theory (the

³⁵ Shepperd et al. (2013) state that researchers are not only not consistent with the terminology they use to describe the phenomenon of unrealistic optimism but they also falsely deduct that different terms stand for the same construct and different measurement approaches yield the same result.

³⁶ Absolute unrealistic optimism is present when a single risk prediction is lower (or reward prediction higher) than an objective representation of that risk, compare Shepperd et al. (2013).

³⁷ Comparative unrealistic optimism is present if the risk prediction made for oneself is lower (or reward prediction higher) than the prediction how this risk is for another comparable person or group, compare Shepperd et al. (2013).

³⁸ Conscious deviations such as deception by e.g. intentionally reporting overly optimistic estimates is not part of this phenomenon. On the contrary to unrealistic optimism, unrealistic pessimism can also occur, compare McKenna (1993). Some authors question if unrealistic pessimism is exactly on the same dimension as unrealistic optimism, and if people do not rather move between optimism and realism, compare Shepperd et al. (2002). However, for convenience sake unrealistic pessimism is often assumed to be exact the opposite of unrealistic optimism, compare Shepperd et al. (2002). When unrealistic pessimism occurs, the likelihood of rewards is under- and the likelihood of losses is overvalued. This leads to a systematically wrong allocation of probabilities and can cause irrational decisions, compare Flyvbjerg et al. (2014); Böttcher and Blattner (2013). The bias has even been documented in practice: the World Bank (2006) stated that in hindsight their decision makers refused to finance projects because they were too pessimistic about rewards linked to e.g. economic growth rates.

decision maker compares himself with a disadvantaged group) and the self-enhancement theory (the decision maker has an enhanced perception of himself) (McKenna, 1993).

The consequences of unrealistic optimism have been discussed by several researchers³⁹.

Unrealistic optimism leads to a systematically wrong allocation of probabilities and can lead to irrational decisions (Böttcher & Blattner, 2013; Flyvbjerg et al., 2014). Unrealistic optimism may cause unnecessary risk taking and insufficient preparation for problems (Shepperd et al., 2016). However, there are also positive effects of unrealistic optimism - according to Shepperd et al. (2013) unrealistic optimism may cause greater goal persistence, positive affect, and hope.

In the field of infrastructure projects developers and managers have been shown to be unrealistically optimistic about their projects and thus create proposals that are frequently viewed as too optimistic by lenders (Flyvbjerg et al., 2014). Lovallo and Kahneman (2003) believe that project failures are not caused by rational decisions having gone wrong, but by flawed decision making based on delusional optimism. Often unrealistic optimism is already deeply rooted within the project sponsors and developers in the planning phase of a project - source of this unrealistically optimistic project planning are honest mistakes, delusion, and even deception (Flyvbjerg et al., 2014). Delusion refers to the use of biases – whereas deception and mistakes will be ignored as possible causes of unrealistic optimism in the following, as they are not commensurable with the reductionist school of thought. What consequences of unrealistic optimism are reported for stakeholders in the infrastructure finance industry? Unrealistic optimism can lead investors in general to invest in negative net present value projects (Heaton, 2002). Baker and Nofsinger (2002) state that unrealistic optimism causes investors to do less critical analysis.

³⁹ However, very few researchers have been able to prove these consequences. According to Shepperd, Pogge, and Howell (2016) less than 10% of the relevant studies include results on consequences of unrealistic optimism. Therefore there is no clear agreement whether decision makers that are in general affected by unrealistic optimism, always make optimistic predictions, compare Krizan and Windschitl (2007).

Various studies have focused on identifying moderators for unrealistic optimism⁴⁰ to understand why this phenomenon occurs. These moderators can be clustered into three broad groups: affective states, heuristics and cognitive biases, and event related factors.

A number of studies have shown that affective states such as mood, depression, and state and trait anxiety affect unrealistic optimism (Helweg-Larsen & Shepperd, 2001). Further there are two affective state mediated factors that can be linked to stakeholder groups, proximity to feedback and accountability. Helweg-Larsen and Shepperd (2001) mention that people show less unrealistic optimism when feedback is proximal. Other affective state mediated variables such as event severity are not discussed in the following because previous literature reports inconsistent effects (Helweg-Larsen & Shepperd, 2001).

As a second enhancing/diminishing factor for unrealistic optimism, heuristics and cognitive biases were identified in previous literature. Shepperd et al. (2013) mention representative heuristics as cause for unrealistic optimism and the factors prior experience with negative events and comparison with close others that are proven to reduce the use of representative heuristics and thus unrealistic optimism. Further unrealistic optimism is caused when people overestimate their personal control of the events (Böttcher & Blattner, 2013; Shepperd et al., 2002; Weinstein, 1980). Other heuristics and cognitive biases that were named as potential causes for unrealistic optimism are person-positivity bias and underestimating other's control.

The third group of moderators relates to the event, for which the risk and reward prediction is made. Unrealistic optimism occurs less for uncontrollable (Helweg-Larsen & Shepperd, 2001) and for very rare negative events (Shepperd et al., 2013).

⁴⁰ Shepperd et al. (2013) argue that it is false to assume that moderators of one form of unrealistic optimism are also moderators of other forms of unrealistic optimism. Therefore, in the following only those moderators will be named, that have been identified for comparative unrealistic optimism at group level.

4.3.3.2 Representative heuristic

A heuristic is a cognitive process that simplifies decision making and is used especially when the decision maker is faced with high uncertainty (Özen, 2016). The representative heuristic is the tendency to judge probability based on misleading associations with seemingly similar events (Barberis & Thaler, 2003) i.e. to generalize⁴¹. When using the representative heuristic choices are weighted carefully according to their disadvantages and advantages (Özen, 2016). Similar events, often from past experience (Özen, 2016), are judged based on essential characteristics in order to provide information for the decision process (Bar-Hillel, 1980). Other characteristics as obvious as statistical information may be ignored in order to highlight the similarities between the events (Özen, 2016). The representative heuristic has two main facets - namely the base rate neglect and the sample size neglect (Barberis & Thaler, 2003). Base rate neglect is when decision makers being presented with base rate information ignore the base rate and make judgements that violate objective probability (Barberis & Thaler, 2003). Sample size neglect is when decision makers ignore the facts that variation is more likely in smaller samples, thus small samples are less representative (Barberis & Thaler, 2003). The use of heuristics such as the representative heuristic simplifies decision making but causes biases when they are not used efficiently (Özen, 2016). Bar-Hillel (1980) states: *“There seems to be little argument with the general contention that probability judgments are biased by representativeness”* (Bar-Hillel, 1980, p. 579). The use of representative heuristic has been shown for estimating the likelihood of a future event (Bar-Hillel, 1974).

Regarding infrastructure projects no recent literature could be identified that includes the representative heuristic. However, in expert interviews with two lenders pessimism and a reluctance to provide a loan was mentioned for projects that were in a similar industry or geography as projects that defaulted in the past. Based on these findings representative

⁴¹ Appropriate generalizations i.e. associations with similar events are not included in the definition of the heuristic.

heuristic is tested in this study as a heuristic using a negative event/outcome as stereotype and thus predicting a more negative future than applicable.

What causes experts to use the representative heuristic? Loss aversion distorts the perception of past gains and losses, thus it can increase the use of the representative heuristics (Böttcher & Blattner, 2013).

4.3.3.3 Overconfidence bias

Overconfident decision makers think their judgement is more accurate than it actually is (Baker & Nofsinger, 2002; Hirshleifer, 2015). Vetter et al. (2011) define the concept in the following way: “*Overconfidence is any behavior based on systematically incorrect assessments of one’s knowledge and skills as well as the actual ability to control future events*” (Vetter et al., 2011, p. 3).

Researchers have offered many different explanations of the phenomenon. According to Klayman, Soll, González-Vallejo, and Barlas (1999) “*It is unlikely that any single mechanism can explain all types of confidence judgments*” (Klayman et al., 1999, p. 244). As (1) miscalibration, (2) illusion of control, and (3) the above average effect are the most investigated facets of overconfidence in literature, compare Deaves, Lüders, and Luo (2009), the following parts will focus on these.

Some researchers see biases in information processing and effects of unbiased judgmental error as explanations of overconfidence (Klayman et al., 1999). As information processing bias miscalibration is often named⁴²- the tendency to overestimate one’s own knowledge preciseness (Klayman et al., 1999). Miscalibration is present when a person cannot assess the amount of mistakes he or she makes (Vetter et al., 2011). This feature of overconfidence is based on the fact that people’s judgement about the knowledge they have is

⁴² The same phenomena is called illusion of knowledge by Baker and Nofsinger (2002) and over precision by Barberis and Thaler (2003).

typically overestimated i.e. people think they have more and better information available than they have (Klayman et al., 1999).

According to Baker and Nofsinger (2002) the phenomenon of overconfidence is grounded in the illusion of control⁴³. Decision makers underlie the illusion of control when they believe they have more influence on the outcome of the project than they actually have (McKenna, 1993; Vetter et al., 2011). This phenomenon can occur even when the events are determined purely by chance.

According to Barberis and Thaler (2003) overconfidence bias is formed also by overplacement, also called the above average effect by Vetter et al. (2011). The better-than-average effect aspect of overconfidence stands for the tendency of some people to believe that their abilities and knowledge are above average when they are not (Kruger & Dunning, 1999). Kruger and Dunning (1999) explain this by the fact that the metacognitive skills that incompetent decision makers lack also prevent them to see their own incompetence.

Appropriate confidence is needed to make decisions that are not too risky and to know when advice and more information is needed (Soll & Klayman, 2004). According to Vetter et al. (2011) the three above described facets of overconfidence cause people to overestimate their abilities and thus take unrealistically optimistic performance estimates. These estimates can cause excessively risky decisions that lead to entrepreneurial and project failure (Vetter et al., 2011). Additionally, overconfidence inhibits from learning and improving the decision process (Böttcher & Blattner, 2013). Rather success is recalled than a failure and people may not search for more information for their decision (Böttcher & Blattner, 2013).

Overconfidence is named frequently in the relevant literature for various decision situations and various kinds of decision makers (Böttcher, Blattner 2013) e.g. managers were found to

⁴³ The same phenomena is called overestimation by Barberis and Thaler (2003). Other authors see illusion of control and overconfidence as different biases e.g. Houghton et al. (2000).

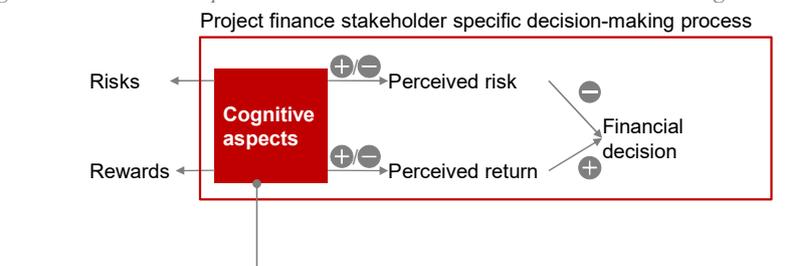
be overconfident about their company's future performance and bankers were found to be overconfident about future stock performance. In decision situations in which uncertainty is very high, such as complex infrastructure projects, Hirshleifer (2015) finds that overconfidence tends to be stronger.

An important moderator of overconfidence is task difficulty – overconfidence increases with the difficulty of the decision task (Klayman et al., 1999). However, independent of the task itself overconfidence varies between different individuals (Vetter et al., 2011). Here three different groups of moderators have been identified: cognitive, motivational, and knowledge related (Vetter et al., 2011), with knowledge related factors as main influence (McKenzie, Liersch, & Yaniv, 2008). As subtypes, subjective knowledge, objective knowledge, and experienced based knowledge have been identified in relevant literature (Carlson, Vincent, Hardesty, & Bearden, 2009). These moderators will be defined and described in detail in chapter 4.4.4.

4.4. Development of a causal bias model for decision making in infrastructure PF

As discussed above in PF the perception of risks and projected future cash flows plays an important role. Heuristics and biases are often involved in these perceptions and can result in biased decision making (Böttcher & Blattner, 2013). To answer the research question displayed in Figure 11, this chapter is dedicated to creating a theoretical causal bias model.

Figure 11: Unrealistic optimism in PF can lead to over- and underevaluating risks/rewards



RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

Source: Adapted from Hampl and Wüstenhagen (2012)

4.4.1 Unrealistic optimism

As mentioned in chapter 4.3.3.1, unrealistic optimism in an infrastructure PF decision means that the decision maker believes that the infrastructure project at hand is less affected by a certain risk than comparable projects. In previous literature unrealistic optimism in the field of infrastructure projects' developers and managers is well documented by Flyvbjerg et al.

(2014) and Lovallo and Kahneman (2003). Not only project managers fall victim to this bias, even the World Bank (2006), that is involved in PF, stated in a report from 2006: *“From time-to-time, the Bank reviewed the quality of its cost-benefit analysis[...]. Past reviews indicated the presence of an “optimism bias” in the estimated rates of return on infrastructure projects, resulting (on average) in a difference of 5-10 percentage points between ex-ante and ex-post rates of return”* (World Bank, 2006, pp. 17–18). The UK Treasury even officially demanded ministries to develop methods to avoid unrealistic optimism in projects (Flyvbjerg, 2006).

Based on these observations, the following hypothesis can be formulated:

Hypothesis 1: Decision makers in European infrastructure PF are unrealistically optimistic

4.4.2 Influencing factors of unrealistic optimism

Out of the above-named influencing factor groups those that are included in the model will be discussed in the following.

Affective state factors and event related factors in general are neglected in this model since they are dependent on the specific situation in which the decision maker processes the decision and are not likely to explain the behavior of a group of stakeholders⁴⁴. However, affect state mediated factors that can be linked to stakeholder groups are included: (1) incentive system distinctiveness and (2) feedback culture distinctiveness. Both these factors are company related factors, i.e. ways how a company can influence unrealistic optimism of

⁴⁴ Although in very specific situations whole groups can be influenced by mood e.g. mood after terror attack.

the individual. As second explanations for unrealistic optimism, (3) representative heuristic, (4) overconfidence bias, and (5) subjective knowledge will be tested⁴⁵.

Incentive systems make decision makers accountable for the outcome of their decision. In decisions with high accountability for the outcome, decision making is often less biased as decision makers are more motivated to think critically and make accurate choices (Tetlock & Kim, 1987). This presumably leads to a decrease in unrealistic optimism (Shepperd et al., 1996)⁴⁶. Thus, the following hypothesis can be formulated:

Hypothesis 2a: The higher the incentive system distinctiveness the lower the level of unrealistic optimism

Shepperd et al. (1996) state: *“There is reason to believe that individuals will abandon their optimism and may even become pessimistic in anticipation of self-relevant feedback”* (Shepperd et al., 1996, p. 844). One reason for this might be that people want to avoid own disappointment when their outcomes fall short behind their predictions (Shepperd et al., 1996). Helweg-Larsen and Shepperd (2001) explain this phenomenon by stating that feedback leads to greater conservatism in personal predictions in order to avoid one’s prediction to be challenged. Shepperd and McNulty (2002) even give a complementing explanation: unexpected good outcomes feel even better and bad outcomes feel even worse than when expected. Krizan and Windschitl (2007) state: *„people become unduly pessimistic about a desirable outcome as a way of protecting themselves from severe disappointment if the outcome fails to materialize”* (Krizan & Windschitl, 2007, p. 111). Thus, the following hypothesis can be formulated:

⁴⁵ Other heuristics and cognitive biases that were named less prominent in recent literature are neglected such as person-positivity bias and egocentric thinking, compare Shepperd et al. (2013).

⁴⁶ However not all incentive mechanisms eliminate irrational decision making, as for instance tournaments may favor irrational decision makers, compare Heaton (2002).

Hypothesis 2b: The more distinct the feedback culture in a company the lower the level of unrealistic optimism

Several researchers believe that the use of the representative heuristic is one of the key factors which influences unrealistic optimism of decision makers (Shepperd et al., 2002; Weinstein, 1980). According to Weinstein (1980) when estimating the exposure to a risk or reward compared to that of another project/person, often the self-chosen comparison target is a stereotype that does not represent the objective statistical average target and thus the entire comparison is faulty. According to Baker and Nofsinger (2002) past failures often lead to low unrealistic optimism (Baker & Nofsinger, 2002). Therefore, the following hypothesis can be formulated:

Hypothesis 2c: The higher the usage of representative heuristic the lower the level of unrealistic optimism

In general overconfidence has been associated with unrealistic optimism (Houghton et al., 2000) in specific especially the overconfidence facets miscalibration and illusion of control. Miscalibration was shown to have a positive effect, Meyer (2016) found that the more miscalibrated decision makers were, the more unrealistically optimistic they were as well. Along with several other researchers e.g. Shepperd et al. (2002) and Weinstein (1980), demonstrate that people tend to be more optimistic about future events that they believe they can control. Confirming this opinion, Böttcher and Blattner (2013) state that the overconfidence facet illusion of control and unrealistic optimism often go hand in hand, causing decision makers to be blinded for possible negative outcomes⁴⁷. As stated above decision makers underlie the illusion of control when they believe they have more influence

⁴⁷ However it is important to note that most existing research indicating that overconfidence precipitates unrealistic optimism uses correlational data and thus “*the comparative control illusion lacks empirical support as an explanation for comparative optimism*”, compare Shepperd et al. (2002).

on the outcome of the project than they actually have (Vetter et al., 2011) even when the events are determined purely by chance such as lotteries or dice games. People tend to overestimate the control they themselves have in avoiding negative outcomes and securing positive ones, but they do not do so for others (Shepperd et al., 2002). The third facet of overconfidence, the better-than-average effect was shown to have no direct influence on unrealistic optimism (Meyer, 2016). Thus, regarding the in this effort examined facets of overconfidence bias, the following hypothesis can be formulated:

Hypothesis 2d: The higher the level of miscalibration and illusion of control the higher the level of unrealistic optimism; the better-than-average effect has no significant influence on unrealistic optimism

Subjective knowledge “[...] *reflects what we think we know* [...]” (Carlson et al. 2009, p. 864). This might be knowledge that decision makers objectively have or have not. Vetter et al. (2011) defines subjective knowledge as: “*subjects’ self-assessments of their knowledge in comparison to their peers*” (Vetter et al., 2011, p. 5). It can be argued that subjective knowledge does not only have an indirect effect on unrealistic optimism through overconfidence, but also a direct effect. People with unrealistic optimism tend to have less knowledge about their risks but are not aware that - “*individuals categorized as unrealistically optimistic [...] were generally at higher risk yet believed they were at lower risk and worried less about their risk suggesting defensive processing of the information*” (Radcliffe & Klein, 2002, p. 844). On this account, the following hypothesis can be formulated:

Hypothesis 2e: The higher the level of subjective knowledge the higher the level of unrealistic optimism regarding risks

4.4.3 Influencing factors of representative heuristic

As influencing factor of the representative heuristic loss aversion has been identified in recent literature, which itself is grounded in (1) negative past experience and (2) regret (Barberis & Huang, 2001; Böttcher & Blattner, 2013; Kahneman & Tversky, 1974).

Loss aversion describes the bias in which people are more sensitive to losses than to gains (Barberis & Huang, 2001) and thus weigh losses heavier than gains in a decision making involving probability (Kahneman & Tversky, 1974). These losses could be either failures on the current project or on previous projects. Due to the fact that loss aversion distorts the perception of past gains and losses, it can increase the use of representative heuristic (Böttcher & Blattner, 2013). According to evidence of Barberis and Huang (2001), the degree of loss aversion is influenced by prior gains and losses – if people loose then they are even more sensitive to future losses than before. Therefore, also negative experience can be seen to directly influence the use of representative heuristics. Consequently, the following hypothesis can be formulated:

Hypothesis 3a: The higher the amount of negative experiences the higher the level of representative heuristics

Regret is an outcome from a decision that influences upcoming decisions (Dietrich, 2010). Often regret is associated with blaming oneself for a seemingly wrong decision (Zeelenberg, Van Dijk, Manstead, & Van der Pligt, 2000). Böttcher and Blattner (2013) see regret about past decisions as phenomenon that increases loss aversion, as regret always amplifies the personal experience one has with losses. As described above, due to the fact that loss aversion increases the use of representative heuristics (Böttcher & Blattner, 2013), this phenomenon

can be seen to directly influence the use of representative heuristics. Thus, the following hypothesis can be formulated:

Hypothesis 3b: The higher the level of regret the higher the level of representative heuristic

4.4.4 Influencing factors of overconfidence

Influence of overconfidence on decision makers seems to vary depending on the various kinds of knowledge of the decision maker (Carlson et al., 2009; McKenzie et al., 2008; Vetter et al., 2011). As influencing factors of overconfidence (1) subjective knowledge, (2) objective knowledge, and (3) experienced based knowledge have been identified in recent literature. Vetter et al. (2011) state: *“An in-depth investigation of three types of knowledge, namely experienced, objective and subjective knowledge, reveals that different types of knowledge can have contrasting effects on overconfidence”* (Vetter et al., 2011, p. 1). Further for the male gender overconfidence seems to occur more often than for the female gender (Soll & Klayman, 2004).

Several researchers concluded that subjective knowledge is positively related to overconfidence (Carlson et al., 2009; Vetter et al., 2011). According to Carlson et al. (2009) decision makers who consider to have superior knowledge also consider to have superior control (illusion of control). Vetter et al. (2011) offer as supplementing explanation that decision makers with high subjective knowledge often are victims of illusion of control because they are unlikely to consult others in their decision making and base their decision only on self-assessed knowledge. Therefore, the following hypothesis can be formulated:

Hypothesis 4a: The higher the level of subjective knowledge the higher the level of the illusion of control facet of overconfidence

Objective knowledge is the actual knowledge a decision maker has and can use for his decision-making process (Kruger & Dunning, 1999). According to Vetter et al. (2011)

decision makers with a very low level of objective knowledge typically are overconfident and overestimate their performance in terms of the above-average effect facet of overconfidence. The higher the objective knowledge, the lower the overconfidence – it even goes so far that decision makers with very high objective knowledge often underestimate their abilities (Vetter et al., 2011). Thus, the following hypothesis can be formulated:

Hypothesis 4b: The higher the level of objective knowledge the lower the level of better-than-average facet of overconfidence

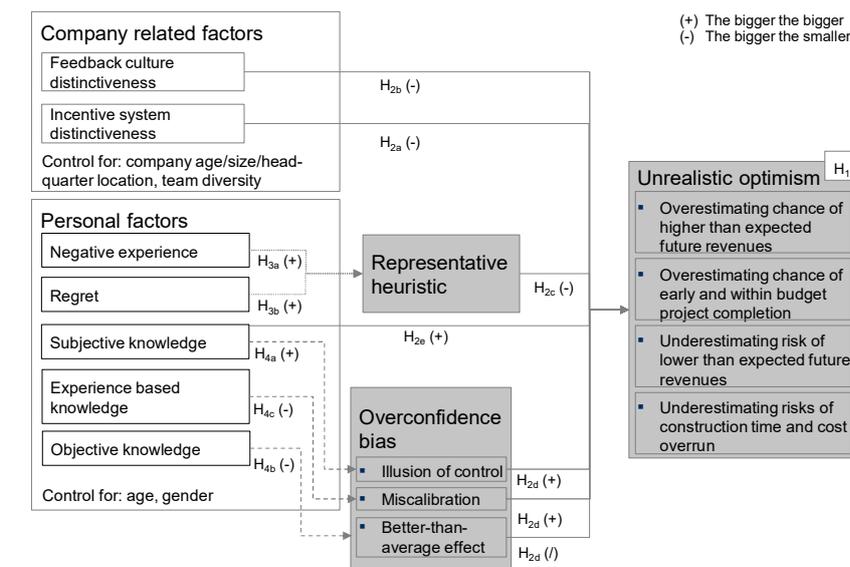
Experienced based knowledge is knowledge used in an actual decision process that was gained based on past experiences (Meyer, 2016). Vetter et al. (2011) demonstrated that decision makers with high experienced knowledge overestimated the relevance of their past knowledge and thus tend to show high miscalibration. However, this effect is not generally described. According to Boyson (2003) decision makers take less risk over time. This is consistent with the finding of Vetter et al. (2011) that specific types of experienced knowledge lead to lower overconfidence levels. Because of diverging findings in literature, the following hypothesis is going to be tested:

Hypothesis 4c: the higher the level of experience based knowledge the lower the level of the miscalibration facet of overconfidence

4.4.5 Synthesis of causal model of individual decision maker unrealistic optimism

The model in the following summarizes the causal model hypothesized above. Company related factors, personal factors, as well as an underlying bias/heuristic are hypothesized to act as enhancing/diminishing factors of unrealistic optimism in European infrastructure PF.

Figure 12: Hypothesized causal model of individual decision maker unrealistic optimism in infrastructure PF



4.5. Development of hypotheses about differences in unrealistic optimism between lenders and investors on individual level

In the chapter 4.4 a causal model of PF decision maker unrealistic optimism was developed for the European infrastructure PF industry. However, the question remains, if all stakeholder groups involved in PF decision making in European infrastructure projects are equally unrealistically optimistic. In the following hypotheses are developed concerning (1) differences in unrealistic optimism and (2) drivers of the difference in unrealistic optimism.

4.5.1 Differences in unrealistic optimism

Baker and Nofsinger (2002) state that unrealistic optimism causes investors to do less critical analysis. Several authors in the field of project management have called out investors i.e. project sponsors as being too optimistic (Baker & Nofsinger, 2002; Daniel & Hirshleifer, 2015; Flyvbjerg, 2009, 2014). Even the World Bank (2006), that is involved in PF often as equity investor, stated that in hindsight the presence of unrealistic optimism in financing decisions became apparent (World Bank, 2006).

Flyvbjerg (2013) argues that unrealistic optimism in projects can be best avoided by taking an outside view. Lenders are often involved in infrastructure projects much later than

investors, and thus can provide this view by taking a different angle at valuing the project. However, by taking an outside view, lenders are not automatically neutral in their risk assessment. Although they follow quite standardized decision processes, human judgement still plays a large role in risk assessment (McNamara & Bromiley, 1997), allowing room for biases (Vaaler & McNamara, 2011). At the same time, lenders rather have the tendency to concentrate on avoiding defaulting loans, rather than focusing on maximizing the banks profit opportunities i.e. loan volume (Öhman & Lundberg, 2015). Thus, especially senior lenders are rather pessimistic i.e. have low unrealistic optimism (Grimsey & Lewis, 2002). From this the following hypothesis can be drawn:

Hypothesis 5: Due to their role in PF, lenders are on individual level less unrealistically optimistic than investors

4.5.2 Drivers of the difference in unrealistic optimism

If a difference in unrealistic optimism exists, this difference might be explainable by the causal model put forward in chapter 4.4 of this work. Namely (1) company factors such as feedback and incentive system distinctiveness, (2) the personal factors subjective, objective, and experience based knowledge, as well as (3) overconfidence bias and representative heuristics could explain why a difference exists.

Due to the bank specific leverage and the public focus the recent financial crisis put on banks' incentive systems, it can be assumed that lenders in infrastructure project financing have more distinctive incentive systems than investors. Incentive systems serve to address the classical principal agent problem and align shareholder interests with those of the managers and decision makers (Cai, Cherny, & Milbourn, 2010). "*A majority of financial institutions' profits come from borrowing money from depositors or institutional creditors and then lending it out at a higher rate*" (Cai et al., 2010, p. 4). Banks typically have a high debt-to-equity ratio, in order to fulfill their role as financial intermediary (Efing, Hau, Kampkötter, &

Steinbrecher, 2015). Due to this specific situation “*the problem of compensation providing executives with incentives to take on higher risks in the interest of shareholders is worse in the banking world*” (Cai et al., 2010, p. 4). Efung et al. (2015) also conclude: “*The issue of optimal incentive pay is particularly relevant for banks because of their high leverage*” (Efung et al., 2015, p. 126). In addition to this, after the financial crisis, policies such as Basel II were designed that focus on the incentives of executive and nonexecutive lenders (Phelan & Clement, 2009).

Regarding the feedback system, there is no previous literature which indicates, that there should be a difference between institutions that act as lenders and those that act as investors. McNamara and Bromiley (1997) state, that decision makers in commercial lending automatically receive feedback on their decisions. However, the same should hold for investors, as they constantly track the value of their investments and monitor value losses closely. Thus, the following hypotheses can be formulated:

Hypothesis 6a: Lenders have a more distinct incentive system than investors

Hypothesis 6b: The feedback culture of lenders and investors are equally distinct

There is no previous literature that indicates, that there should be a difference in subjective, objective, or experienced based knowledge between institutions that act as lenders and those that act as investors. Thus, the following hypothesis can be formulated:

Hypothesis 7: Lenders and investors have equal levels of subjective, objective, and experienced based knowledge

In decision situations in which uncertainty is very high, such as large infrastructure projects, Hirshleifer (2015) finds that overconfidence tends to be stronger. This applies both for lenders and investors in infrastructure PF, and overconfidence has in fact been observed both among

lenders (Heath & Read, 2014) and investors (Daniel & Hirshleifer, 2015) in other sectors. As stated above, there is no indication, that drivers of overconfidence, namely subjective and experienced based knowledge, differ between lenders and investors. The same argumentation should hold for representative heuristic, as also this should mainly depend on the level of uncertainty in the decision situation. Therefore, the following hypothesis can be drawn:

Hypothesis 8: Lenders and investors have a similar amount of overconfidence and use the representative heuristic equally much

4.6. Development of company characteristic model of unrealistic optimism

After developing theoretical models and hypothesis to provide the foundation for answering RQ2 and RQ3, in the following the theoretical foundation for RQ4 will be provided.⁴⁸ To answer this research question hypotheses are developed about the characteristics of companies that are less unrealistically optimistic than others. In terms of the characteristics the focus will be placed on (1) institutional structure, (2) overconfidence on company level, and (3) objective company characteristics.

4.6.1 Institutional structure

In chapter 4.4 it is hypothesized that companies can put systems into place that reduce the danger of assessing risks regarding future revenues unrealistically optimistic. This claim can be supported by previous research (Durand, 2003; McNamara & Bromiley, 1997). According to Durand (2003): “*organizational context is a major factor influencing a firm’s estimation capability*” (Durand, 2003, p. 822). (1) Feedback and incentive systems are examples of institutional structures that provide the organizational context. As additional institutional structure characteristics (2) subjective knowledge on team level and (3) team diversity will be discussed in the following.

⁴⁸ What are the characteristics of companies that are less unrealistically optimistic than others?

In chapter 4.4 it is hypothesized that individual decision makers with a distinctive feedback system in their company are less likely to be unrealistically optimistic. Feedback is an important element of debiasing individuals, according to Arkes (1991) a distinctive feedback culture improves the decision makers accuracy-confidence calibration. In terms of company unrealistic optimism, a similar effect as on individual level is thinkable. Therefore, it should be tested on company level if feedback culture distinctiveness is a characteristic that distinguishes above average unrealistically optimistic companies from those that are below average unrealistically optimistic.

Also hypothesized in chapter 4.4 is that individual decision makers with a distinctive incentive system in their company are less likely to be unrealistically optimistic. In terms of company unrealistic optimism, a similar effect is thinkable. It should be thus tested on company level if incentive system distinctiveness is a characteristic that distinguishes companies regarding their unrealistic optimism.

Another aspect indicated by previous research e.g. Vetter et al. (2011) and hypothesized in chapter 4.4 is that individual decision makers with high subjective knowledge often are victims of illusion of control. One possible explanation for this finding is that these people are unlikely to consult others in their decision making process and base their decision only on self-assessed knowledge (Vetter et al., 2011). In terms of company subjective knowledge, a similar effect is thinkable – companies should be less likely to involve outside experts, if there is a companywide understanding that they have high knowledge. Therefore, it should be tested on company level if subjective knowledge characterizes overconfident companies and therefore has an indirect effect on unrealistic optimism.

In general teams are better forecasters than individuals (Schoemaker & Tetlock, 2016). Using “*multiple experts with alternative points of view*” is named as an useful debiasing technique against unrealistic optimism (Montibeller & Winterfeldt, 2015, p. 1235). Why is this so? In a

team the information storage capacity, the so called mental model, is much larger than in individuals if knowledge is heterogeneous and is shared within the team (Houghton et al., 2000; Kerr et al., 1996). Also, calibration of groups is better if high and low estimates from different individuals are combined into a single confidence interval (Plous, 1995). But can teams also effect the decision making of the individual? Team settings provide the environment in which individuals make their decisions. The group polarization literature states that individual opinions are polarized in homogenous groups (Schulz-Hardt, Frey, Lüthgens, & Moscovici, 2000). Houghton et al. (2000) propose that further research is needed on the effect of team heterogeneity on bias at the team level "*future studies on the effects of these characteristics [team characteristics] on biases may help resolve some of these contradictions*" (Houghton et al., 2000, p. 347). In terms of heterogeneity or diversity of teams there are several different aspects: sex diversity, age diversity, cultural diversity, and academic/work experience diversity. Consequently, it should be tested on company level if team diversity is a characteristic that distinguishes above average unrealistically optimistic companies from those that are below average unrealistically optimistic.

4.6.2 Overconfidence on company level

Another hypothesis made in chapter 4.4 was that being unrealistically optimistic concerning costs and time overruns is influenced by different facets of the overconfidence bias.

Overconfidence has been shown to exist on company level (Durand, 2003), which makes it even more likely, that a similar effect can be seen on company level as on individual level. More detailed, (1) illusion of control and (2) miscalibration should be analyzed as potential characteristics that indicate the level of unrealistic optimism on company level, as they are hypothesized to have an effect on unrealistic optimism individual level. The above-average effect is hypothesized to have no effect in chapter 4.4, therefore it can be disregarded as relevant company characteristic concerning unrealistic optimism.

The hypothesis made in chapter 4.4 for illusion of control on individual level in large infrastructure projects was already suggested by Durand (2003) on company level for the manufacturing industry: “*Organizational illusion of control increases positive forecast bias*” (Durand, 2003, p. 825). This adds to the importance of testing the illusion of control facet of overconfidence on company level as characteristic of unrealistically optimistic companies.

In chapter 4.4 it is further hypothesized that miscalibration of individuals has an impact on unrealistic optimism. Given that illusion control exists on individual and on company level (Durand, 2003), this variable should be tested as relevant company characteristic as well.

4.6.3 Objective company characteristics

Objective company characteristics such as (1) age and (2) size were reported to have an impact on risk assessment (Durand, 2003; McNamara & Vaaler, 2000; Ucbasaran, Westhead, Wright, & Flores, 2010) and should therefore be included in the set of characteristics to be tested.

Ucbasaran et al. (2010) found that entrepreneurs who have no experiences in business failure are significantly more unrealistically optimistic. On company level it could mean that older companies, who have thus also more experience are more likely to have witnessed project failures and thus should be less unrealistically optimistic. Therefore, this variable should be tested on company level as characteristic that distinguished companies on their unrealistic optimism.

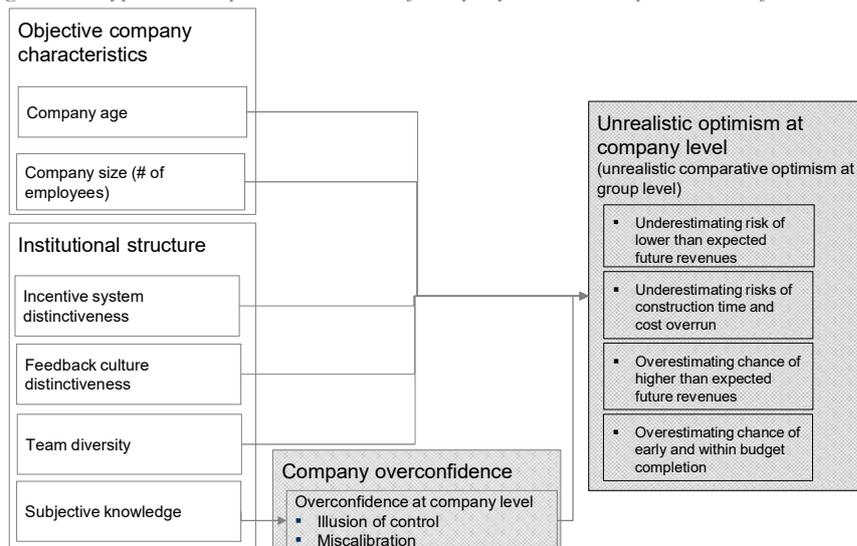
For the manufacturing industry Durand (2003) found that larger companies are more unrealistically optimistic because they believe they are subject to illusion of control.

Therefore, this variable should be tested as well as company characteristic in the field of the infrastructure PF industry.

4.6.4 Synthesis of hypothesized predictive model

As can be seen in the model below, objective company characteristics, institutional structure and company overconfidence are hypothesized to indicate the extent to which a company overall is unrealistically optimistic.

Figure 13: Hypothesized predictive model of company unrealistic optimism in infrastructure PF



Source: Own illustration

4.7 Synthesis of proposed causal model, hypotheses, and predictive model

In order to answer RQ2, RQ3, and RQ4 models and hypotheses were developed as a first step.

For the decision making of the individual (RQ2⁴⁹) a causal unrealistic optimism model is hypothesized in chapter 4.4, showing how company related factors (feedback culture distinctiveness and incentive system distinctiveness), personal factors (negative experience, regret, objective knowledge, subjective knowledge, and experience based knowledge), the overconfidence bias, and representative heuristic influence unrealistic optimism.

⁴⁹ How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

Further it is hypothesized in chapter 4.5 that due to their role in PF, lenders are on individual level less unrealistically optimistic than investors (RQ3⁵⁰). This difference is hypothesized to be grounded in differences in the incentive system distinctiveness. All other causal drivers of unrealistic optimism are believed to be the same for the different stakeholder groups.

In chapter 4.6, objective company characteristics, institutional structure, and company overconfidence are hypothesized to indicate the extent to which a company overall is unrealistically optimistic (RQ4⁵¹).

⁵⁰ Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

⁵¹ What are the characteristics of companies that are less unrealistically optimistic than others?

5. Empirical test of developed causal model, hypotheses, and predictive model

The hypothesized causal model, hypotheses, and the hypothesized predictive model need to be tested. In the following it is described (1) how biases, influencing factors, and causality are measured. Further (2) the population of interest and the (3) sample are described. Then results of empirical tests of the (4) causal model of individual decision maker unrealistic optimism, (5) hypotheses about differences between stakeholders, and (6) predictive model on company unrealistic optimism are presented.

5.1 Methods and their previous use in literature

In the following it is elaborated how (1) biases and influencing factors are measured in the survey and how high quality of data is ensured. Then it is elaborated how (2) causality in the model is measured, (3) differences between stakeholder groups are measured, (4) differences between companies are measured, and (5) how a predictive model can be built on company level.

5.1.1 Measuring biases and identified enhancing/diminishing factors in a survey

As mentioned in chapter 1.3, biases are commonly not tested in real life project decisions but rather in laboratory like decision situations with relevant decision makers. The approach used for (1) unrealistic optimism, (2) representative heuristics, and (3) overconfidence in this effort relies on previous literature and is elaborated in the subsequent paragraphs.

Unrealistic optimism, in the comparative form at group level (which is the focus in this study), is commonly measured in interviews or a survey (Shepperd et al., 2013). There are various direct and indirect methods for assessing comparative optimism at group level in a survey. At present, contradicting opinions are found whether the direct or the indirect survey method

captures unrealistic optimism more accurately⁵². After weighing advantages and disadvantages carefully, the indirect method was chosen for this study.

The indirect survey method asks participants to provide an estimate of their own risk of experiencing an event, in this study e.g. a cost overrun of an infrastructure construction project. In a separate question the participant is asked how likely (on a Likert scale e.g. from 1 to 7) it is for peers to experience the same event (Helweg-Larsen & Shepperd, 2001).

Unrealistic optimism is present when for possible negative outcomes such as a project cost overrun the difference between the assessments for peers and for self is negative – the greater the difference the more visible is the bias present.

It is common to distinguish between optimism regarding risk and optimism regarding opportunities (Meyer, 2016). In the field of infrastructure finance, estimator related risks can be divided into those regarding project cost/completion time, and those regarding future revenues, as was described in chapter 3. Cost is however often seen as the most visible criterion of a project's success (Ogunsemi & Jagboro, 2006). Therefore, using the indirect method four different aspects of unrealistic optimism are measured in this survey. For risks, unrealistic optimism regarding risk of construction time/cost overrun and less revenues in the future than expected is measured separately. For opportunities, unrealistic optimism regarding chance of early/within budget completion and more revenues in the future than expected is measured separately.

Reacting to critique of the comparative unrealistic optimism at group level the recommendations of Shepperd et al. (2013) are considered in the survey. First, the comparison group is described as precise as possible in the survey by stating "*other decision*

⁵² According to Helweg-Larsen and Shepperd (2001) the direct method might produce greater bias than the indirect method, however the direct method is easier to understand for survey participants, requires fewer items, and takes less response time. The indirect method on the other hand allows researchers to identify how moderators affect the optimism, compare Helweg-Larsen and Shepperd (2001). Further Shepperd et al. (2013) recommend the use of the indirect method, because it allows to see if either the own risk is relatively low or the risk of the comparison group is estimated comparatively high.

makers (lenders and investors) involved in infrastructure PF in Europe", as it is vital that the participants understand exactly which group they are supposed to compare themselves to. Second, two different kinds of scales are used (Likert and percentage scale) as each type of scale entails different disadvantages and advantages⁵³. Unrealistic optimism regarding risk of construction time and cost overrun and unrealistic optimism regarding chance of early and within budget completion are measured with a percentage scale, unrealistic optimism regarding risk of lower than expected future revenues and chance of higher than expected future revenues are measured with a 7-point Likert scale.

In order to test for representative heuristic some research tests for base rate neglect and sample size separately (Barberis & Thaler, 2003; Kahneman & Tversky, 1974), others test directly for the occurrence of the representative heuristic (Zaiane, 2015). To limit the number of items in the survey the direct test is to be used with the question Zaiane (2015) developed.

To test for overconfidence the three facets illusion of control, miscalibration, and better-than-average effect need to be measured.

In order to measure illusion of control, a similar method to that of Vetter et al. (2011) is used. Participants are asked four questions, derived from previous overconfidence studies and slightly adapted in wording to the domain of infrastructure PF. Answers are measured on a 7-point Likert scale. To arrive at a single measure for this facet of overconfidence, the answers are averaged across the four questions.

It is common to test for miscalibration by conducting a calibration study (Vetter et al., 2011). Calibration studies are "*conducted to measure how well participants are aware of what they do not know exactly*" (Vetter et al., 2011, p. 8). A calibration study entails first letting survey participants answer several knowledge questions in their domain, then letting

⁵³ The Likert scale "*can create a range restriction, but is less susceptible to innumeracy problems*", compare Shepperd et al. (2013, p. 407). The 0-100% scale does not provide range restrictions, however it is reported that participants sometimes have problems with this scale due to poor numerical skills, compare Shepperd et al. (2013). Thus, one set of questions is asked for each of the two scale types.

participants estimate the confidence interval of being right, and finally measuring the difference between their estimate and their performance (Vetter et al., 2011). All three steps are elaborated in the following. Knowledge is tested by five questions⁵⁴ from the domain of PF⁵⁵ with a single numerical estimate⁵⁶ answer for each question (Vetter et al., 2011) e.g. “*What % amount of PF loans 2016 in EMEA was for projects in the power sector?*”. The questions were derived from discussions with PF experts. Objectively correct answers were derived from the PFI report 2016 and 2017 (Project Finance International, 2017). While answering single estimate knowledge questions, the participants have to provide an estimate of how sure they are that their answer is right (Klayman et al., 1999; Vetter et al., 2011). A common method for this is asking for a confidence range judgement i.e. asking participants to provide an interval for each knowledge question, with which they are 90% sure that it will contain the right response (Vetter et al., 2011). Finally, the so called hit rate is measured to determine how accurate the estimation of the participants was i.e. how often their intervals included the right answer (McKenzie et al., 2008). If one of the interval boundaries equals the objective correct answer it is counted as a hit. The hit rate then represents reverse miscalibration – a low hit rate means the participant is highly miscalibrated. To analyze results concerning the hit rate further, also the interval size i.e. the average size of the 90% confidence intervals chosen, as well as the interval mistake are measured, as suggested by Vetter et al. (2011) and Meyer (2016). The interval mistake is the average distance of the interval midpoint and the objectively correct answer (Meyer, 2016; Vetter et al., 2011).

⁵⁴ Although Klayman et al. (1999) remarks that it is common to ask 20 to 100 questions, the number of questions should be limited to increase the likelihood of achieving a sufficient number of participants. Other researchers propose that “*five questions is a sufficient number to get a reliable classification of participants based on their degree of miscalibration*”, compare Vetter et al. (2011, p. 8).

⁵⁵ Instead of choosing an investor and a lender related domain, as Klayman et al. (1999) state that: “*It is possible that larger and more homogeneous sets of questions are less prone to biased information processing*”, compare Klayman et al. (1999, p. 221).

⁵⁶ Another approach is to use two choice questions, compare Klayman et al. (1999), such as “*Which kind of projects typically run more over budget a) greenfield, b) brownfield?*”. According to Klayman et al. (1999), questions with a single numerical answer elicit typically larger bias than two-choice questions, thus this study will use questions with a single numerical answer.

For the better-than-average effect the method used by of Kruger and Dunning (1999) and Vetter et al. (2011) is applied. Participants are asked to compare themselves with their peers on the performance of the five knowledge questions. This value is then compared to the actual performance in the knowledge questions derived in the calibration method described above (actual interval errors).

In the following it is explained how latent independent variables besides the bias are measured: (1) incentive system distinctiveness, (2) feedback culture distinctiveness, (3) negative experience, (4) regret, (5) subjective knowledge, (6) objective knowledge, and (7) experience based knowledge.

To measure how distinctive the incentive system is, Meyer (2016) poses four questions concerning the level of accountability for own decisions and the dependence of own compensation, own career path, and success of the company from project success. These exact questions are used in this survey. Results from the questions are measured on a 7-point Likert scale. To arrive at a single measure an average is taken across the questions.

In order to test how distinctive feedback culture is, Meyer (2016) poses five questions – also here these exact questions are used in this survey, testing how fast feedback from colleagues and superiors is delivered, how important feedback from colleagues and superiors is for the decision maker, and how important feedback is within the company culture. Results from the five questions are measured on a 7-point Likert scale. To arrive at a single measure, an average is taken across the five questions.

The existence of a previous negative experience is tested by asking participants if they themselves or a peer had a negative experience (related to their stake in the project e.g. credit default for lenders, loss of equity value for investors, project delay for project sponsors) in a project they were involved in. The two aspects are each measured on a 7-point Likert scale and to arrive at a single measure an average across the two is taken.

To measure regret the direct approach is taken, asking respondents if and how much they regret a previous decision in the domain of project financing. This is measured on a 7-point Likert scale.

In order to test subjective knowledge the approach suggested by Meyer (2016) is used, asking participants to evaluate their own domain related skills, performance, and success compared to that of their peers. Results from the questions are measured on a 7-point Likert scale and to arrive at a single measure an average is taken.

The approach suggested by Vetter et al. (2011) is used to assess objective knowledge, using the interval error from the calibration study. The interval error is the difference between the interval's midpoint and the true value (Vetter et al., 2011).

To quantify the experienced based knowledge of a person, again the approach suggested by Vetter et al. (2011) is used. Vetter et al. (2011) ask participants about the years of total work experience, work experience they have in the specific industry the study is focused on, work experience in the relevant task, and their experience with responsibility in that specific task. Finally the hierarchy level is measured as an additional indicator of experienced based knowledge (Vetter et al., 2011).

As control variables on the personal level age and gender of the participants was asked for in the survey. On company level company age, size, headquarter location, as well as team diversity were chosen as control variables. Objective company characteristics (company age, company size, headquarter location) are determined through web research and measured as of the 31st of June 2017. Through asking participants for their approximate company size, age, and the headquarter location, as well as given them the chance to provide their company name voluntarily, objective company characteristics can be assigned to participants. Team diversity is most often measured in terms of sex, age, ethnicity, education, functional background, and several other attributes. In the survey team diversity was tested in terms of the most

mentioned aspects from other studies (Jackson, Joshi, & Erhardt, 2003). Therefore, it was inquired how diverse the team the individuals are working in is regarding age, culture, academic background, and job experience. The aspects are each measured on a 7-point Likert Scale. Further the percentage of males in the team is inquired. All five aspects are standardized on individual level, to account for the different scales, then the average is taken.

To ensure high data quality, possible response biases were considered when creating the survey: (1) tendency towards the mean, (2) social desirability, and (3) question order effects.

By changing the wording of a 7-point Likert's scale's end points from completely agree/completely disagree to agree/disagree, the tendency toward the mean i.e. when respondents generally avoid extreme judgments, was counteracted against.

Social desirability is the tendency to answer a question in a way that it does not violate any social expectations. To avoid this, instructions were provided in the questionnaire stressing the scientific importance of honest answers and assurance of complete anonymity.

Question order effects are response biases that are due to a question's position within the questionnaire. A strategy to reduce ordering effects is the permutation of the order of questions and answers (McKenzie et al., 2008) Therefore, whenever possible participants were presented with the questions in a random order.

5.1.2 Measuring the causality in the model of decision maker unrealistic optimism

Ringle (2004) states that although strictly speaking causality can only be tested by observations⁵⁷, causal models can however be estimated by either a covariance structural analysis or the partial least squares-analysis. Since these methods are new, applicability is not yet proven. Therefore, in this study a regression is used to measure the causality in the model

⁵⁷ Using an experimental design with random assignment of participants to the systematically manipulated experimental conditions while holding all potential disturbing variables constant is the only scientific way to "prove" causality.

developed in chapter 4.4 (RQ2⁵⁸). Using a regression allows to measure both independent and dependent variables at the same time and derive the causal relationship by logical considerations⁵⁹.

5.1.3 Measuring the differences between investors and lenders

To answer RQ3⁶⁰ and test the hypotheses developed in chapter 4.5, participants of the survey were asked which stakeholder group they belonged to, with the alternatives private investor, public investor, credit sales, credit risk, and other. In a first step, all stakeholders that selected “other” needed to be assigned to the relevant group. Seven stakeholders selected “other” as category and offered a description, what “other” meant. According to either this description or the information provided on the company these stakeholders worked for, they were assigned to the relevant stakeholder group. The assignment resulted in the following stakeholder groups: lenders n = 67 (credit risk management n = 16, credit sales n = 51), investors n = 35 (public investors n = 7, private investors n = 28).

To test Hypothesis 5⁶¹, independent-samples t-tests and Mann-Whitney U tests were performed between lenders and investors on the three different facets of unrealistic optimism for which causal drivers are identified. To explain the results on Hypothesis 5, one-way Anovas and Kruskal-Wallis tests were performed on the sub-stakeholder groups private investor, public investor, credit sales, and credit risk.

⁵⁸ How do personal and company factors influence heuristics and unconscious bias of infrastructure PF decision stakeholders and how do these heuristics and unconscious bias influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

⁵⁹ Many authors therefore use a correlative approach. However, Vetter et al. (2011) demand from further research “*more sophisticated statistical tests should be conducted to analyze not only relationships but also the causality between the knowledge and overconfidence variables*”, compare Vetter et al. (2011, p. 14).

⁶⁰ Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

⁶¹ Due to their role in PF, lenders are on individual level less unrealistically optimistic than investors.

Hypothesis 6⁶², 7⁶³, and 8⁶⁴ were tested with independent-samples t-tests and Mann-Whitney U tests. To explain the results on Hypothesis 6 and 7 additional correlation analyses with sub-questions on feedback and incentive system were performed to examine the stakeholder group difference also on subcomponents of the incentive and feedback system.

5.1.4 Building a predictive model of company unrealistic optimism

The characteristics of companies in terms of three classes of factors (objective company characteristics, company overconfidence, and institutional structure) are compared through the analysis of variance to identify factors that distinguish companies with above average from companies with average and below average levels of unrealistic optimism. Thus, unrealistic optimism on company level is used as a dichotomous dependent variable (above/below average unrealistic optimism), defined on company level.

The analysis of company characteristics proposed in chapter 4.6 (RQ4⁶⁵) is performed using data from the survey presented above, complemented with company specific data.

How to measure relevant variables such as aspects of institutional structure (feedback culture distinctiveness, incentive system distinctiveness, and subjective knowledge), and overconfidence bias (miscalibration, subjective knowledge, and illusion of control) on individual level was elaborated in chapter 5.1.1. To get a company's average for these variables, an average of the individual employees was taken⁶⁶. The use of subjective employee data might raise concerns – however, previous research has concluded that when asking employees not for their personal but rather a general company estimate, the use of subjective

⁶² Lenders have a more distinct incentive system than investors, the feedback culture of lenders and investors is equally distinct.

⁶³ Lenders and investors have equal levels of subjective, objective, and experienced based knowledge.

⁶⁴ Lenders and investors have a similar amount of overconfidence and use the representative heuristic equally much.

⁶⁵ What are the characteristics of companies that are less unrealistically optimistic than others?

⁶⁶ It is worth mentioning that Houghton et al. (2000) recommend not to aggregate individual data but to collect data directly from team. Out of practical reasons, it was however decided to go with the aggregation method also used by other authors in this field such as McNamara and Bromiley (1997).

data is useful for the study of strategic issues (Durand, 2003). While Durand (2003) proposes to interview one person per company (CEO), it was decided to exclude all companies from the sample where only one individual took part in the survey to account for self-selection bias of respondents.

A limited number of predictors that fulfill the criteria put forward by Nassimbeni (2001) is selected (adequate level of significance, no close correlation). Having limited the relevant factors, the predictive model is created based on the results of the company comparison regarding unrealistic optimism. Goal of the predictive model is to identify which characteristics best predict the tendency of a company to be unrealistically optimistic.

5.2 Population of interest

The population of interest are (1) lenders, (2) private investors, and (3) public investors active in PF decision making in Europe. Relevant decision makers were identified over LinkedIn. Those decision makers were chosen whose profile on LinkedIn showed that they were currently working in the relevant department of the identified banks and whose business E-Mail addresses were found online or contact could be established through LinkedIn.

To identify the relevant population of lenders those banks were targeted that were included in the Project Finance International Top 100 ranking 2016 (Project Finance International, 2017), had a lead-arranging role in at least one European infrastructure PF deal with debt >75 million in 2016, and performed at least 5 PF deals in 2016. This yielded an overall lender population of 472 bankers from 45 companies.

To identify the relevant population for private investors those companies were targeted that were included in the 2016 Infrastructure Investor Top 50 ranking (Wang, 2016), have invested in infrastructure in Europe, and have participated in PF deals in the past. This yielded an overall private investor population of 374 investors from 37 companies.

To identify the relevant population for public investors those public departments/institutions were targeted that were member of the International Project Finance Association in 2016 and that focused on energy and transport/infrastructure, as these are the biggest fields of public infrastructure PF projects in Europe as reported in chapter 2.2. This yielded an overall public investor population of 45 officials from 11 European public departments/institutions.

5.3 Description of sample

The total response rate of the survey is 16.3%, overall 9,8% answered the survey completely. This response rate is typical for online survey with E-Mail invitation (Fan & Yan, 2010; Saleh & Bista, 2017).

Before analyzing the data, further quality checks were performed. Of the participants that aborted, only the data of those that answered the survey section about unrealistic optimism (80% of survey) were used in the analysis, resulting in 102 participants⁶⁷. It was analyzed if any of the participants needed extremely short or extremely long time to answer the survey. There are no extreme outliers as reported by visual inspection of boxplots and all completed the survey in a time that is realistic. Data entries that were illogical e.g. years of experience of taking PF decisions longer than years of experience in PF were corrected by using LinkedIn profiles as reference. Missing data entries were imputed with the mean as this is a common practice⁶⁸ (Zhang, 2016).

The sample distribution over stakeholder groups is not even – therefore the sample is not entirely representative of the overall population. The lender and public investor response rate

⁶⁷ n = 43 were excluded due to early abortion of survey, of which n = 3 did not answer a single question, the rest aborted at the following questions: n = 3 at question checking for appropriateness of participants for study, n = 5 at question about the person's work experience, n = 6 at question about team characteristics, n = 6 at question about incentive system distinctiveness, n = 1 at question about feedback culture, n = 8 at question about prior project experience, n = 10 at question about the person's performance, n = 2 at question about illusion of control.

⁶⁸ For the following number of participants, data was imputed: representative heuristics n = 2, illusion of control n = 2, better-than-average self-assessment n = 14, objective knowledge n = 17, unrealistic optimism risk self regarding construction cost and time overrun n = 1, unrealistic optimism risk colleague regarding construction cost and time overrun n = 1, unrealistic optimism reward colleague regarding construction cost and time overrun n = 1.

is about 20%, the private investor response rate 10%. However, there are explanations for the comparatively low response rate of private investors. In response to the survey invitation, several private investors mentioned that answering survey is against their company policy. Further, private investors in the infrastructure field tend to be less specialized on PF, so the population contacted might not be entirely exact.

Table 12: Overview of study participation

	People contacted			People responded			Brutto response rate, percent	Netto response rate, percent	
	Company	E-Mail	LinkedIn	Total	Complete responses	Aborted			Total
Lender	45	419	53	472	67	34	101	21.4	14.2
Private investor	37	345	29	374	16	18	34	9.1	4.3
Public investor	11	38	7	45	4	6	10	22.2	8.9
Total	93	802	89	891	87	58	145	16.3	9.8

The analysis of participants that responded to the survey showed that those that aborted the survey are not different in contact method (LinkedIn vs. E-Mail), country, or language. The number of reminders and the time of participation (T-test of first 51 vs. second 51 answers) did not have an influence on the main constructs analyzed⁶⁹.

5.4 Test of the causal model of individual decision maker unrealistic optimism

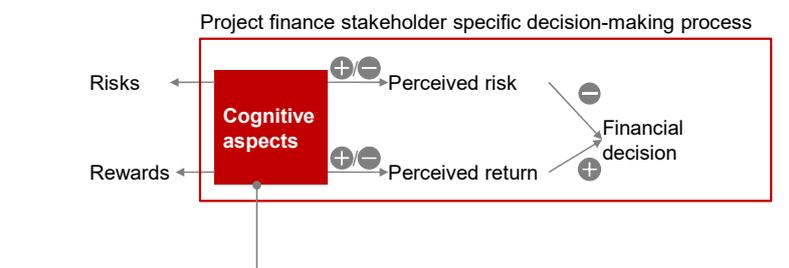
As described in chapter 2, there is an infrastructure finance gap that needs to be closed in Europe. Implementing projects with PF can help to optimize spending and thus contribute to close this gap if efficiency gains achieved are higher than the costs of PF. An important challenge for lenders and investors in making decisions in the context of infrastructure PF is to overcome own biases, as these can lead to perceived risks which differ dramatically from actual risks. While there is some literature on biases in the decision making of project

⁶⁹ For all four facets of unrealistic optimism there is a violation of the normality assumption as reported by the Shapiro-Wilk test $p < 0.05$. Therefore, the non-parametric Mann-Whitney U test was run to determine if there were differences between the first 51 and last 51 responses. Distributions of optimism variables for first 51 responses and last 51 responses are similar, as assessed by visual inspection. Median optimism variables are not statistically significantly different.

planners, no research in the field of infrastructure PF focusses of the decision situation of lenders.

The goal is therefore to answer the research question displayed in Figure 15 below. To answer this, a review of the behavioral finance literature was conducted in chapter 4 to create a theoretical causal bias model, including all biases applicable to large infrastructure projects implemented with PF, as well as relevant influencing factors.

Figure 14: Unrealistic optimism in PF can lead to over- and underevaluating risks and rewards



RQ2: How do personal and company factors influence heuristics and unconscious biases of infrastructure PF decision stakeholders and how do these heuristics and unconscious biases influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”?

Source: Adapted from Hampl and Wüstenhagen (2012)

In the following, (1) the results of the empirical testing of the model are presented and (2) implications for theory and practice discussed.

5.4.1 Results causal model of individual decision maker unrealistic optimism

In the following first results regarding (1) unrealistic optimism (H_1) as such are presented, followed by (2) the results regarding the hypothesized causal relationships (H_{2-4}).

5.4.1.1 Analysis of unrealistic optimism in infrastructure PF

To find out if decision making behavior is biased by unrealistic optimism, participants were asked to indicate how large the likelihood of experiencing certain events was compared to the likelihood for colleagues. Overall there is clear evidence for unrealistic optimism in the sample. The risk of a cost/time escalation, as well as the risk of receiving smaller revenues than expected is regarded as much smaller than the chance of lower construction cost/less construction time, as well as higher revenues. This is consistent with other findings in the

literature which state that people see positive events as more likely than negative events (Sharot, Riccardi, Raio, & Phelps, 2007).

Results show that on average decision makers estimate the probability that one of the projects they are responsible for right now will face massive time and cost overruns in the future at 19.29%. The same risk is seen at 23.16% for colleagues. So, the risk of construction time and cost overrun is estimated 3.86% higher for colleagues (paired $t(101) = -3.047$, $p = 0.003$).

Results show that decision makers estimate the probability that one of the projects they are responsible for right now will deliver less revenues in the future than they estimated on average at 3.43 on a 7-point Likert scale. The same risk is seen at 3.53 for colleagues. So, the risk of lower than expected future revenues is estimated 0.25 points higher for colleagues (paired $t(101) = -3.089$, $p = 0.003$).

Results show that decision makers estimate the probability that one of the projects they are responsible for right now will exceed all their expectations by delivering the project faster and less expensive on average at 30.7%. The same probability is seen at 31.77% for colleagues. So, the chance of faster and less expensive delivery is estimated 1.12% higher for colleagues (paired $t(101) = -1.289$, n.s.⁷⁰).

Results show that decision makers estimate the probability that one of the projects they are responsible for right now will exceed all their expectations by having higher future revenues on average at 3.63 on a 7-point Likert scale. The same probability is seen at 3.53 for colleagues. So, the chance of higher than expected future revenues is estimated 0.098 points lower for colleagues (paired $t(101) = 1.055$, n.s.⁷¹).

⁷⁰ $p = 0.200$.

⁷¹ $p = 0.294$.

5.4.1.2 Analysis of causal relationships

In the following the results of the regressions are presented that test the hypothesized causal relationships for (1) unrealistic optimism regarding chance of early and within budget completion, (2) unrealistic optimism regarding chance of higher than expected future revenues, (3) unrealistic optimism regarding risk of construction time and cost overrun, and (4) unrealistic optimism regarding risk of lower than expected future revenues.

As a second step, results for the regression on the underlying overconfidence bias is presented⁷².

First, a multiple regression was run to predict unrealistic optimism regarding chance of early and within budget completion from feedback distinctiveness, incentive distinctiveness, better-than-average self-assessment, miscalibration, illusion of control, and representative heuristic. The control variables age, gender, company age, company size, and team diversity were omitted as they did not correlate with unrealistic optimism regarding chance of early and within budget completion as can be seen in Table 27 in the Appendix. The control variable country was also omitted as no significant differences could be found between the different countries on the dependent variable⁷³. Prerequisites for using the multiple linear regression method are fulfilled⁷⁴. The multiple regression model does not statistically significantly

⁷² The results of the representative heuristic are not presented, as this does not influence unrealistic optimism.

⁷³ Due to violation of normality assumption the non-parametric Kruskal-Wallis test was performed. Distributions of unrealistic optimism regarding chance of early and within budget completion are not entirely similar for the different countries, as assessed by visual inspection of a boxplot. Scores are not statistically significantly different between the different countries, $\chi^2(11) = 12.170$, $p = 0.351$.

⁷⁴ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is also given, as assessed by a Durbin-Watson statistic of 1.660. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. However, there are three outliers and three studentized deleted residuals greater than ± 3 standard deviations. These outliers have unusual but possible values, so they were kept in the analysis. Looking at unusual points, two risky leverage values > 0.2 became apparent, however no data needed to be removed from analysis as Cook's distance value is not above 1 for any of these values.

predict unrealistic optimism regarding chance of early and within budget completion, $F(6, 95) = 0.139, p = 0.991$.

Second, a linear multiple regression⁷⁵ was run to predict unrealistic optimism regarding chance of higher than expected future revenues from feedback distinctiveness, incentive distinctiveness, better-than-average self-assessment, miscalibration, illusion of control, representative heuristic, and experienced based knowledge. The control variables age, gender, company age, company size, and team diversity were omitted again as they did not correlate with unrealistic optimism regarding chance of higher than expected future revenues, as can be seen in Table 28 in the Appendix. The control variable country was also omitted as no significant differences could be found between the different countries on the dependent variable⁷⁶. Overall, prerequisites for using the multiple linear regression method are fulfilled⁷⁷. The multiple regression model statistically significantly predicts unrealistic optimism regarding chance of higher than expected future revenues, $F(6, 95) = 2.833, p = 0.014$. R^2 for the overall model was 15.20% with an adjusted R^2 of 9.8%, a below small size effect according to Cohen (1988). Only the variable feedback culture distinctiveness adds statistically significantly to the prediction, $p < 0.050$. Regression coefficients and standard errors can be found in Table 13.

⁷⁵ There is the much-debated question if scale variables can be approximated as continuous variables and used in a multiple linear regression, or if an ordinal regression needs to be run instead. In this work scales with >12 items are treated as continuous (unrealistic optimism regarding future revenues e.g. has 13 possible values: -6+6), therefore a multiple linear regression can be used.

⁷⁶ Due to violation of normality assumption the non-parametric Kruskal-Wallis test was performed. Distributions of unrealistic optimism regarding chance of early and within budget completion are not entirely similar for the different countries, as assessed by visual inspection of a boxplot. Scores are not statistically significantly different between the different countries, $\chi^2(11) = 15.760, p = 0.150$.

⁷⁷ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is also given, as assessed by a Durbin-Watson statistic of 1.665. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. However, there is one studentized deleted residual greater than ± 3 standard deviations. This outlier has an unusual but possible value, so it was kept in the analysis. Looking at unusual points, two risky leverage values >0.2 became apparent, however no data needed to be removed from analysis as Cook's distance value is not above 1 for any of these values.

Table 13: Summary of multiple regression analysis on unrealistic optimism regarding chance of higher than expected future revenues

Variable	B	SE _B	β
Intercept	1.132	0.925	
Feedback culture distinctiveness	-0.267	0.117	-0.240*
Incentive system distinctiveness	-0.023	0.090	-0.026
Hit rate (reverse miscalibration)	-0.368	0.349	-0.104
Illusion of control	0.142	0.105	0.131
Better-than-average effect	0.009	0.005	0.180
Representative heuristic	-0.212	0.216	-0.093

Note: * $p < 0.050$; B = unstandardized regression coefficient, SE_B = standardized error of coefficient, β = standardized coefficient

Third, a multiple regression was run to predict unrealistic optimism regarding risk of construction time and cost overrun from feedback distinctiveness, incentive distinctiveness, better-than-average self-assessment, miscalibration, illusion of control, representative heuristic, and subjective knowledge. The control variables again were omitted as they did not correlate with unrealistic optimism regarding risk of construction time and cost overrun as can be seen in Table 25 in the Appendix. Prerequisites for using the multiple linear regression method are fulfilled⁷⁸. The control variable country was also omitted as no significant differences could be found between the different countries on the dependent variable⁷⁹. The multiple regression model statistically significantly predicts unrealistic optimism regarding risk of construction time and cost overrun, $F(7, 94) = 2.160$, $p = 0.045$. R^2 for the overall model is 13.9% with an adjusted R^2 of 7.4%, an effect that does not even classify as small according to Cohen (1988). Two variables add statistically significantly to the prediction, $p < 0.050$, hit rate (reverse miscalibration) and illusion of control. The effect size of hit rate is,

⁷⁸ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is given, as assessed by a Durbin-Watson statistic of 1.634. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. However, there are four outliers detected by standardized residuals and by studentized deleted residuals greater than ± 3 standard deviations. All outliers have unusual but possible values, so they were kept in the analysis. Looking at unusual points, two risky leverage values > 0.2 became apparent, however no data needed to be removed from analysis as Cook's distance value is not above 1 for any of these values.

⁷⁹ Due to violation of normality assumption the non-parametric Kruskal-Wallis test was performed. Distributions of unrealistic optimism regarding chance of early and within budget completion are not entirely similar for the different countries, as assessed by visual inspection of a boxplot. Scores are not statistically significantly different between the different countries, $\chi^2(11) = 10.775$, $p = 0.462$.

however, nearly three times as big as the effect size of illusion of control. Regression coefficients and standard errors can be found in Table 14 below.

Table 14: Summary of multiple regression analysis on unrealistic optimism regarding risk of construction time and cost overrun

Variable	B	SE _B	β
Intercept	-14.977	13.485	
Feedback culture distinctiveness	0.873	1.615	0.058
Incentive system distinctiveness	-0.724	1.256	-0.059
Hit rate (reverse miscalibration)	11.851	4.816	0.244*
Illusion of control	4.196	1.468	0.284*
Better-than-average effect	-0.024	0.073	-0.036
Representative heuristic	0.334	2.989	0.011
Subjective knowledge	-1.133	1.370	-0.083

Note: * $p < 0.050$; B = unstandardized regression coefficient, SE_B = standardized error of coefficient, β = standardized coefficient

Fourth, a multiple linear regression was run to predict unrealistic optimism regarding risk of lower than expected future revenues from feedback culture distinctiveness, incentive system distinctiveness, better-than-average self-assessment, hit rate, illusion of control, representative heuristic, and subjective knowledge. The control variables were again omitted as they did not correlate with unrealistic optimism regarding risk of lower than expected future revenues as can be seen in Table 26 in the Appendix. The control variable country was also omitted as a significant difference could only be found between decision makers in Germany and France, but not between any other of the 12 countries included in the sample⁸⁰. Prerequisites for using the multiple linear regression method are fulfilled⁸¹. The multiple regression model

⁸⁰ Due to violation of normality assumption the non-parametric Kruskal-Wallis test was performed for all countries with more than two participants. Distributions of unrealistic optimism regarding chance of early and within budget completion are not entirely similar for the different countries, as assessed by visual inspection of a boxplot. Scores are statistically significantly different between the different countries, $\chi^2(11) = 23.870$, $p = 0.013$. Pairwise comparisons were performed using the Dunn (1964) procedure with a Bonferroni correction for multiple comparisons. Adjusted p -values are presented. Values are mean ranks unless otherwise stated. This post hoc analysis revealed statistically significant differences in unrealistic optimism scores between Germany (80.00) and France (38.64) ($p = 0.043$), but not between any other group combination including the countries Australia, Canada, England, Italy, Japan, Netherlands, Spain, Sweden, USA, South Africa.

⁸¹ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is given, as assessed by a Durbin-Watson statistic of 2.317. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. However, there is one outlier detected by studentized deleted residuals greater than ± 3 standard deviations. This outlier has an unusual but possible value, so it was kept in the analysis. Looking at unusual points, four risky leverage values > 0.2 became apparent, however no data needed to be removed from analysis as Cook's distance value is not above 1 for any of these.

statistically significantly predicts unrealistic optimism regarding risk of lower than expected future revenues, $F(7, 94) = 3.402, p = 0.003$. R^2 for the overall model is 20.2% with an adjusted R^2 of 14.3%, a small size effect according to Cohen (1988). Two variables add statistically significantly to the prediction, $p < 0.050$ incentive distinctiveness and subjective knowledge, with a similar effect size. Regression coefficients and standard errors can be found in Table 15.

Table 15: Summary of multiple regression analysis on unrealistic optimism regarding risk of lower than expected future revenues

Variable	B	SE _B	β
Intercept	-1.513	0.812	
Feedback culture distinctiveness	0.152	0.097	0.160
Incentive system distinctiveness	-0.273	0.076	-0.357*
Hit rate (reverse miscalibration)	0.259	0.290	0.085
Illusion of control	0.172	0.088	0.186
Better-than-average effect	0.002	0.004	0.039
Representative heuristic	0.016	0.180	0.008
Subjective Knowledge	0.235	0.083	0.274*

Note: * $p < 0.050$; B = unstandardized regression coefficient, SE_B = standardized error of coefficient, β = standardized coefficient

Of the underlying overconfidence bias with its three facets and the representative heuristic, only the two overconfidence facets miscalibration and illusion of control were identified as enhancing/diminishing factors of unrealistic optimism. Therefore, in the following results on enhancing/diminishing factors of (1) miscalibration and (2) illusion of control will be presented.

A cumulative odds ordinal logistic regression with proportional odds was run to determine the effect of experienced knowledge on miscalibration. The control variables were omitted as they did not correlate with miscalibration as can be seen in Table 29 in the Appendix. Prerequisites for using the ordinal logistic regression method are fulfilled⁸². The final model statistically significantly predicts the dependent variable over and above the intercept-only model, $\chi^2(6) =$

⁸² There are proportional odds, as assessed by a full likelihood ratio test comparing the fitted model to a model with varying location parameters, $\chi^2(24) = 29.062, p = 0.218$. The deviance goodness-of-fit test indicates that the model is a good fit to the observed data, $\chi^2(489) = 295.335, p = 1.000$, but because of continuous independent variables in the equation, many covariate patterns (83%) are missing and thus, many cells have a zero frequency. Therefore, the overall goodness-of-fit statistics needs to be treated with suspicion.

13.176, $p < 0.040$. An increase in PF job experience (expressed in years) is associated with an increase in hit rate (decrease in miscalibration), with an odds ratio of 0.875, $p < 0.050$. An increase in PF job experience in decision making (expressed in years) is associated with a decrease in hit rate (increase in miscalibration), with an odds ratio of 1.157, $p < 0.050$. As suggested by Vetter et al. (2011) a correlation between interval mistake, interval size and experienced knowledge was performed in a second step, as can be seen in Table 16. This showed that an increase in job experience, as well as PF job experience significantly reduces the interval mistake. Further, decision makers with more job experience and PF job experience are less insecure and chose smaller intervals.

Table 16: Pearson's correlations for interval mistake and interval size

Variable	Interval mistake	Interval size	Hierarchy level	Years job experience	Years PF job experience
Interval size	.83				
Hierarchy level	-0.012	-0.108			
Years job experience	-0.252*	-0.235*	0.527*		
Years PF job experience	-0.202*	-0.198*	0.513*	0.754*	
Years PF decision responsibility	-0.181	-0.150	0.497*	0.717*	0.845*

Note: * $p < 0.050$

A multiple regression was run to predict illusion of control from subjective knowledge.

Control variables were omitted as they did not correlate with illusion of control as can be seen in Table 30 in the Appendix. Prerequisites for using the multiple linear regression method are fulfilled⁸⁴. The multiple regression model statistically significantly predicts illusion of control, $F(1, 100) = 4.269$, $p = 0.041$. R^2 for the overall model is 4.1% with an adjusted R^2 of 3.1%, a below small size effect according to Cohen (1988). The independent variable adds

⁸³ Relationship not linear, therefore Pearson's correlation not possible.

⁸⁴ There is linearity as assessed by partial regression plot and a plot of studentized residuals against the predicted values. Independence of residuals is given, as assessed by a Durbin-Watson statistic of 1.490. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. There is one studentized deleted residual greater than ± 3 standard deviations. This outlier was inspected, however it was concluded that it has an unusual but possible value, so it was kept in the analysis. There is no value with leverage values > 0.2 or Cook's distance above 1.

statistically significantly to the prediction, $p < 0.050$, regression coefficients and standard errors can be found in Table 17 below.

Table 17: Summary of multiple regression analysis on illusion of control

Variable	B	SE _B	β
Intercept	3.646	0.469	
Subjective knowledge	0.187	0.090	0.202*

Note: * $p < 0.050$; B = unstandardized regression coefficient, SE_B = standardized error of coefficient, β = standardized coefficient

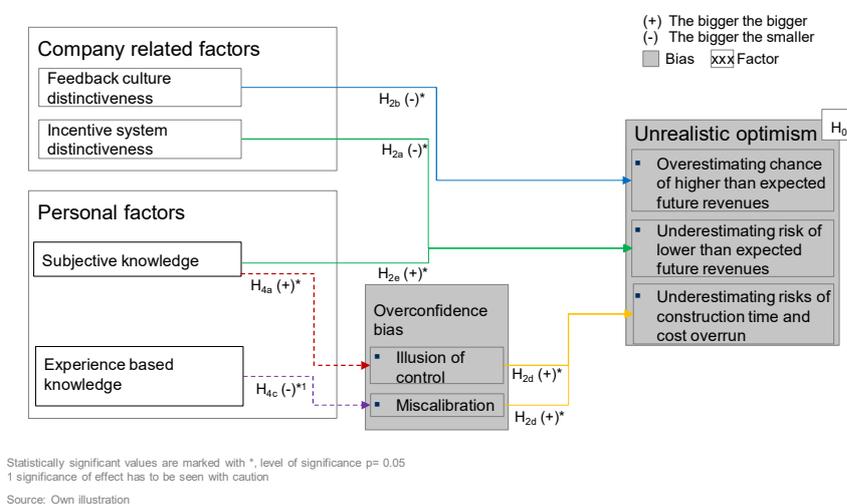
5.4.2. Discussion causal model of individual decision maker unrealistic optimism

The use of PF can be way to close the financing gap large infrastructure projects face if the assumption holds that the risk transfer from public institutions and corporates to PF stakeholders leads to a more efficient project delivery. Although this notion is commonly taken for granted, so far research has not sufficiently explored, whether the transfer of estimator related risks, namely unrealistic optimism to lenders and investors, really does lead to a more realistic assessment of risks or not. Instead, the assumed positive effect from risk transferring, has been based on findings from both behavioral economics and studies in other industries. Yet it reasonably has not been proven. Especially in times of increasing uncertainty in infrastructure projects due to changing user needs and disruptive technologies (Woetzel et al., 2017) that should lead to higher probability of bias in decision making, investigating if the transfer of estimator related risks provides advantages, however, is vital.

The goal of this study is therefore to close this gap by answering RQ2: How do personal and company factors influence heuristics and unconscious bias of infrastructure PF decision stakeholders and how do these heuristics and unconscious bias influence the perception of risks and rewards, in this study subsumed under “unrealistic optimism”? To answer this research question, a theoretical causal bias model was created from literature, limited to the most important aspects through open interviews, and tested using multiple linear and ordinal regressions with a dataset collected through a survey with relevant stakeholders.

Major findings from the causal model were that overall unrealistic optimism exists in infrastructure PF. Furthermore, a number of direct and indirect factors that lead to this unrealistic optimism in decision making were identified as can be seen in the figure below. Accordingly, directly influencing factors are subjective knowledge on a personal and feedback culture/incentive system effectivity on a company level. Additionally, unrealistic optimism was influenced by overconfidence bias, which itself was driven by subjective knowledge and reduced by experienced based knowledge, both factors on the personal level.

Figure 15: Resulting causal model



The results of this study are highly relevant considering the current discussion as usually researchers have argued that the involvement of an outside view, i.e. lenders and investors, gives an important advantage regarding the assessment of revenue and risks of large and complex infrastructure projects (Flyvbjerg, 2013). In light of the findings from the model, however, this assumed advantage must be questioned – at least in relation to unrealistic optimism and the resulting perceptions of risks and rewards. Furthermore, by not only demonstrating that unrealistic optimism exists among PF decision makers, but also identifying direct and indirect factors that lead to this bias, this research study provides a better understanding – both to researchers as to practitioners – of how to influence unrealistic optimism. The knowledge gained about causal drivers of unrealistic optimism can be used by

decision makers as a basis to establish a more realistic risk assessment; the unrealistic optimism therefore is not an unchangeable characteristic of stakeholders but one that can be influenced and thus reduced.

The table below provide an overview of the results of testing the hypotheses put forward.

These will be discussed in more detail in the following.

Table 18: Relevant results causal bias model for decision making in infrastructure PF

	Hypothesis
Company related factors	<input checked="" type="checkbox"/> Confirmation H ₁ as lenders/investors in PF are overall unrealistically optimistic
	<input checked="" type="checkbox"/> Confirmation H _{2a} as incentive system distinctiveness reduces unrealistic optimism (regarding risk of lower than expected future revenues)
	<input checked="" type="checkbox"/> Confirmation H _{2b} as feedback culture distinctiveness reduces unrealistic optimism (regarding chance of higher than expected future revenues)
Bias and heuristics	<input checked="" type="checkbox"/> Rejection H _{2c} as representative heuristics has no effect on unrealistic optimism
	<input checked="" type="checkbox"/> Partly confirmation H _{2d} : the overconfidence facet miscalibration reduces unrealistic overconfidence, the illusion of control facet increases unrealistic optimism, and the better-than-average effect has no impact on overconfidence (unrealistic optimism regarding risk of construction time and cost overrun)
Personal factors	<input checked="" type="checkbox"/> Confirmation H _{2c} as subjective knowledge increases unrealistic optimism (regarding risk of lower than expected future revenues)
	<input type="checkbox"/> H _{3a} , H _{3b} : Hypothesis not tested as H _{1c} was not confirmed
	<input checked="" type="checkbox"/> Confirmation H _{4a} : Subjective knowledge increases overconfidence (illusion of control)
	<input type="checkbox"/> H _{4b} : Hypothesis not tested as like shown in H _{1d} , the better-than-average effect has no significant influence on unrealistic optimism
	<input checked="" type="checkbox"/> Partly confirmation H _{4c} as PF job experience reduces miscalibration, however PF decision making job experience increases miscalibration

A major result of this study is that not only project insiders but also people with an outside view on projects like PF decision makers are subject to unrealistic optimism in the infrastructure project industry, and thus subconsciously add estimator related risks to the equation. This result is both surprising and expectable at the same time. Advocates of PF will find it surprising, having reasoned that PF provides a benefit also regarding risk assessment. Critics on the other hand will have expected support for their belief that implementing projects with PF creates no advantage overall. With the scientific data for this specific field now available due to the survey conducted for this study, the applicability of unrealistic optimism in the infrastructure industry could be proven. However, it must be kept in mind that estimator related risks concern only the unconscious decision process. It is still possible that lenders and investors provide better risk assessment than project insiders such as project planners due to their higher motivation to control risks.

Taking a closer look at the specific industry in focus, the overall unrealistic optimism of lenders and investors is not surprising as literature has reported this bias for developers in this industry before (Flyvbjerg et al., 2009), and as institutions such as the World Bank have committed to experiencing this bias within their institution (World Bank, 2006). The theorem of Kahneman and Tversky (1982) states that if faced with uncertainty decision makers are more likely to fall prey to cognitive biases in their decision-making process. The fact that lenders and investors in European infrastructure PF are overall unrealistically optimistic seems therefore likely specific to the infrastructure industry, that is characterized with high uncertainties, especially in the field of PF. At this moment speculative, but nevertheless possible, a conclusion might be that decision makers that are uncommonly optimistic are attracted by the infrastructure field with its high uncertainty, for instance because they are subject to illusion-of-control and therefore believe they can control the uncertainty and risk involved in this industry.

Besides industrial characteristics two alternative explanations stand out. First, since the focus of this study is European infrastructure PF decision makers, it is possible that the overall unrealistic optimism in general is driven by Western culture. In previous studies, authors reported that people from Western cultures are more likely subject to unrealistic optimism than people from Eastern cultures, namely Japan (Chang, Asakawa, & Sanna, 2001; Rose, Endo, Windschitl, & Suls, 2008). Second, it is also possible that not all stakeholders are similarly unrealistically optimistic, but that e.g. the low unrealistic optimism of the lenders was outweighed by the high unrealistic optimism of investors. This will be tested in the next chapter of this work.

The finding that PF stakeholders are optimistic is important, as it shows that not only planners and project managers, but also the decision makers that evaluate the project at a later

stage are unrealistically optimistic⁸⁵. Thus, PF does not per se mean that outsiders assess projects and the involved risks objectively. For an infrastructure project this can mean that there is a systematically wrong allocation of risk probabilities (Böttcher & Blattner, 2013; Flyvbjerg et al., 2014) as well as late response to warning signs when a project is already running (Haji-Kazemi, Andersen, & Klakegg, 2015; Meyer, 2016). Thus, an efficient risk transfer cannot be guaranteed. This puts the argumentation that PF does not only relieve the public budgets but also minimizes risks by involving outsiders with additional expertise into perspective. Potentially the relieve of the public budget might be acquired through transferring risks to parties that underestimate them unconsciously. However, as pointed out above it is possible that lenders and investors provide a more realistic risk assessment due to their higher motivation to control risks. Further, involving PF decision makers might also lead to a more realistic assessment as their different perspective can might lead to a more realistic discussion if risks with project insiders such as project planners.

Furthermore, the potential positive effects of unrealistic optimism should not be neglected. According to Shepperd et al. (2013) these are greater goal persistence, positive affect, and hope. To which amount and in which stages of a project these effects influence risk and reward perception is to be investigated. Future research should therefore focus on both the negative and positive effects of unrealistic optimism in infrastructure.

This study identified several factors directly or indirectly influencing the described unrealistic optimism. This is important because knowledge about influencing factors is an important means to reduce the bias, thus to control estimator related risks. From the causal model it can be derived that there is no driver that influences all different facets of unrealistic optimism on individual level. Instead, (1) company factors (incentive and feedback culture distinctiveness),

⁸⁵ However, as planners were not tested in this study, it is possible that lenders and investors are less extreme in their unrealistic optimism.

(2) other biases (overconfidence), and (3) personal factors (subjective knowledge) are found to influence different aspects of unrealistic optimism.

It is especially interesting and unexpected to see that the two company factors feedback and incentive system diminish only the facet of unrealistic optimism regarding the risk of lower than expected future revenues of projects, but not the risk of costs and time overruns. This is surprising because based on existing literature, incentive systems as well as feedback systems should affect both the revenue and the cost/time assessment. According to Tetlock and Kim (1987), for example, distinctive incentive systems should make decision making less biased in general as decision makers are more motivated to think critically and to make accurate choices. Regarding feedback systems, general decision accuracy has been found to relate to more distinct feedback systems as it leads to people subconsciously trying to avoid own disappointment when their outcomes fall short behind their predictions (Shepperd et al., 1996).

Potentially this overall curious finding can be explained by the important role of future revenues in the infrastructure PF industry. Revenues have a high impact on overall NPV of a project and often determine the success of an investment, as they in contrary to construction time and costs occur over a long period of time. At the same time revenues of infrastructure projects are often uncertain and dependent on individual politician's decisions. Thus, it may be that within this industry the focus of feedback and incentive systems lies more on revenues than on construction time and costs.

A different explanation might be that depending on contracting, rewards and risks might have a lesser impact on stakeholders than revenues. An alternative explanation could be that decision makers' construction cost/time and revenue assessments respond differently to feedback and incentive systems. Whether any of this is the case in infrastructure projects remains to be evaluated.

The finding overall indicates that unrealistic optimism is not strictly rooted within the individual decision maker but can be influenced by institutions and companies through the institutional environment the decision makers is in.

An additionally unexpected finding of this study is that the representative heuristic does in fact not influence unrealistic optimism in infrastructure PF. This goes against previous research focused on other industries, which indicates that the use of the representative heuristic is one of the key factors which leads decision makers to unrealistic optimism (Shepperd et al., 2002; Weinstein, 1980). According to Weinstein (1980), when estimating the exposure to a risk or reward compared to that of another project/person, often, the self-chosen comparison target is a stereotype that does not represent the objective statistical average target resulting in a faulty comparison that can cause high or low unrealistic optimism.

Furthermore, in expert interviews performed exploratively prior to the survey, the representative heuristic was named by all interview partners as a possible subconscious influential factor for their decisions. Despite the theoretical and practical seeming relevance, however, in this study neither the suspected negative nor an - unexpected - positive impingement on unrealistic optimism could be detected.

A possible explanation for this divergent finding is that due to the unique characteristic of each individual large infrastructure project and the different stakeholders involved in each project, decision makers do not compare projects to past failures and therefore do not fall prey to representative heuristic. Alternatively, taking the awareness of the interview partners towards representative heuristic into account, another possible explanation for its missing impact on decisions could be that being aware of this problem or being trained in handling this heuristic prevents being trapped in it (Kaustia & Perttula, 2009). Third, one should be careful not to let representative heuristic itself transfer findings from e.g. the Weinstein study to fields that are not comparable.

While the representative heuristic does not have any impact on unrealistic optimism in this study, unrealistic optimism concerning costs and time overruns, on the other hand, is impacted by different facets of the overconfidence bias. Specifically, the facets illusion of control as an enhancing factor and miscalibration as a diminishing factor influence the level of unrealistic optimism. However, the overconfidence bias relates only to the assessment of risks and not rewards, and only to construction cost/time and not to revenues. This can be explained by the higher uncertainty of construction costs and completion time, compared to revenue, of infrastructure projects stemming from complicated stakeholder interfaces in the construction phase. This higher uncertainty increases the probability of falling prey to biases (Kahneman & Tversky). An alternative explanation is that there is simply more room for biases regarding cost and time overrun in the construction phase, as due diligences used in the project evaluation often focus more on the revenue side.

Focusing on the facets of overconfidence, only illusion of control is identified in this study as factor that enhances unrealistic optimism. The enhancing influence of illusion of control is underlined by previous research, e.g. Shepperd et al. (2002). Already in 1980, Weinstein demonstrated that people tend to be more optimistic about future events that they believe they can control.

The second facet of overconfidence, the better-than-average effect, does not have any effect on unrealistic optimism in this study. This was also expected, as this replicates recent findings (Meyer, 2016).

Contrary to what Meyer (2016) found for the real estate industry, however, in this study miscalibration has a diminishing effect on unrealistic optimism, with a three times stronger effect on unrealistic optimism than illusion of control. This is a surprising finding that calls for further examination, as it implies that decision makers that expressed unjustified certainty in the accuracy of their estimations are less unrealistically optimistic, while those that place justified certainty in the accuracy of their prediction are more prone to unrealistic

optimism. With the lack of further information, explanations can only be speculative.

Presuming that inaccuracy in estimations is followed by negative feedback, one can imagine that those decision makers, who were inaccurate in their estimations previously, might be more careful when assessing risks and thus tend to be less unrealistically optimistic. This remains to be examined.

Besides company related factors there are two personal factors, subjective and experienced based knowledge, that were identified to have an influence on unrealistic optimism in the infrastructure industry. Experienced based knowledge has an indirect diminishing effect on optimism due to its effect on overconfidence. This is consistent with the finding of Vetter et al. (2011), who describe that experienced knowledge leads to lower overconfidence levels. The finding that subjective knowledge is directly related to overconfidence and unrealistic optimism is also consistent with what several researchers concluded (Carlson et al., 2009; Vetter et al., 2011). Vetter et al. (2011) explain that decision makers with high subjective knowledge often are victims of illusion of control because they are unlikely to consult others in their decision making and base their decision only on self-assessed knowledge. The same explanation should hold for the relationship of subjective knowledge and unrealistic optimism.

In the following the (1) theoretical and (2) practical contributions are presented, (3) limitations are named, and finally (4) a brief outlook is given.

5.4.2.1 Theoretical contributions

This work tests the applicability of hypotheses derived from existing literature to a new field of industry and to new stakeholder groups that have not been examined before. By testing hypotheses that were previously tested in different decision situations, the findings of this study not only represent a practical-relevant application, but also a robustness check of previous theory. Specifically, the study adds to current discussions within the field of (1)

literature about behavioral decision making in projects, (2) PF literature in general, and (3) literature about behavioral decision making concerning bias management. The more detailed contribution per literature stream is summarized in the following.

The literature concerned with the reductionist school of thought about behavioral decision making in projects, presented in chapter 4.3.2.1, analyses deviations from rational decisions that stem from bias. While studies in this field have brought about many interesting insights on what kind of different biases represent a deviation from the rational decision maker, these biases have mostly been tested empirically with students and not industry relevant decision makers such as lenders and investors. Thus, an important gap to close within this literature stream, has been to test the applicability and generalizability of findings from previous research to a different decision situation. This study represents a first attempt at closing this gap by demonstrating that indeed behavioral finance models can be applied to infrastructure PF decision making, yet need modifications. Causal connections between both company and personal factors, and unrealistic optimism that were found in other industries apply also in the field of large infrastructure PF. Furthermore, knowledge types known to influence facets of overconfidence for IT projects do also hold for infrastructure projects, such that this finding seems to be generalizable. However, a major modification to previous models seems to be the relatedness of other biases and heuristics to unrealistic optimism. Especially the influence of the representative heuristic on unrealistic optimism seems to differ by industry and is not transferable without questioning. Further, an additional contribution can be made in terms of measuring unrealistic optimism. In certain decision situations unrealistic optimism has several different facets that need to be examined individually. While previous literature sometimes distinguishes only between the facets regarding rewards and risks, in infrastructure project finance decision situations these also need to be distinguished between cost overrun/construction time and revenues. So instead of the commonly used two facets, in this decision situation there are four relevant facets of unrealistic optimism. These facets are

driven by different factors in terms of incentive system distinctiveness, feedback culture distinctiveness, illusion of control, and subjective knowledge. This more distinctive way of measuring unrealistic optimism highlights the potential problem that previous findings about unrealistic optimism cannot necessarily be applied to different facets of this bias that exist in different decision situations.

This paper also adds to PF literature in general, presented in 2.1.2.1, by contributing to both, the finance and management literature stream in this research area. Specifically, this study opens the discussion about the mitigation of estimator related risks, that has been missing so far. While previous research that concerns itself with the potential upsides and downsides of PF mentions lenders with regard to risk mitigation, specifically the mitigation of estimator related risk has not received any attention up to this date. A main contribution to both these substreams is the result that not only planners and project managers but also the decision makers that evaluate the project at a later stage are unrealistically optimistic. That means that not only project insiders, but also people with an outside view on projects, e.g. like PF decision makers, are subject to unrealistic optimism and thus subconsciously add estimator related risks to the equation. These results are highly relevant as currently Flyvbjerg (2013) argues that the involvement of an outside view i.e. lenders and investors, gives an important advantage regarding the assessment of revenue and risks of large and complex infrastructure projects. The results put this argumentation that PF minimizes risks by involving outsiders with additional expertise into perspective. However, it is possible that outsiders, even though they are subject to biases, provide more realistic project risk assessments than insiders due to their higher motivation to control risks and their complementing perspective.

Finally, findings contribute to the bias management literature. As highlighted in chapter 4.3.2.4, the influence of institutional factors on biases of individuals is not completely known and unintended outcomes are possible. Applying the learning of behavioral finance to this

new context, this work currently represents the only one that develops a causal model (RQ2) that differentiates between personal factors, organizational factors, and other biases/heuristics as enhancing/diminishing factors of individual unrealistic optimism. Feedback culture and incentive system distinctiveness both showed to have a diminishing effect on unrealistic optimism, indicating that management can influence decision making of the individual.

5.4.2.2 Practical contributions

Lessons learned from the findings are that it is indeed an important challenge for lenders and investors to overcome own biases when making decisions in the context of PF.

The identification of factors that enhance/diminish unrealistic optimism can serve to create awareness in companies and individuals that are likely to be victim of unrealistic optimism in high uncertainty decisions. The finding that stakeholders in European infrastructure PF are unrealistically optimistic relativizes the anticipation that by using PF automatically a more realistic assessment of risk and rewards also in large infrastructure projects is generated. Together with the identification of several causal driving/reducing factors of unrealistic optimism there are now two main streams of practical contributions.

For the assessment which organizational structure (private, public, or PPP project ownership; project, corporate/public, or asset finance) is applicable for a certain project, it is important to know that sharing estimator related risks with lenders and investors does not diminish the risks automatically.

Further by shedding light on the estimator related risks that exist among lenders and investors in this sector, this work lays the foundation to controlling this risk. At the same time the identification of factors that enhance/diminish unrealistic optimism with these stakeholders, provides first measures both on a personal and a systemic level to control the risk.

Companies should be aware of the phenomenon unrealistic optimism in the assessment of risks and rewards and of its causal drivers and reducers, and address them in their debiasing workshops. Further companies need to be careful to recruit and staff people with high subjective based knowledge on projects, where the correct assessment of risks and rewards is vital. Companies should install distinctive feedback and incentive systems, as well as ensure that each project team has at least one experienced decision maker from the industry when it comes to assessing risks and rewards. Additionally, companies should be aware that a big data environment can drive subjective knowledge. Finally, until its non-influence in large infrastructural projects is causally examined companies should not completely neglect representative heuristic as decision bias.

5.4.2.3 Limits

Limitations of the model, measuring model, and data captured are explained in the following. However, the positive aspects of the chosen study design should compensate for these limitations. The study uses appropriate industry specific decision makers from different stakeholder groups, and the approach as well as survey questions are based on best practice from previous research.

This model of unrealistic optimism has naturally limits as a complete theory of behavioral finance in PF decision making. Due to the design of the study, the influence of the unrealistic optimism on the actual decision making is for example not captured. However, this has already been shown in previous studies, e.g. by Heaton (2002) and Baker and Nofsinger (2002), who state that the decision making is less critical and can lead to wrong decisions. Important other factors to be weighted in, but left out in the model due to the focus on the reductionist view, are factors such as asymmetric information.

Each measurement approach has its limitations. The most important points are summarized in the following. Only a limited number of questions was used to increase the participant group

by reducing the expected time needed to participate. However, questions were used from best practice of previous studies in this field. Further, participants consciously participated in the study, thus their awareness might have reduced the unconscious bias measured. Nevertheless, causal effects should still be the same.

Further, due to the limited sample size of 102 participants, the number of variables for the regressions needed to be limited. With a larger sample size, it would have been thinkable to include additional control variables. Further it is thinkable that only unrealistically optimistic people answered the survey and those that are not optimistic did not. However due to the representativeness of the sample regarding other factors this seems unlikely.

5.4.2.4 Outlook

Considering that up to now research in behavioral finance regarding unrealistic optimism covers either its occurrence with a focus on industries/decision situations or its drivers without taking into view the special features of different industries, the field of what remains to be done is wide. At the same time the capital flow is enormous and needs to be put on safer grounds. Therefore, further investigation in this area is highly important.

The generalizability of two hypotheses put forward in the discussion above should be examined. In chapter 5.4.2.1 it was proposed that the infrastructure industry might attract unrealistically optimistic decision makers. If a cross industry comparison could prove this, it might be beneficial to involve real industry outsiders into projects. Further the proposition that more experienced decision makers are better decision makers regarding unrealistic optimism, put forward in chapter 5.4.2.1, should be tested. In addition to testing the two hypotheses, an investigation of the cultural influence on unrealistic optimism might be extremely helpful for companies in the process of teambuilding, since teams nowadays can be multicultural.

Moreover, the influence of company factors on unrealistic optimism should be investigated further. It became apparent that it might be possible for companies to put systems into place

that reduce estimator related risks regarding future revenues. It should therefore be tested if companies with more distinct feedback and incentive systems should overall have more realistic decision makers. Further, since recruiting and company specific aspects might differ between industries and companies, it should be investigated if there are differences in unrealistic optimism and its drivers for different stakeholder groups such as investors and lenders.

In addition to this, the representative heuristic has no relevance for the risk and reward assessment in this study. If this can be confirmed for other decision situations, a closer look should be taken into the reasons for it. Is the kind of investigated industry with its singularities the reason for this finding? Or do companies already effectively tackle this problem by debiasing decision makers?

In terms of applicability it should be tested if the model developed in this study is applicable for other stakeholders in infrastructure PF, e.g. developers, planners, and consultants. Another question is if the model is also applicable in other geographies, other industries, and other decision situations. Finally, it should be tested how a relevant model would look like on team level. An elaboration of the model would for instance be a closer look at both the positive and negative aspects of unrealistic optimism, which could be helpful to get better idea of the overall effect estimator related risks have in PF in this special industry.

5.5. Testing difference in unrealistic optimism between lenders and investors

In chapter 4.4 a causal model of PF decision maker unrealistic optimism was developed. However, the question remains if all stakeholder groups are equally unrealistically optimistic. If lenders are identified as stakeholder group less affected by estimator related risk, it would mean that PF in fact had an advantage over public or corporate finance since by involving lenders not only a monitoring partner is gained, but estimator related risks would be controlled

by a stakeholder that can manage it better (contracting theory, resource based view of the firm).

In chapter 4.5 hypotheses were developed concerning differences in unrealistic optimism and drivers of the difference in unrealistic optimism, answering RQ2: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

In the following, using the data from the causal model Anovas were performed to compare whether the different stakeholder groups are significantly different on “unrealistic optimism“. Also, an analysis of variance was performed for the enhancing and diminishing factors in the causal model to show what causes the difference between the groups.

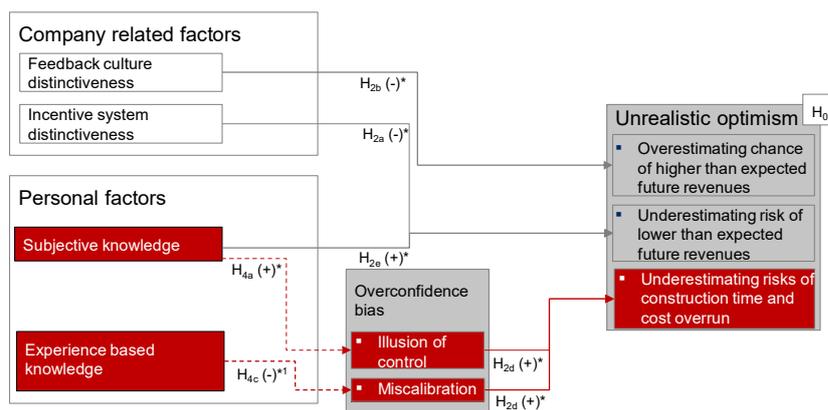
5.5.1 Results difference in unrealistic optimism between lenders and investors

Overall the results indicate no significant difference between lenders and investors on unrealistic optimism regarding risk of construction time and cost overrun, as well as unrealistic optimism regarding risk of lower than expected future revenue. However, lenders seem to be more affected than investors by unrealistic optimism regarding chance of higher than expected future revenues.⁸⁶ In the following, detailed results for all three facets of unrealistic optimism and their enhancing/diminishing factors are presented: (1) unrealistic optimism regarding risk of construction time and cost overrun (2) unrealistic optimism regarding risk of lower than expected future revenue, and (3) unrealistic optimism regarding chance of higher than expected future revenues.

First, focus is on the causal relationship highlighted in Figure 16.

⁸⁶ Unrealistic optimism regarding chance of higher than expected future revenues was not tested as no drivers were identified in the causal model.

Figure 16: Focus on unrealistic optimism regarding risk of construction time and cost overrun



Statistically significant values are marked with *, level of significance $p \leq 0.05$
 1 significance of effect has to be seen with caution

Source: Own illustration

An independent-samples t-test was run to determine if there are differences in unrealistic optimism regarding risk of construction time and cost overrun between lenders and investors. Prerequisites are only partly fulfilled. There are outliers in the data, as assessed by inspection of a boxplot, however these resulted from the calculation of the variable⁸⁷. As measurement error and data entry error can be ruled out, outliers are genuinely unusual values that should not be excluded. Scores for each stakeholder group are not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.050$) and kurtosis/skewness z-scores not within ± 3.29 ⁸⁸. As independent-samples t-tests are robust towards violation of normality, further prerequisites were tested. There is homogeneity of variances, as assessed by the Levene's test for equality of variances ($p = 0.386$). Data is presented as mean \pm standard deviation. As mentioned in chapter 4, unrealistic optimism regarding risk of time and cost overrun for individuals themselves and colleagues is measured on a percentage scale, resulting in a scale from -99 to 99 for the bias. The test shows that lenders seem to be more unrealistically optimistic (4.21 ± 14.34) than investors (3.24 ± 9.66) regarding risk of construction time and cost overrun, the

⁸⁷ The variable was calculated by subtracting the risk for the survey participant from the risk the participant allocated to colleagues. No extreme outliers are present in these variables.

⁸⁸ This can potentially result in biased significance of the test. However, both distributions were skewed in a similar manner (both positively skewed), reducing the severity of this risk. The critical value of 3.29 is recommended by Tabachnick and Fidell (2007).

difference of 0.97 is however not significant (95% CI, -4.28 to 6.23), $t(100) = -0.367$, $p = 0.714$.

Because of the violation of the normality assumption in the t-test, the non-parametric Mann-Whitney U test was run complimentary. Prerequisites for this test are fulfilled. Distributions of unrealistic optimism regarding risk of construction time and cost overrun for lenders and investors are similar, as assessed by visual inspection. Median unrealistic optimism regarding risk of construction time and cost overrun for lenders (0) and investors (0) is not statistically significantly different, $U = 1211.500$, $z = 0.077$, $p = 0.939$.

To explain results, group comparisons were performed on sub-stakeholder level. A one-way Anova was conducted to determine if there are differences between credit risk management ($n = 16$), credit sales ($n = 51$), public investors ($n = 7$), and private investors ($n = 28$). Prerequisites are only partly fulfilled. There are outliers, as assessed by inspection of a boxplot, however, as for the previous tests it was concluded that these data points were genuinely unusual but possible values that should not be excluded. The data is also not normally distributed for each group, as assessed by Shapiro-Wilk's test ($p < 0.05$) and kurtosis/skewness z-scores not within ± 3.29 , however, the one-way Anova is reported to be robust against violations of this assumption (Laerd Statistics, 2017). There is homogeneity of variances, as assessed by Levene's test of homogeneity of variances ($p = 0.304$). The test shows a tendency of the lender subgroups credit risk management (3.3 ± 6.8) and credit sales (4.6 ± 15.9) to be more unrealistically optimistic regarding risk of construction time and cost overrun than private investors (2.3 ± 8.1). Most unrealistically optimistic in this study are public investors (5.7 ± 15.1). However, the difference between these stakeholder groups is not statistically significant, $F(3,98) = 0.249$, $p = 0.862$. Reason for this can be the small sample size in the different groups.

Because of the violation of the normality assumption in the one-way Anova, the non-parametric Kruskal-Wallis test was conducted complimentary to confirm the results.

Distributions of unrealistic optimism regarding risk of construction time and cost overrun are not entirely similar for the four groups, as assessed by visual inspection of a boxplot. Scores are not statistically significantly different between the different stakeholder groups, $\chi^2(3) = 0.114$, $p = 0.990$.

Despite there being no statistically relevant difference on unrealistic optimism regarding risk of construction time and cost overrun, it was further analyzed if there were differences in the enhancing/diminishing factors (1) illusion of control and (2) miscalibration. The aim of this was to identify if the stakeholders can learn from each other on these dimensions.

As illusion of control is an enhancing factor of unrealistic optimism regarding risk of construction time and cost overrun, an independent-samples t-test was run to determine if there were differences in illusion of control between lenders and investors (measured on a 7-point Likert Scale). Prerequisites for this analysis are partly fulfilled. There are no extreme outliers in the data, as assessed by inspection of a boxplot. Illusion of control scores are normally distributed for investors, as assessed by Shapiro-Wilk's test ($p > 0.050$), but not for lenders. Skewness z-scores for lenders are within ± 3.29 , however kurtosis z-scores are 3.66 and violate normality. There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.136$). Illusion of control for lenders (4.56 ± 0.97) is lower than for investors (4.68 ± 0.64), however, the difference of -0.12 is not significant (95% CI, -0.48 to 0.23), $t(100) = -0.689$, $p = 0.493$.

Because of the violation normality assumption in the t-test, a Mann-Whitney U test was run. Distributions of illusion of control for lenders and investors are similar, as assessed by visual inspection. Median illusion of control for lenders (4.50) and investors (4.59) is not statistically significantly different, $U = 1306.000$, $z = 0.724$, $p = 0.469$.

As enhancing factor of illusion of control, differences in subjective knowledge were also investigated. Both normality assumption as reported by Sharpio-Wilk's test $p < 0.050$ and

kurtosis z-scores for lenders not within ± 3.29 , as well as equality of variance assumption as reported by Welch's test are violated. Therefore, a Mann-Whitney U test was run to determine if there are differences in subjective knowledge between lenders and investors. Distributions of subjective knowledge for lenders and investors are similar, as assessed by visual inspection. Median subjective knowledge scores for lenders (5.00) and investors (5.33) are not statistically significantly different, $U = 1308.500$, $z = 0.747$, $p = 0.455$.

As miscalibration is the second enhancing factor of unrealistic optimism regarding risk of construction time and cost overrun, an independent-samples t-test was run to determine if there are differences in hit rate (reverse miscalibration, measured on a scale from 0 to 1) between lenders and investors. Prerequisites for this analysis are fulfilled⁸⁹. Hit rate for lenders (0.35 ± 0.26) is lower than for investors (0.39 ± 0.26), the difference of -0.04 is however not significant (95% CI, -0.15 to 0.06), $t(100) = -0.804$, $p = 0.423$.

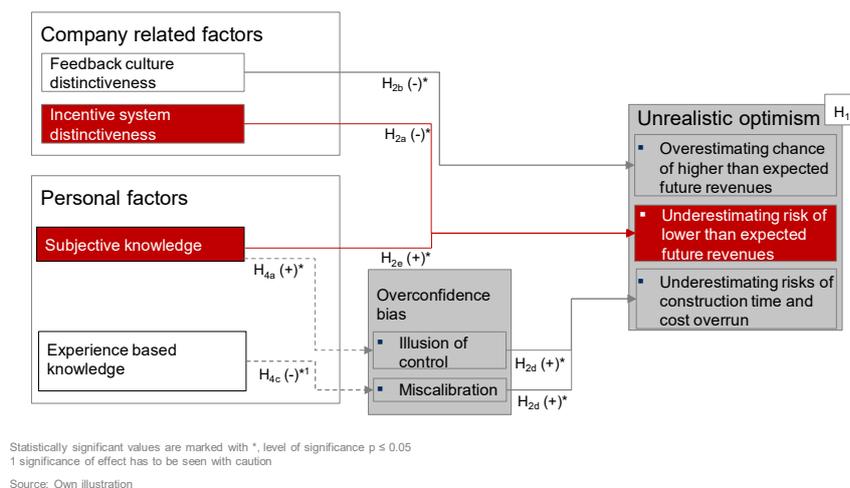
As driver of miscalibration differences in experienced based knowledge were investigated using an independent-samples t-test. Prerequisites for this analysis are fulfilled⁹⁰. Experience based knowledge for lenders (-0.01 ± 0.80) shows to be lower than for investors (0.02 ± 0.95), the difference of -0.03 is however not significant (95% CI, -0.38 to 0.32), $t(100) = -0.179$, $p = 0.858$.

After showing that there are no significant differences between stakeholders in unrealistic optimism regarding risk of construction time and cost overrun and its enhancing/diminishing factors, now focus is placed on unrealistic optimism regarding risk of lower than expected future revenue, as highlighted in Figure 17.

⁸⁹ There are no outliers in the data, as assessed by inspection of a boxplot. Hit rate scores are normally distributed as assessed by skewness/kurtosis z-scores within ± 3.29 . There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.620$).

⁹⁰ There are no outliers in the data, as assessed by inspection of a boxplot. Experience based knowledge scores are normally distributed as assessed by Shapiro-Wilk's test ($p > 0.050$). There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.261$).

Figure 17: Focus on unrealistic optimism regarding risk of lower than expected future revenue



A Mann-Whitney U test was run to compare lenders and investors on unrealistic optimism regarding risk of lower than expected future revenues⁹¹ (measured on an ordinal scale from -6 to +6). Distributions of unrealistic optimism regarding risk of lower than expected future revenues for lenders and investors are similar, as assessed by visual inspection. Median unrealistic optimism regarding risk of lower than expected future revenues for lenders (0) and investors (0) is not statistically significantly different, $U = 1370.500$, $z = 1.445$, $p = 0.146$.

Because only medians could be compared, further analysis using a Kruskal-Wallis test was conducted on sub-stakeholder level. Again, distributions of unrealistic optimism regarding risk of lower than expected future revenues are not entirely similar for the four groups, as assessed by visual inspection of a boxplot. Furthermore, scores are not statistically significantly different between the different stakeholder groups, $\chi^2(3) = 4.554$, $p = 0.208$.

Despite there being no difference in unrealistic optimism regarding risk of lower than expected future revenues, it was further analyzed if there are differences in incentive system distinctiveness. Already tested above, there is no significant difference between lenders and investors on subjective knowledge, which was found not only to be a driver of the illusion of

⁹¹ A parametric test was not possible due to violation of normality assumption as reported by Shapiro-Wilk's test $p < 0.050$ and kurtosis/skewness z-scores not within ± 3.29 , as well as the violation of equality of variances as reported by Welch's test.

control facet of the overconfidence bias but also drives the risk of underestimating lower than expected future revenues directly.

An independent-samples t-test was run to determine if there are differences in incentive system distinctiveness (measured on a 7-point Likert Scale) between lenders and investors. Prerequisites for this analysis are fulfilled⁹². The incentive system of lenders (4.38 ± 0.96) seems to be less distinct than that of investors (4.97 ± 1.11), the difference of -0.58 is significant (95% CI, -1.00 to -0.17), $t(100) = -2.801$, $p = 0.006$.

Because of the significant difference in the incentive system between the stakeholders, while at the same time there is no difference in unrealistic optimism regarding risk of lower than expected future revenues, two further analyses were performed. It was first analyzed which dimensions of incentive system are different between the two stakeholder groups. Second it was analyzed which dimensions of incentive system correlate with unrealistic optimism regarding risk of lower than expected future revenues.

An independent-samples t-test was run to determine if there are differences in incentive system components (measured on a 7-point Likert Scale) between lenders and investors. Prerequisites are fulfilled⁹³. The incentive system success of company of lenders is less distinct (4.40 ± 1.54) than that of investors (5.49 ± 1.37), the difference of 1.09 is significant (95% CI, 0.48 to 1.69), $t(100) = 3.566$, $p = 0.001$. The incentive system accountability of lenders (5.02 ± 1.18) seems to be less distinct than that of investors (5.08 ± 1.62), however, the difference of -0.07 is not significant (95% CI, -0.49 to 0.62), $t(100) = 0.235$, $p = 0.814$. The incentive system compensation of lenders seems to be less distinct (3.88

⁹² There were no extreme outliers in the data, as assessed by inspection of a boxplot. Incentive system distinctiveness scores for each stakeholder group were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.050$). There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.161$).

⁹³ All four dimensions compensation, career path, success of company, and accountability violate the normality assumption, as assessed by Shapiro-Wilk's test ($p > 0.050$) however not by kurtosis/skewness z-scores. There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.050$).

± 1.68) than that of investors (4.51 ± 1.92), however, the difference of 0.64 is not significant (95% CI, -0.12 to 1.39), $t(100) = 1.680$, $p = 0.084$. The incentive system career path of lenders seems to be less distinct (4.23 ± 1.40) than that of investors (4.78 ± 1.75), however, the difference of 0.55 is not significant (95% CI, -0.07 to 1.18), $t(100) = 1.749$, $p = 0.083$.

With only success of company differentiating significantly between the stakeholder groups, it was further analyzed which dimension correlated most with unrealistic optimism regarding risk of lower than expected future revenues. A Pearson's correlation test was performed that showed that only career path and accountability that are not significantly different between lenders and investors, correlate with unrealistic optimism regarding risk of lower than expected future revenues. However, correlation is only small according to Cohen (1988). Results can be found in the table below.

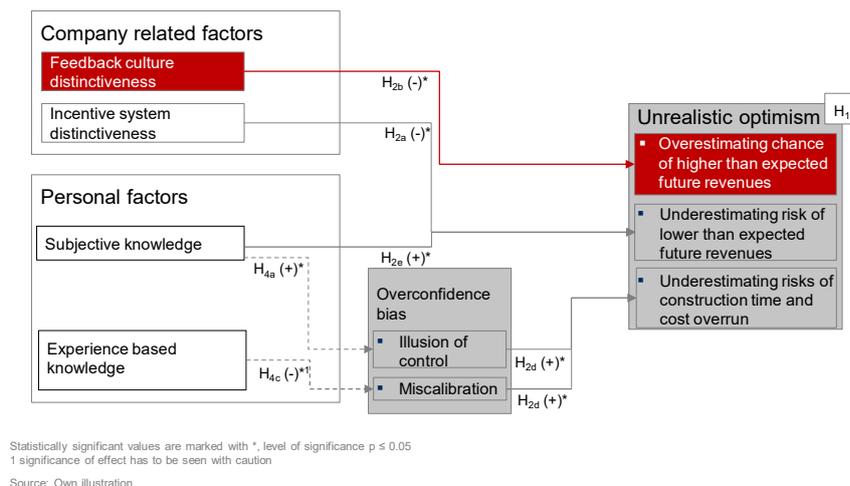
Table 19: Pearson's correlations for unrealistic optimism regarding risk of lower than expected future revenues and incentive system dimensions

Variable	Unrealistic optimism risks of future revenues	Compensation	Career path	Success of company
Compensation	-0.108			
Career path	-0.197*	0.589*		
Success of company	-0.086	0.227*	0.253*	
Accountability	-0.238*	0.236*	0.138	0.056

Note: * $p < 0.050$

Finally, in the following focus is placed on determining if there are differences in the causal relationship of the third facet of unrealistic optimism, as highlighted in Figure 18.

Figure 18: Unrealistic optimism regarding chance of higher than expected future revenues



An independent-samples t-test was run to determine if there are differences in unrealistic optimism regarding chance of higher than expected future revenues (measured on an ordinal scale from -6 to +6) between lenders and investors. Prerequisites for this analysis are partly fulfilled. There are outliers in the data, as assessed by inspection of a boxplot. As measurement error and data entry error could be ruled out, it was decided not to exclude these outliers. Scores for each stakeholder group are not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.050$) and kurtosis/skewness z-scores not within $\pm 3.29^{94}$. However, as the independent-samples t-test is somewhat robust against violations of normality further prerequisites are tested. There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.691$). Lenders are more unrealistically optimistic regarding chance of higher than expected future revenues (0.25 ± 0.87) than investors (-0.16 ± 1.01), the difference of 0.48 being significant (95% CI, 0.03 to 0.79), $t(100) = -2.149$, $p = 0.034$.

Because of the violation of the normality assumption in the independent-samples t-test with distributions skewed in a different manner, the non-parametric Mann-Whitney U test was run complimentary. Prerequisites for this test are fulfilled. Distributions of unrealistic optimism regarding chance of higher than expected future revenues for lenders and investors

⁹⁴ Both distributions are skewed in a different manner (lenders positively skewed, investors negatively skewed), increasing the risk of a biased significance level.

are similar, as assessed by visual inspection. Median unrealistic optimism regarding chance of higher than expected future revenues for lenders (0) and investors (0) is not statistically significantly different, $U = 1058.500$, $z = -1.198$ $p = 0.231$.

To explain results, group comparisons were performed on sub-stakeholder level. A one-way Anova was conducted to determine if there are differences in unrealistic optimism regarding chance of higher than expected future revenues between credit risk management ($n = 16$), credit sales ($n = 51$), public investors ($n = 7$), and private investors ($n = 28$). There are outliers, as assessed by boxplot, however these points are possible values and thus kept in the sample. The data is not normally distributed for each group, as assessed by Shapiro-Wilk's test ($p < 0.050$) and kurtosis/skewness z-scores; but there is homogeneity of variances, as assessed by Levene's test of homogeneity of variances ($p = 0.291$). Scores decrease from lenders to investors, with credit risk management (0.31 ± 0.87), credit sales (0.25 ± 0.87), public investors (-0.14 ± 0.38), and private investors (-0.25 ± 1.11), but the differences between these sub-stakeholder groups is not statistically significant, $F(3, 98) = 2.272$, $p = 0.085$.

Because of the violation normality assumption in the one-way Anova, the non-parametric Kruskal-Wallis test was conducted to confirm the results. Distributions of unrealistic optimism regarding chance of higher than expected future revenue are not entirely similar for the four groups, as assessed by visual inspection of a boxplot. The scores for unrealistic optimism regarding chance of higher than expected future revenues are not statistically significantly different between the different stakeholder groups, $\chi^2(3) = 3.629$, $p = 0.304$.

As feedback culture distinctiveness is a diminishing factor of unrealistic optimism regarding chance of higher than expected future revenues, an independent-samples t-test was run to determine if there are differences in feedback culture distinctiveness (dimensions measured on a 7-point Likert Scale) between lenders and investors. Prerequisites for this analysis are

fulfilled⁹⁵. The feedback system of lenders proves to be less distinctive (5.29 ± 0.89) than that of investors (5.69 ± 0.68), the difference of -0.40 is significant (95% CI, -0.74 to -0.06), $t(100) = -2.357$, $p = 0.020$.

Due to this surprising result, comparisons on the individual dimensions of feedback culture distinctiveness were run. The two dimensions feedback importance colleagues and feedback importance superiors violate the normality assumption, as assessed by Shapiro-Wilk's test ($p < 0.050$) and kurtosis/skewness z-scores not within ± 3.29 . Due to differences in sample size the non-parametric Mann-Whitney U test was run. Distributions of compensation for lenders and investors are not similar for feedback importance colleagues and feedback importance superiors, and feedback culture company. Feedback importance superiors scores for lenders (mean rank = 52.02) and investors (mean rank = 50.58) is not statistically significantly different, $U = 1168.500$, $z = -0.250$, $p = 0.802$. However, feedback importance colleagues scores for lenders (mean rank = 47.22) and investors (mean rank = 58.01) are statistically significantly different, $U = 1480.500$, $z = 2.019$, $p = 0.043$.

The three dimensions feedback speed colleagues, feedback speed superiors, and feedback culture company are normally distributed as assessed by skewness/kurtosis z-scores within ± 3.29 . Therefore, an independent-samples t-test was run to determine if there are differences in these feedback system components between lenders and investors. Prerequisites are fulfilled. The feedback culture company of lenders proves to be less distinct (5.18 ± 1.46) than that of investors (6.08 ± 0.98), the difference of 0.90 is significant (95% CI, 0.41 to 1.38), $t(100) = 3.699$, $p = 0.000$. The feedback speed colleagues of lenders seems to be less distinct (4.94 ± 1.44) than that of investors (5.32 ± 1.03), however, the difference of 0.39 is not significant (95% CI, -0.15 to 0.92), $t(100) = 1.438$, $p = 0.154$. Also the feedback speed

⁹⁵ There are no extreme outliers in the data, as assessed by inspection of a boxplot. Feedback distinctiveness scores for investors are normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.050$), for lenders the Shapiro-Wilk's test is violated, but kurtosis/skewness z-scores are within ± 3.29 , thus normality is given. There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.294$).

superiors of lenders seems to be less distinct (4.82 ± 1.38) than that of investors (5.03 ± 1.24), the difference of 0.21 is again not significant (95% CI, -0.33 to 0.76), $t(100) = 0.773$, $p = 0.441$.

With only feedback importance colleagues and feedback culture company differentiating significantly between the stakeholder groups, it was further analyzed which dimension correlated most with unrealistic optimism regarding chance of higher than expected future revenues. A Pearson's correlation test was performed⁹⁶ that shows that feedback speed colleagues and superiors, feedback importance colleagues, and feedback culture in the company correlate with unrealistic optimism regarding chance of higher than expected future revenues. Results can be found in the table below. However, only feedback speed colleague has a moderate correlation with unrealistic optimism regarding the chance of higher than expected future revenues.

Table 20: Pearson's correlations for unrealistic optimism regarding chance of higher than expected future revenues and feedback system dimensions

Variable	Unrealistic optimism chance future revenues	Feedback speed colleagues	Feedback speed superiors	Feedback importance colleagues	Feedback importance superiors
Feedback speed colleagues	-0.301*				
Feedback speed superiors	-0.209*	0.593*			
Feedback importance colleagues	-0.288*	0.102	0.127		
Feedback importance superiors	0.024	0.131	0.222*	0.405*	
Feedback culture company	-0.195*	0.436*	0.383*	0.260*	0.248*

Note: * $p < 0.050$

5.5.2 Discussion difference in unrealistic optimism between lenders and investors

As mentioned already in previous chapters, it is out of question that an infrastructure investment gap exists in Europe. PF might be a way to close this gap. However, the current debate presented in chapter 2 questions if private capital, as it is the case in PF, should be used for public infrastructure. Reasons for this are the among others complexity and high cost of

⁹⁶ The test assumes bivariate normal distribution, is however somewhat robust to deviations from normality, so the variables feedback importance colleagues/superiors was also included. A Spearman's rank-order correlation gave a nearly identical result.

PF (Yescombe, 2013) that might not be outweighed by efficiency savings and savings due to risk transfer (Hodge & Greve, 2007). The goal of this chapter was to answer RQ3 by conducting group comparisons: Are certain stakeholders less biased than other stakeholders and are therefore better equipped to assess risks of large European infrastructure projects? Can personal or company related factors be identified to drive differences between lenders and investors and made accessible for best practice learning?

Neither for unrealistic optimism regarding risk of construction time and cost overrun nor unrealistic optimism regarding risk of lower than expected future revenues statistically relevant differences between the stakeholder groups lenders and investors can be found, although the incentive system of lenders is less distinct than that of investors when it comes to the importance that is placed on “success of company”. However, this study can identify lenders as being more unrealistically optimistic than investors in terms of unrealistic optimism regarding chance of higher than expected future revenues. Yet, this result needs to be viewed with caution due to the violation of the normality assumption in the independent-samples t-test. Although the significance level might be biased the finding is strengthened by the detection of a statistically significant lower feedback importance from colleagues for lenders than for investors. At the same time the finding is surprising, as assumptions driven from literature pointed to lenders as being more reliable in the assessing of risks and rewards. In the following there is a short description of the results concerning the hypotheses put forward:

- ☒ Rejection H_5 , as lenders and investors as well as sub-stakeholder groups are equally unrealistically optimistic regarding risk of construction time and cost overrun, as well as risk of lower than expected future revenues, and lenders are even more unrealistically optimistic regarding chance of higher than expected future revenues
- ☒ Rejection H_{6a}/H_{6b} , as lenders have a less distinctive feedback and incentive system than investors

- ☑ Confirmation H₇, as lenders and investors have equal levels of subjective and experienced based knowledge
- ☑ Confirmation H₈, as lenders and investors have a similar amount of overconfidence (miscalibration and illusion of control)

As mentioned above, investors have on average more distinct incentive and feedback systems than lenders, this difference however mostly exists in aspects of the systems, that do not influence unrealistic optimism.

Why would a lender's feedback and incentive system be less distinct than that of investors regarding large infrastructural projects? A possible explanation is that investors are more motivated in the long run to monitor projects as their potential upward benefit of a project (Ehlers, 2014) is much larger than the one of lenders.

The finding that the institutional structure is different for different stakeholder groups means that these stakeholder groups can learn from each other. Incentive systems should be focused on accountability and career path, while feedback systems should be focused on speed, importance placed on colleague's feedback and the overall feedback culture to effectively influence unrealistic optimism.

Following the hypothesis H₄ put forward above, lenders were expected to be less unrealistically optimistic than investors. Further, in principle, private investors compared to public investors should have a higher motivation to avoid risks and a better way to diversify risks if they are properly identified. So, it would be expected that private investors are less unrealistically optimistic than public ones. These expectations had to be rejected. Lenders and investors are equally unrealistically optimistic regarding risk of construction time and cost overrun and regarding risk of lower than expected future revenues, and there is no significant difference between private and public investors. For unrealistic optimism regarding risk of construction time and cost overrun public investors have the highest average unrealistic

optimism, however differences between stakeholders are not significant. This can be explained by the lack of significant difference in overconfidence (miscalibration and illusion of control) between the stakeholder groups, which drives unrealistic optimism regarding risk of construction time and cost overrun. The fact that there is no difference in the facets of overconfidence can be explained by the fact that there is no difference in the drivers of overconfidence (subjective knowledge and experience based knowledge) between the stakeholder groups. So potentially lenders and investors hire similar profile employees and thus have employees which are equally likely to be unrealistically optimistic.

Also concerning unrealistic optimism regarding risk of lower than expected future revenues there were no differences between the stakeholder groups. This can be explained by a lack of difference in the incentive system dimensions accountability and career path that have a diminishing effect on unrealistic optimism regarding risk of lower than expected future revenues.

The finding that there is no significant difference between lenders and investors across unrealistic optimism regarding risk of construction time and cost overrun as well as unrealistic optimism regarding risk of lower than expected future revenues means that lenders are not subject to lower estimator related risks than investors. Lenders can thus generally speaking not always fulfill their monitoring role when it comes to assessing project proposals with risk assessments of unrealistically optimistic developers and investors.

Beyond the causal drivers of unrealistic optimism this finding can further be explained by the fact that potentially one cannot really differentiate between these two stakeholder groups in terms of employees' education and knowledge. A fluctuation of employees between the lending and investing company branches, as well as access to and use of similar training systems is possible.

The finding that there is no significant difference between the investor subgroup public investors and the three lender/investor private sector subgroups across unrealistic optimism

regarding risk of construction time and cost overrun and across unrealistic optimism regarding risk of lower than expected future revenues means that private actors can misjudge risks as well as the than public ones. This finding is underlined by Vaaler and McNamara (2004), who reject the common hypothesis that experts are generally unbiased in their decision making. Although lower estimator related risk can therefore not be weighed in as an advantage when considering involving the private sector in a project, higher motivation of the private sector might lead to more diligent risk assessment. Further, the private sector capital is needed to close the infrastructure finance gap, especially in times of a public debt brake.

Alternatively, the finding could be explained by the small sample size in the stakeholder subgroups. Beyond the causal drivers of unrealistic optimism and the small sample size this finding can further be explained by the fact that the infrastructure industry differs in many characteristics from other sectors in which lenders and investors work. Therefore, the difference that is suggested in literature both between private and public investors as well as between lenders and investors simply does not apply in this industry.

But what makes the infrastructure industry different? As mentioned in chapter 2, governments quite often intervene by providing guarantees and other financial support when projects run into financial difficulties (Heath & Read, 2014) and thus risks are not fully transferred to the private sector, as initially intended. An example of this is the UK government providing financial support for the underground PPPs signed in 2003, when these ran into financial distress (Shaoul, Stafford, & Stapleton, 2012). Such a course of action runs the risk that lenders and investors rely on the government in case of financial distress and therefore assess risks less accurate. This would mean that governments should interfere less, if they want PF to have the intended effects in the long run.

Lenders are more unrealistically optimistic regarding chance of higher than expected future revenues. Between the subgroups of lenders and investors different severities of unrealistic optimism could be found, with public investors being most and private investors least

unrealistically optimistic. However, due to the small sample sizes in the subgroups no statistical significance could be detected.

Overall the difference between lenders and investors is clearly driven by the less distinct feedback system of lenders in the dimensions feedback importance colleagues and feedback culture company.

This finding means that these dimensions of the feedback system can be used to improve assessing risk. Lenders should learn from investors' best practices to be able to avoid assessing rewards too optimistically. The fact that this structural factor can explain the stakeholder group difference further means that public sector institutions can in principle introduce the same best practice institutional structure as private companies. However, due to the specific characteristics of the public sector with civil servant culture and election periods, public institutions might have difficulties to implement these institutional structures.

In the following the (1) theoretical and (2) practical contribution presented, (3) limitations named, and finally (4) a brief outlook is given.

5.5.2.1 Theoretical contributions

Up to this date, this is the first work that compares infrastructure PF lenders to investors regarding their unrealistic optimism in risk and reward assessment to identify stakeholder group specific biases and enable learning from industry specific best practice. As mentioned in chapter 4, four literature streams are relevant regarding cognitive aspects, perceived risk, and decision making in PF: (1) literature about behavioral decision making in projects, (2) PF literature in general, (3) literature about factors affecting risk assessment, and (4) literature about behavioral decision making concerning bias management. The findings gained from the comparison of lenders and investors have important theoretical contributions and fill gaps in all but the stream about behavioral decision making. In the following these contributions are highlighted per research stream.

Previous management literature in the field of PF, as introduced in chapter 2.1.2.2 and 4.3.2.2, has not shown who can bear estimator related risks best, and how to control these risks. By comparing lenders and investors this dissertation closes the gap and adds to the findings of Flyvbjerg (2014) on investor unrealistic optimism in large infrastructure projects by showing that not only investors are unrealistically optimistic but also lenders. At the same time, the theory of Flyvbjerg (2013) that outsiders get decisions right needs to be questioned. Lenders are involved in projects typically later as investors, so they should have more of an outside view – still they are not less unrealistically optimistic.

Further, the findings also contribute to the literature about factors affecting risk assessment. This literature stream, as presented in chapter 4.3.2.3, places a focus on individual effects on risk assessment, focusing especially on credit risk assessment. However, up to this date no study was conducted with PF lending officers and their PF credit decision situation. The findings presented above show that PF credit risk assessment, exactly like commercial credit assessment, is indeed influenced by biases. While one must be cautious to transfer behavioral decision-making findings to new decision situations, the PF credit and commercial credit situation seem to be similar in terms of leaving room for unconscious biases.

The bias management literature focuses on how companies can prevent biased decision making, as explained in chapter 4.3.2.4. However, the influence of institutional factors on the decision making of the individual remains somewhat a gap in this literature field. By not only looking at institutional factors on a general level but measuring them on a very detailed level, this work closes the gap concerning the impact incentive and feedback system have on decision making involving risk.

5.5.2.2 Practical contributions

This effort enables a better awareness for misjudgments based on seemingly common knowledge and reveals means to improve the risk assessment performance on both the investor and lender side.

Companies and public institutions should keep in mind that the assessment of risks and rewards can neither be transferred unquestioned to a specific stakeholder group nor to a specific subgroup, as all involved groups are subject to estimator related risk. This means that also when assessing the monitoring role of lenders and their role as an evaluator of a project's financial viability as an advantage of PF, their potential unrealistic optimism must be kept in mind.

Lenders should, to fulfill their monitoring role, not assume that they are less prone to unrealistic optimism. Instead banks should use their institutional environment to reduce bias. In terms of the institutional structure lenders can learn from investors with regard to the feedback system in the dimensions feedback importance colleagues and feedback culture company. Further, they can conduct bias trainings to create more awareness, and account for biases to a certain extend in their risk estimates.

Lessons learned from the findings are further that overall feedback system and incentive system distinctiveness have a reducing impact on estimator related risk. In specific, companies should increase the speed with which feedback is delivered, the importance their employees place on their colleagues' feedback, as well as the overall feedback culture in the company. In terms of the incentive system, companies should place high importance on how the success of the individual influences her or his career advancement, as well as on the individuals feeling of accountability for her or his actions.

The impact an institutional environment has on decision making further highlights the importance for public institutions to have a distinctive feedback and incentive system to profit from private sector best practices.

5.5.2.3 Limits

Besides the limitations of the causal model already named in chapter 5.4.2.3, the model itself and the measurement model have certain limitations that are explained in the following.

Not captured in this causal model are factors besides the feedback and the incentive system that might distinguish lenders and investors, e.g. the recruiting process. Further, the influence of unrealistic optimism on actual decision making is not measured in the causal model. An additional limitation is that the motivation to assess risks and the unrealistic optimism were not tested simultaneously, so actual risk assessment quality could not be compared. Finally, it can be argued that the model only focuses on the individual decision-making process, while e.g. loan decisions often involve group decision making.

Naturally the measurement approach has its limitations. The stakeholder group was only measured at the current point of time. It was not captured if lenders had previously worked as investors and vice versa. Further only the formal role of the decision makers was tested and not if e.g. as investors they had performed “lender like” deals and vice versa.

The limited sample size of 102 participants, which is unevenly distributed among the different stakeholder groups could potentially have influenced significance levels of the tests performed.

5.5.2.4 Outlook

The significant difference between stakeholders on specific dimensions of the company factors feedback culture and incentive system show that it should be worth investigating differences on company level additionally to the here examined stakeholder level. The great heterogeneity in the stakeholder groups that were the focus of this chapter might come from

the fact that every company is different, e.g. companies in the same industry and function can be differentiated by their incentive system.

5.6. Testing company influence on individual decision making

Companies involved in infrastructure PF lending and investing activities face the challenge to provide an institutional environment that prevents biased decision making. To identify a pattern that allows to predict which kind of companies provide an institutional setting that fuels decision maker unrealistic optimism, it is important to identify characteristics of companies that tend to be above average respectively below average unrealistically optimistic. These characteristics can further show companies what they can do to prevent biases rather than to cause them. Previous research did not touch upon these characteristics, neither in an evaluating, a predicting, nor a learning-from-best-practice context. Therefore, goal of this section is to answer RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?

To answer this research question, possible characteristics that differentiate biased and non-biased companies were presented in chapter 4.5. In the following, these characteristics in terms of three classes of factors (objective company characteristic, overconfidence, and institutional characteristics) are compared through the analysis of variance. Since the focus in this chapter lies on the overall performance of companies, in the following it is the companies, that will be called unrealistically optimistic or not, knowing that in a literal sense a company of course cannot be unrealistically optimistic. Unrealistic optimism on company level is used as dichotomous dependent variable (above/below average unrealistic optimism), defined on company level (average of at least two employees). A limited number of predictors that show an adequate level of significance and are not correlated (Nassimbeni, 2001) is selected. In a final step the predictive model is created to identify which characteristics best predict the tendency of a company to be unrealistically optimistic.

5.6.1 Results company influence on individual decision making

The comparison of above and below average unrealistic optimistic companies revealed several significant differences regarding (1) chance of early and within budget completion, (2) risk of construction time and cost overrun, and (3) risk of lower than expected future revenues. These will be presented in detail the following.

Companies with above average unrealistic optimism regarding chance of early and within budget completion typically have a less distinct feedback system than those with below average unrealistic optimism regarding this facet.

Companies with above average unrealistic optimism regarding risk of construction time and cost overrun typically are younger, smaller, have higher illusion of control on company level as well as a more distinct incentive system than those with below average unrealistic optimism regarding this facet. Companies with above average illusion of control in turn have higher subjective knowledge than those with below average illusion of control. Those companies with a greater standard deviation of their employees on unrealistic optimism regarding risk of construction time and cost overrun typically are younger, smaller and have higher illusion of control (and those that have no standard deviation have lower illusion of control than those with deviation).

Companies with above average unrealistic optimism regarding risk of lower than expected future revenues typically are younger than those with below average unrealistic optimism regarding risk of lower than expected future revenues.

However, the predictive models for unrealistic optimism regarding chance of early and within budget completion, risk of construction time and cost overrun, and risk of lower than expected future revenues with above factors were statistically not significant. Most likely this is due to the small sample size of $N = 17$.

In the following detailed results of statistical tests concerning first the comparison of above and below average optimistic companies followed by the predictive models are provided.

5.6.1.1 Description of the relevant subsample

The relevant sample for this chapter was extracted from the sample described in chapter 5.3 of this work. 23 individuals had to be removed from the sample of 102, as they did not provide their company name and no name could be assigned to them. 26 individuals (lenders $n = 16$, private investors $n = 7$, public investors $n = 3$) did not provide their company name, however it could be deferred from other information provided in the survey such as stakeholder group, headquarter location, and company size. Only those companies were used in the sample, where responses from at least two employees were available.

In the following a comparison of the relevant subsample, with the full sample in chapter 5.3 can be seen:

Table 21: Comparison of sample and subsample

	Number companies	Number individuals
Full sample chapter 5.3 and 5.4	41	102
Relevant sample chapter 5.6	17	55

To show if the subsample is representative for the sample, analysis of variances was performed between the 55 individuals in the subsample and the 47 individuals excluded from the subsample on all the relevant variables⁹⁷. Depending on the data characteristics Mann Whitney U-tests and independent t-tests were used. The analysis did not show any significant difference between the subsample and the individuals not included in the subsample.

⁹⁷ Dependent variables as well as independent variables team diversity, feedback culture distinctiveness incl. subcategories, incentive system distinctiveness incl. subcategories, company size, company age, hitrate, average subjective knowledge, better-than-average self-assessment, illusion of control.

5.6.1.2 Analysis of the difference in variance

Companies were grouped in above and below average on the four facets regarding unrealistic optimism: (1) unrealistic optimism regarding chance of early and within budget completion, (2) unrealistic optimism regarding chance of higher than expected future revenues, (3) unrealistic optimism regarding risk of construction time and cost overrun, and (4) unrealistic optimism regarding risk of lower than expected future revenues. Of the seventeen companies, one was grouped above average on all four dimensions, two were grouped above average on three dimensions, eight were grouped above average on two dimensions, four were grouped above average on one dimension, and two were always grouped below average.

In a second step it was analyzed if the groups were significantly different regarding institutional structure (feedback culture distinctiveness, team diversity, subjective knowledge, and incentive system distinctiveness), objective company characteristics (company age and company size), and overconfidence on company level (miscalibration and illusion of control). In the following, only the statistically significant differences will be reported.

The institutional structure element feedback culture distinctiveness, singled out as only characteristic that differentiates companies with above and below average unrealistic optimism regarding chance of early and within budget completion. Prerequisites for non-parametric tests are not fulfilled⁹⁸, therefore a Mann-Whitney U test was run. Distributions of feedback culture distinctiveness are not similar, as assessed by visual inspection. Distribution of feedback culture distinctiveness is significantly different between above average (mean rank 6.95) and below average unrealistic optimistic companies (mean rank 11.93) $U = 55.500$, $z = 2.017$, $p = 0.043$. Because a parametric test was not possible on feedback culture distinctiveness, further tests were conducted on the five different aspects of feedback culture distinctiveness (feedback speed colleagues/superiors, feedback importance

⁹⁸ There is no normal distribution according to kurtosis/skewness z-scores not within ± 3.29 and there is one extreme outlier.

colleagues/superiors, and feedback culture company). Prerequisites for an independent t-test are fulfilled, however no significant differences could be found⁹⁹.

Statistical tests yielded no significant differences between companies that are above and below average on unrealistic optimism regarding chance of higher than expected future revenues.

Concerning the third facet of unrealistic optimism several significant differences could be found between the groups concerning (1) company age, (2) company size, (3) incentive system distinctiveness, and (4) illusion of control.

An independent-samples t-test showed that there were differences in company age between companies whose employees are above and below average on unrealistic optimism regarding risk of construction time and cost overrun. Prerequisites for this test are partly fulfilled. There is one extreme outlier in the data, as assessed by inspection of a boxplot. However, this point is unusual but possible, so it was kept in the analysis. Company age scores are normally distributed as assessed by kurtosis/skewness z-scores within ± 3.29 . There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.330$). Companies with above average unrealistic optimism regarding risk of construction time and cost overrun are younger (1988.2 ± 16.46) than companies with below average optimism (1942.83 ± 67.97), the difference of 45.37 years is significant (95% CI, 0.36 to 90.37), $t(13.504) = 2.170$, $p = 0.048$.

A Welch t-test showed that there are differences in company size between companies whose employees are above and below average on unrealistic optimism regarding risk of construction time and cost overrun. Prerequisites for this test are fulfilled¹⁰⁰. Companies with

⁹⁹ Feedback speed colleagues $t(15) = -2.015$, $p = 0.062$; feedback speed superiors $t(15) = -1.696$, $p = 0.110$, feedback importance colleagues $t(15) = 0.584$, $p = 0.568$, feedback importance superiors $t(15) = 1.095$, $p = 0.291$, feedback culture company $t(15) = -1.777$, $p = 0.096$.

¹⁰⁰ There is no outlier in the data, as assessed by inspection of a boxplot. Company size scores are normally distributed as assessed by kurtosis/skewness z-scores within ± 3.29 . There is no homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.008$).

above average unrealistic optimism regarding risk of construction time and cost overrun are smaller in terms of the number of employees ($8,339.2 \pm 8,223.45$) than companies with below average unrealistic optimism ($52,455.33 \pm 63,212.86$), the difference of $-44,116.13$ employees is significant (95% CI, $-84,728.44$ to $-3,503.83$), $t(11.858) = -2.370$, $p = 0.036$.

An independent samples t-test showed that there are differences in incentive system distinctiveness (measured on a 7-point Likert Scale) between companies whose employees are above and below average on unrealistic optimism regarding risk of construction time and cost overrun. Prerequisites for this test are fulfilled¹⁰¹. Companies with above average optimism regarding risk of construction time and cost overrun seem to have a more distinctive incentive system (5.49 ± 0.80) than companies with below average optimism (4.56 ± 0.64), the difference of 0.93 is significant (95% CI, -0.15 to 1.71), $t(15) = 2.547$, $p = 0.022$. Because this outcome stands in contrast to the individual effect that was found in the previous chapter, independent samples t-tests were performed on the four different elements of the incentive systems: (1) the level of accountability for own decisions and the (2) dependence of own compensation, (3) own career path, and (4) success of the company of project success. Prerequisites are fulfilled¹⁰². Companies with above average unrealistic optimism regarding risk of construction time and cost overrun can neither be differentiated on accountability $t(15) = 0.435$, $p = 0.669$, nor on success of the company $t(15) = 0.461$, $p = 0.652$. However, statistical significant differences can be found on the other two aspects of incentive system distinctiveness. Companies with above average unrealistic optimism regarding risk of construction time and cost overrun have an incentive system that places higher importance on compensation (5.73 ± 0.81) than companies with below average unrealistic optimism regarding risk of construction time and cost overrun (4.09 ± 0.80), the difference of 1.65 is

¹⁰¹ There is no outlier in the data, as assessed by inspection of a boxplot. Average incentive scores are normally distributed as assessed by kurtosis/skewness z-scores within ± 3.29 . There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.416$).

¹⁰² There are no extreme outliers in the data and the data is normally distributed as assessed by the Shapiro Wilk test.

significant (95% CI, 0.73 to 2.55), $t(15) = 3.865$, $p = 0.002$. Second, companies with above average unrealistic optimism regarding risk of construction time and cost overrun further have an incentive system that places higher importance on career path advancement (5.67 ± 1.02) than companies with below average unrealistic optimism regarding risk of construction time and cost overrun (4.12 ± 1.01), the difference of 1.55 is significant (95% CI, 0.40 to 2.70), $t(15) = 2.880$, $p = 0.011$.

An independent-samples t-test showed that there are differences in average illusion of control between companies whose employees are above and below average on unrealistic optimism regarding risk of construction time and cost overrun. Prerequisites for this test are fulfilled¹⁰³. Companies with above average unrealistic optimism regarding risk of construction time and cost overrun seem to have higher illusion of control (5.27 ± 0.66) than companies with below average optimism (4.50 ± 0.61), the difference of 0.76 is significant (95% CI, -0.06 to 1.47), $t(15) = 2.300$, $p = 0.036$. Further, an independent-samples t-test showed that there are differences in subjective knowledge between companies whose average employees are below average in company illusion of control and those who are above average on illusion of control. Prerequisites for this test are fulfilled¹⁰⁴. Companies with above average illusion of control have higher subjective knowledge (5.57 ± 0.47) than companies with below average optimism (4.96 ± 0.46), the difference of -0.61 is significant (95% CI, -1.10 to -0.13), $t(15) = -2.696$, $p = 0.017$.

To complete this section, companies were grouped in above and below average regarding unrealistic optimism's fourth facet i.e. the risk of lower than expected future revenues. Here only one detected difference was statistically significant as shown by an independent-samples

¹⁰³ There is no outlier in the data, as assessed by inspection of a boxplot. Average incentive scores were normally distributed as assessed by kurtosis/skewness z-scores within ± 3.29 . There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.974$).

¹⁰⁴ There are no outliers in the data, as assessed by inspection of a boxplot. Average subjective knowledge scores are normally distributed as assessed by Shapiro Wilk test. There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.984$).

t-test, namely the objective company characteristic company age. Prerequisites for this test are partly fulfilled. There is one extreme outlier in the data, as assessed by inspection of a boxplot. However, this point is unusual but possible, so it was kept in the analysis. Company age scores are normally distributed as assessed by kurtosis/skewness z-scores within ± 3.29 . There is homogeneity of variances, as assessed by Levene's test for equality of variances ($p = 0.330$). Companies with above average on unrealistic optimism regarding risk of lower than expected future revenues seem to be younger (1994.00 ± 11.47) than companies with below average optimism (1940.42 ± 66.38), the difference of 19.83 years is significant (95% CI, 10.54 to 96.63), $t(15) = 1.761$, $p = 0.019$.

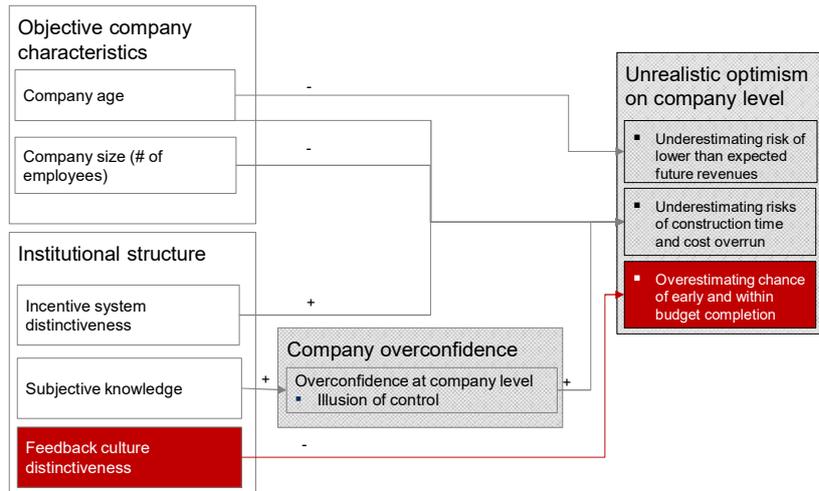
5.6.1.3 Construction of a predictive model

Having identified statistically relevant aspects that are correlated with unrealistic optimism on company level, the following step is to build a model predicting a company's unrealistic optimism on the basis of its objective company characteristics, institutional structure, and overconfidence on company level. Out of the four facets of unrealistic optimism for three characteristics could be identified that differentiate companies on unrealistic optimism, namely unrealistic optimism regarding (1) chance of early and within budget completion, (2) risk of construction time and cost overrun, and (3) risk of lower than expected future revenues.

For none of these three facets of unrealistic optimism a significant predictive model was found. In the following the failed modelling attempts are reported to provide a base for further research.

Concerning company unrealistic optimism regarding the chance of early and within budget completion feedback culture distinctiveness singled out as only characteristic that differentiates companies with above and below average optimism, as highlighted in Figure 19.

Figure 19: Focus on company unrealistic optimism regarding chance of early and within budget completion



Source: Own illustration

A linear multiple regression was therefore run to predict company unrealistic optimism regarding chance of early and within budget completion from feedback distinctiveness.

Prerequisites for using the multiple linear regression method are fulfilled¹⁰⁵. The multiple regression model does not statistically significantly predict unrealistic optimism regarding chance of early and within budget completion, $F(1, 15) = 0.309$, $p = 0.589$.

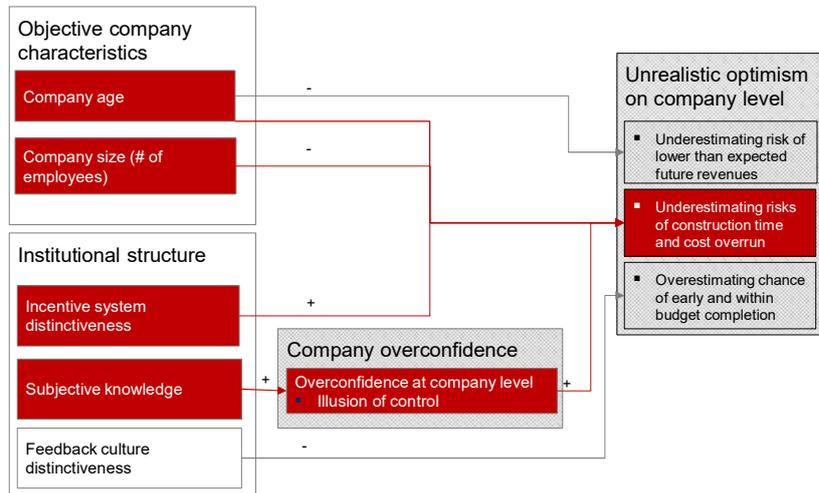
Also, a binary logistic regression was run to predict if a company would be above or below average on unrealistic optimism regarding chance of early and within budget completion. Prerequisites for using binary logistic regression method are fulfilled¹⁰⁶. The binary logistic regression model is not statistically significant, $\chi^2(1) = 3.073$, $p = 0.080$.

¹⁰⁵ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is also given, as assessed by a Durbin-Watson statistic of 2.297. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. However, there is one outlier. This outlier has an unusual but possible value, so it was kept in the analysis.

¹⁰⁶ Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box and Tidwell (1962) procedure. A Bonferroni correction was applied as suggested by Tabachnick and Fidell (2014), using all two terms in the model resulting in statistical significance being accepted when $p < 0.025$. Based on this assessment, the continuous independent variable was found to be linearly related to the logit of the dependent variable. There is one studentized residual with a value of 3.448 standard deviations, which was kept in the analysis.

For company unrealistic optimism regarding the risk of construction cost and time overrun, several characteristics differentiate companies with above and below average optimism. These characteristics are highlighted in Figure 20.

Figure 20: Focus on company unrealistic optimism regarding risk of construction time and cost overrun



Source: Own illustration

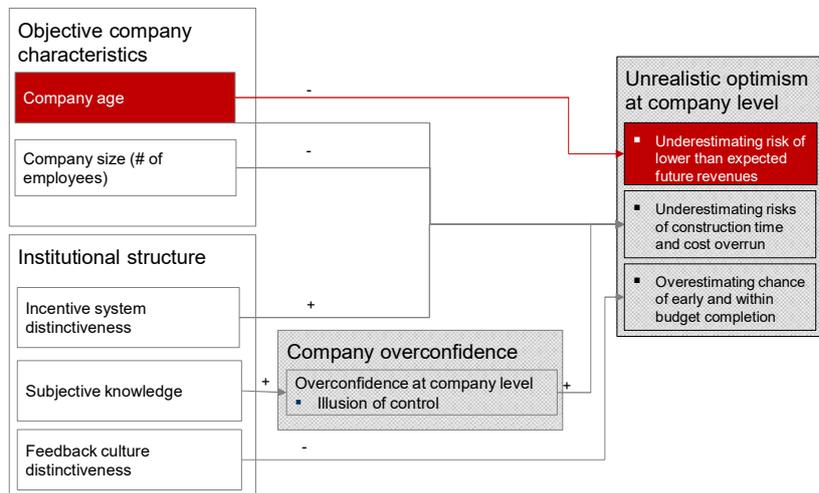
Again, a linear multiple regression was run, now to predict company unrealistic optimism regarding risk of construction time and cost overrun from incentive system distinctiveness, illusion of control, company age, and company size. Prerequisites for using the multiple linear regression method are fulfilled¹⁰⁷. The multiple regression model does not statistically significantly predict unrealistic optimism regarding risk of construction time and cost overrun, $F(4, 12) = 2.844$, $p = 0.072$.

A binary logistic model could not be run due to the minimum case number of 15 cases per independent variable required.

¹⁰⁷ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is also given, as assessed by a Durbin-Watson statistic of 1.928. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality was it, as assessed by a Q-Q Plot. There is no outlier.

For company unrealistic optimism regarding the risk of lower than expected revenues again only one characteristic, company age, singled out as statistically relevant differentiating companies with above and below average optimism, as highlighted in Figure 21.

Figure 21: Focus on company unrealistic optimism regarding risk of lower than expected revenues



Source: Own illustration

A binary logistic regression was run to predict company unrealistic optimism regarding risk of lower than expected future revenues from company age. Prerequisites for using the multiple linear regression method are fulfilled¹⁰⁸. The logistic regression model is statistically significant, $\chi^2(1) = 3.843$, $p = 0.050$. The model explains 28.80% (Nagelkerke R^2) of the variance in unrealistic optimism regarding risk of lower than expected future revenues and correctly classified 58.8% of cases. However, the area under the ROC curve is 0.549 (95% CI, 0.051 to 0.549), which is a poor discrimination, not much better than a coin toss. Sensitivity is 83.3%, specificity is 0.0%, positive predictive value is 66.7% and negative predictive value is 0.0%. Company age is not significant as predictor variable $p = 0.212$.

A linear multiple regression was run additionally to predict company unrealistic optimism regarding risk of lower than expected future revenues from company age.

¹⁰⁸ Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box and Tidwell (1962) procedure. A Bonferroni correction was applied as suggested by Tabachnick and Fidell (2014), using all two terms in the model resulting in statistical significance being accepted when $p < 0.025$. Based on this assessment, the continuous independent variable was found to be linearly related to the logit of the dependent variable. There are no outliers.

Prerequisites for using the multiple linear regression method are fulfilled¹⁰⁹. The multiple regression model does not statistically significantly predict unrealistic optimism regarding risk of lower than expected future revenues, $F(1, 15) = 2.189$, $p = 0.160$.

5.6.2 Discussion company influence on individual decision making

As seen in chapter 5.4 of this dissertation effort, companies can reduce the unrealistic optimism of the individual employees with correctly set feedback and incentive systems.

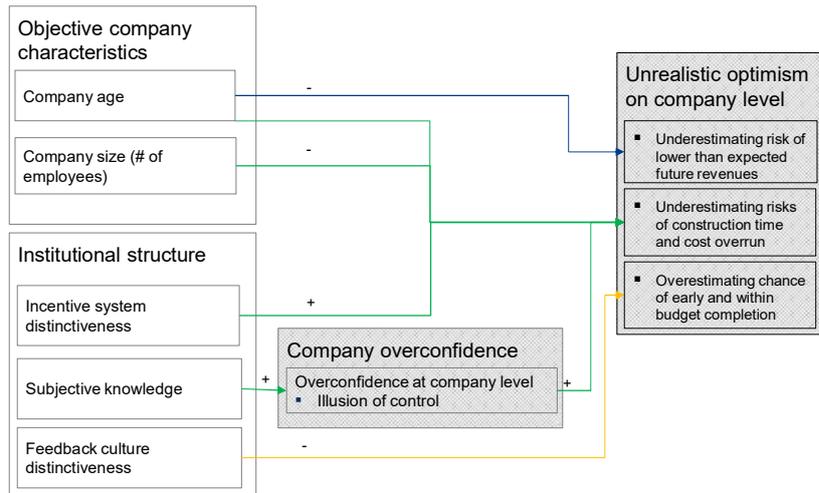
Unrealistic optimism is thus at least partly situational and not strictly rooted in the head of the decision maker no matter the circumstance. However, not yet addressed was if unrealistic optimism is purely individual and can be influenced by a company's institutional structure, or if there are further differences between companies. Thus, the goal of this study was to close this gap by answering RQ4: What are the characteristics of companies that are less unrealistically optimistic than others?

To answer this research question, a predictive model for further testing was build based on literature research, as well as analysis of mean and different regression techniques with a dataset collected among relevant stakeholders.

Figure 22 illustrates the model that resulted from this explorative analysis.

¹⁰⁹ There is linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals is given, as assessed by a Durbin-Watson statistic of 2.297. There is homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity is visible, as assessed by tolerance values greater than 0.1. The assumption of normality is met, as assessed by a Q-Q Plot. However, there are no outliers.

Figure 22: Factors that characterize differences between above and below average companies on unrealistic optimism



Source: Own illustration

Major findings were that there are in fact differences between companies regarding average unrealistic optimism. At the same time these companies have certain characteristics concerning their institutional structure, their overconfidence, and their objective company characteristics. Therefore, classifying companies regarding unrealistic optimism in this industry is relevant, studies and well as practical considerations should not be limited to a classification of stakeholder groups, as it has been done in previous research.

These results are highly relevant as the knowledge about characteristics related to unrealistic optimism at company level can be used as a basis to establish a more realistic risk assessment. At the same time unrealistic optimism is not an unchangeable characteristic of a company but one that can be actively influenced and thus controlled. In the following the most relevant detailed findings concerning (1) the institutional structure, (2) company overconfidence, and (3) objective company characteristics will be discussed.

This study identified incentive system distinctiveness and feedback culture distinctiveness as characteristics that are related to unrealistic optimism on company level. Surprisingly, while these institutional structure characteristics influenced only the facets of unrealistic optimism regarding future revenues of projects on individual level, on company level they characterize companies that differentiate each other regarding costs and time overruns. Team diversity

interestingly was not related to any facet of unrealistic optimism. In the following these three outstanding findings are discussed in more detail.

First, it is especially unexpected to see that high incentive system distinctiveness seems to characterize companies with high unrealistic optimism regarding risk of construction time and cost overrun. This finding is so unreckoned because on individual level incentive system distinctiveness was found to reduce unrealistic optimism regarding risk of lower than expected future revenues and had no significant effect on unrealistic optimism regarding risk of construction time and cost overrun. However, this finding is somehow in line with previous literature that warned of unintended effects of incentive system components such as tournaments (Heaton, 2002).

A closer look on the incentive system's subcomponents throws light on this seemingly inconsistent finding. On company level the subcomponents compensation and career path importance were identified to drive unrealistic optimism regarding the risk of construction time and cost overrun. On individual level no significant impact of any incentive system subcomponent was detected. On the other hand, examining the impact incentive system distinctiveness has on another facet of unrealistic optimism, namely the one concerning risk of lower than expected future revenues, a closer look reveals again differences between the individual and the company level. On company level no significant effect of any of the subcomponents of the incentive system could be detected, while on individual level the subcomponents accountability and career path importance were identified to have a bias reducing effect. In other words - while on individual level the accountability and career path component reduce bias concerning less revenues, the compensation and career path component increase bias regarding costs and time overrun on company level.

The different role of costs and revenues has already been highlighted in this work – also here it is thinkable that the described effect can be due to the way the decision makers construction cost/time and revenue assessments respond differently to incentive systems.

While on company level the incentive system affects unrealistic optimism regarding construction costs and time risks, on individual level it rather influences unrealistic optimism regarding revenues. The fact that career path importance has a different effect direction on individual and on company level might be due to the different sample used in this analysis compared to the individual analysis. Although there was no significant difference between the subsample and the excluded fraction in this analysis on any of the factors, it is thinkable that there is a difference between the subsample and those not included in effect direction. Therefore, this finding must be treated with caution.

Independently from this further to be investigated finding, the analysis indicates that the institutional structure of a company is relevant when assessing risks. Companies must be very careful when designing incentive systems and be aware that when placing high importance on compensation as an incentive system tool, they can increase biases on company level, even if on individual level this effect might not show.

The second unexpected finding regarding institutional structure is that high median feedback culture distinctiveness seems to characterize companies with low unrealistic optimism regarding chance of early and within budget completion. Parallel to the finding on incentive system distinctiveness on company level, this finding is unexpected because on individual level, feedback culture distinctiveness reduces unrealistic optimism regarding chance of higher than expected future revenues and has no significant effect on unrealistic optimism regarding chance of early and within budget completion.

Analyses run on feedback system subcomponent level to explain this finding showed no significant differences. Hence the difference described in the result chapter might be due to the focus of the non-parametric test on the median. Again, the overall effect can be explained by the different sample used in chapter 5.4 and 5.5.

Independently from potential explanations, feedback culture distinctiveness as characteristic that distinguishes between above and below average unrealistic optimism must

be treated with caution and should be further explored. However, even though not the same effect could be identified on company level and on individual level, feedback systems seem to be important to influence unrealistic optimism.

The third finding regarding institutional structure is that team diversity is an institutional structure characteristic that in this survey is not significantly different for above and below biased companies regarding unrealistic optimism. This is surprising, because literature hinted strongly that team diversity should lead to a larger mental model and thus to better forecasting ability (Schoemaker & Tetlock, 2016).

This finding can be explained by the situational nature of unrealistic optimism that was revealed in chapter 5.5. The team mental model that is shaped through team diversity might only have impact in specific decision situations where many decision makers work together, not in general risk assessments that are often done in the four-eye principle in the infrastructure PF industry.

Answering the call of Houghton et al. (2000), this work underlines that regarding unrealistic optimism team diversity does not play a role in this specific industry. So, while in chapter 5.4 it was concluded how important e.g. a focus on experience is when putting together a team for PF decisions in the infrastructure industry, it can be concluded that a focus on diversity does not seem as important to control for unconscious cognitive biases. However, since decision making is situational, the effect might be different for different strategic decisions.

Concerning subjective knowledge, illusion of control, and unrealistic optimism regarding risk of lower than expected future revenues the same relationship was found on company level, as it was proven to be on individual decision maker level: subjective knowledge increases illusion of control, which itself increases unrealistic optimism regarding risk of lower than expected future revenues.

To begin with, this can be explained like the individual level finding - companies with high subjective knowledge are unlikely to consult experts and base decisions only on self-assessed knowledge. Additionally, companies in general tend to be more unrealistically optimistic about future events that they believe they can control (Durand, 2003). This homogeneity on company level can imply that subjective knowledge is influenced by company characteristics e.g. the recruiting process. An additional explanation for this homogeneity is the current big data trend in the infrastructure industry. Companies provide their decision makers with countless data points today, so the decision makers believe they have all the information they need to make perfect risk predictions (subjective knowledge) and further believe they have an advantage over companies that seem not to have these data amounts available. However, they might be lacking knowledge of the actual decision situation.

This finding has two important implications. Subjective knowledge is an institutional structure characteristic, that needs to be attacked not only in the recruiting of individuals, but also on company level e.g. through debiasing workshops. At the same time companies with high subjective knowledge need to account for unrealistic optimism regarding risk of lower than expected future revenues in their decision making.

Finally, also objective company characteristics seem to influence unrealistic optimism on company level. Both company age and size are characteristics that differentiate above and below average unrealistically optimistic companies regarding risk of construction time and cost overrun with company age also influencing unrealistic optimism regarding risk of lower than expected future revenues. Above average unrealistic companies were younger and smaller than their more realistic counterparts. This finding is important, as age and size is something companies cannot influence, but can be aware off and take relevant counter measures.

Concerning the age, a first explanation of this finding can be that older companies are more likely to have established decision-making routines which reduce decision complexity and thus leave less room for bias, as previous authors have already shown in different industries (Lowe & Ziedonis, 2006). Further, Lowe and Ziedonis (2006) also argue that older companies have more historic data access and thus face less uncertainty in decisions. Both explanations could also hold in the infrastructure sector, as older companies have typically conducted more deals and thus got more experience, which should establish decision making routines even more.

Unexpected was that large companies seem less subject to unrealistic optimism, which contradicts the findings of Durand (2003). A first explanation of this finding can be that larger companies are more likely to have established decision-making routines which reduce decision complexity and thus leave less room for bias,

The deduction of this is that both the age and size of a company that evaluates risks does play a role. Therefore, when planning projects, age and size of the involved company/companies should be considered. Especially when it comes to young and small companies, it should be ensured that proper debiasing mechanism are put in place. Potentially this finding has a very important implication for the public sector. Experience of companies and established decision processes are so important that PF is indeed a solution to address certain problems. Both unrealistic optimism regarding risk of construction time and cost overrun and unrealistic optimism regarding risk of lower than expected future revenues is reduced by involvement of older and larger companies. Due to election periods in the public sector, decision makers often do not have the infrastructure decision experience, that decision makers in infrastructure investment funds have. At the same time for instance in Germany large infrastructure projects are not implemented by one specific public institution but are spread over states and provinces and located in different public authorities. In addition, with

the above-mentioned election periods the public body could therefore be seen as a quite small and young company, that is “reborn” at least every four years.

In the following the (1) theoretical and (2) practical contributions are presented, (3) limitations are named, and finally (4) a brief outlook is given.

5.6.2.1 Theoretical contributions

Although literature about behavioral decision making in projects, PF in general, and factors affecting risk assessment take different angles concerning unrealistic optimism, the gap the first three mentioned streams have is overlapping: In this area there is no research that takes the organizational perspective on biased information processing. This work therefore answers the research calls of Durand (2003) and Müllner (2017) by showing how important it is to broaden the focus from only the individual decision maker towards also companies. Previous research did not determine what characterizes companies whose decision makers are on average unrealistically biased and bring a high degree of estimator related risk with them. Filling this gap, this dissertation effort shows that unrealistic optimism does exist on the company level, indicating unrealistic optimism is indeed a situational bias influenced by objective company factors and institutional characteristics and not merely rooted in the head of decision makers. Our research findings therefore not only add to these literature streams but significantly change ongoing discussions, that have mainly concerned the individual decision maker. Instead, better understanding how institutions affect their employees’ biases in decision making, has the potential to result in much larger practical benefits. This research represents a first step in showing what kind of company factors should be considered. It opens up an array of research to examine different decision biases on company level. By providing a theoretical model for unrealistic optimism, this dissertation further serves as a starting point for future research that attempts to predict a company’s likelihood to be subject to unrealistic optimism.

Also in the bias management literature, as described in chapter 4.3.2.4 there is the need for more research on the effects of institutional structures on biased decision making. This dissertation contributes to this gap by showing that effects on company level and effects on individual level can be different when it comes to debiasing decision makers. This study could identify incentive system distinctiveness and feedback culture distinctiveness as characteristics that are related to unrealistic optimism on company level, however on company level different facets of unrealistic optimism are influenced than on individual level, showing that a team does not necessarily represents the sum of individuals.

5.6.2.2 Practical contributions

The managerial implication of the findings above is that by analyzing their company characteristics, managers can identify well-grounded if their decision makers are likely to fall prey to unrealistic optimism. Managers should put significant focus on unrealistic optimism when a company is small, recently founded, incentivized heavily over employee compensation, and provides room for high subjective knowledge e.g. through relying heavily on big data. Especially for companies with these characteristics debiasing trainings and accounting for biases in decision making is important. Companies with very diverse teams should not have a false sense of security - team diversity has no impact on biases on company level.

Further, managers can have impact on their institutional environment to shape it in a way best equipped to avoid overly optimistic decision making. When designing incentive systems managers need to be aware of possible unintended effects on unrealistic optimism. For instance, when placing high importance on compensation as an incentive system tool, they can increase biases on company level, even if on individual level this effect might not show.

Additionally, subjective knowledge is an institutional structure characteristic, that needs to be

attacked not only in the recruiting process of individuals, but also on company level, e.g., through debiasing workshops.

For public institutions an important learning is that experience of companies and established decision processes are so important that PF can indeed be a means to address certain problems. As described above, due to their structure public institutions could be seen as a quite small and young company and therefore have the characteristics of organizations that are on average more likely to be unrealistically optimistic. Thus, it is especially important to conduct debiasing trainings and to account for bias in decision making, as well as to implement an institutional environment that does not fuel unrealistic optimism.

5.6.2.3 Limits

The model itself and the measurement model have certain limitations that are explained in the following.

One limit of the model tested is that it focusses only on infrastructure PF in the European infrastructure industry and thus can neither be transferred directly to decision situations in another industry nor to other continents. Further, important company characteristics such as the recruiting process or established decision-making processes had to be neglected due to the feasibility of this study.

Naturally the measurement approach further has its limitations. This study was based on the same survey as chapter 5.4 and 5.5, thus the same survey related limitations apply. Only a limited number of questions was used and biases in a real decision situation might be amplified compared to a survey where participants were conscious that biases were tested.

Finally, another limitation is the small sample size. Additionally, self-selection bias is also here possible: only the employees of a company answered that were either biased or not biased, thus not reflecting the company overall.

5.6.2.4 Outlook

There are various avenues for future research – the three most important ones are presented in the following. First, using the above findings as starting point, future research should conduct tests with larger samples to build a predictive model. Further company unrealistic optimism should be linked to decision performance – answering the question if companies that are unrealistic optimistic perform worse due to bad decisions. Finally, it should be tested if the company bias effect is just the sum of the individual biases, or if the belonging to a company amplifies cognitive biases of the individual.

6. Conclusion and outlook

In the following the overall conclusion is presented, followed by an outlook.

6.1 Conclusion

Shifting more from asset, public, and corporate finance to PF in Europe can be a way to achieve optimized public and corporate spending and thus contribute to closing the infrastructure finance gap, if the risk management and risk transfer in the PF work optimally.

In chapter 3 a detailed risk typology was presented that highlights how important the topic of estimator related risk, i.e., cognitive biases and especially unrealistic optimism in decision making is when it comes to infrastructure PF. The fact that lenders and investors as project outsiders carry estimator related risks means that banks and funds do not only provide money needed to close the infrastructure finance gap but also take over risks attached to the risk management process.

When analyzing individual lenders and investors regarding their risk assessment in chapter 5.4 it became apparent that overall also individual lenders and investors are unrealistically optimistic. This optimism is influenced by subjective knowledge on personal level, feedback culture/incentive system distinctiveness on company level, and overconfidence bias, which itself is driven by subjective knowledge and reduced by experienced based knowledge. These results are highly relevant as knowledge gained about causal drivers of unrealistic optimism can at the level of involved stakeholders be used as a basis to establish a more realistic risk assessment; the unrealistic optimism therefore is not an unchangeable characteristic of stakeholders but one that can be influenced and thus reduced.

Focusing on the difference between stakeholder groups in chapter 5.5 it became apparent that lenders are more unrealistically optimistic than investors regarding the chance of higher than expected future revenues. This finding is strengthened by the detection of a statistically

significant lower feedback importance from colleagues for lenders than for investors, further highlighting that cognitive biases are not purely rooted in the mind of decision makers but also have a situational component.

How companies can influence this situational component was analyzed in chapter 5.6. It could be shown that important influencing factors of unrealistic optimism on company level are the company's institutional structure, overconfidence, and objective company characteristics.

Theoretical and practical contributions from these findings are elaborated in the following.

6.1.1. Theoretical contributions

The theoretical contribution to the PF, behavioral finance, risk assessment, and bias management research is manifold. This effort (1) develops the current discussion around PF, (2) shows the importance to test behavioral decision-making theory in different practical decision situations in order to develop theory further, (3) provides both a risk typology and models that can serve as a foundation for future research in different research fields, and (4) tests the applicability of methods not commonly used in this research field.

In the PF literature stream no typology of risks has been defined for infrastructure projects financed through PF that shows exactly which risks are taken over by lenders and private investors. Further estimator related risks were not included in existing typologies and taxonomies. By using the knowledge from the megaprojects literature stream together with previous findings in the PF literature stream, this work collects a detailed list of risk factors and shows what the risks of a typical infrastructure project are and who typically carries these risks. This risk typology is an important contribution as it is specific to the PF infrastructure industry and shows concerning estimator related risk that not only planners and project managers, but also project outsiders that evaluate the project at a later stage are unrealistically optimistic. These results are highly relevant as currently it is argued that the involvement of an outside view, i.e. lenders and investors gives an important advantage regarding the

assessment of revenue and risks large and complex infrastructure project have (Flyvbjerg, 2013).

Finally, previous research in PF did not determine what characterizes companies, whose decision makers are on average unrealistically biased and bring a high degree of estimator related risk with them. Filling this gap, this dissertation shows that unrealistic optimism does exist on company level in infrastructure PF in varying degrees of severity, which means that certain companies are better equipped to take over estimator related risks than others.

Moreover, this effort demonstrates the importance to test behavioral decision-making theory in different practical decision situations in order to gain knowledge about commensurability and develop the existing theory further.

By developing the PF specific risk typology and identifying estimator related risk as a risk category, it was shown how important it is to connect the PF literature and the behavioral decision-making literature concerned with the reductionist school of thought. Further, in this field of research an important gap to close was to test the applicability and generalizability of findings from previous research, often tested in theoretical decision situations with students, to different decision situations of experienced industry specific decision makers. In this regard the main theoretical contribution is that existing behavioral finance models and hypotheses can be applied to the specific decision situation at hand (infrastructure PF decision making), but need modifications. Some causal connections between company/personal factors and unrealistic optimism that were found by authors in other industries are verifiable also in this one. Knowledge types known to influence facets of overconfidence for IT projects for instance do also hold for infrastructure projects and thus this finding seems to be generalizable. However, especially the influence of representative heuristic on unrealistic optimism seems to differ by industry and is not transferable without questioning.

Further, in this area there is no research that takes the organizational perspective on biased information processing, including company factors such as company age and company size. As this cannot be tested on students, it is important to use relevant industry decision makers to test models and hypotheses. Filling this gap, this dissertation shows that unrealistic optimism does exist on company level, indicating unrealistic optimism is indeed a situational bias influenced by objective company factors and institutional characteristics and not merely rooted in the head of decision makers.

Additionally, this effort provides a risk typology, models, and hypotheses that can serve as a foundation for future research.

The risk typology developed in chapter 3 is an important contribution as it can serve as a basis for further research on cognitive aspects, perceived risk, and decision making in different industries - highlighting the importance to include the category “estimator related risks in all typologies to come.

The causal model that differentiates between personal factors, organizational factors, and other biases/heuristics as enhancing/diminishing factors of individual unrealistic optimism can serve as a foundation for research on unrealistic optimism in different decision situations. Here it is especially important for future research that organizational factors showed to have a diminishing effect on unrealistic optimism, indicating that companies can influence individual decision making.

The predictive model developed in chapter 4 and 5 can additionally serve as a basis for further research that tries to determine what characterizes companies whose decision makers are on average unrealistically optimistic. Further, the predictive model showed that effects on company and individual level can be different. This study could identify incentive system distinctiveness and feedback culture distinctiveness as characteristics that are related to unrealistic optimism on company level, however they influenced different facets of unrealistic optimism on company respective on individual level.

Finally, this effort demonstrates the applicability of methods not commonly used in this research field.

While the latest typologies in the field of infrastructure projects rely on literature research, in this effort the CIT method was used to gain additional information from industry experts. Relying not only on existing literature but also integrating practical knowledge was proven to be important for the decision situation at hand – estimator related risks could be uncovered as important risk category. Thus, explorative research methods are not only applicable in fields where only little research is present – even in well researched areas, they can uncover new insights.

Regarding the measurement of unrealistic optimism, a key contribution is that in certain decision situations unrealistic optimism needs to be distinguished between its facets regarding rewards and risks, as well as cost/construction time and revenues, resulting in four different facets of unrealistic optimism. These facets are driven by different factors in terms of incentive system distinctiveness, feedback culture distinctiveness, illusion of control, and subjective knowledge. Previous research typically only differentiates the facets regarding rewards and risks. This more distinctive way of measuring unrealistic optimism highlights the potential problem that previous findings about unrealistic optimism cannot be applied to all facets of this bias.

Finally, while previous works e.g. Vetter et al. (2011) and Meyer (2016) use correlations in order to show causality in their bias models, making use of regression allowed to compare effect sizes and thus get a more holistic knowledge on causalities.

6.1.2. Practical contributions

As described in chapter 2, there are four areas of concern when setting up a project structure: (1) organizational structure (project ownership, source of financing), (2) governance structure (capital structure), (3) contractual structure (packaging of work, delivery models, and pricing

scheme), and finally (4) team structure. In the following the lessons learned from this research for the four project structure related aspects will be elaborated.

For public institutions setting up a project, when it comes to the ownership decisions, they need to decide if they want to implement the project themselves as a public project or if they want to involve the private sector, to benefit from efficiency gains. When assessing the ownership structure public decision makers should keep in mind that the assessment of risks and rewards can neither be transferred unquestioned to a specific stakeholder group or subgroup, as all involved groups are subject to unrealistic optimism.

When assessing how much debt to equity to use, decision makers should keep in mind that concerning unrealistic optimism regarding risk of lower than expected future revenues lenders are more affected than investors. Thus, a high debt to equity might allow equity investors to maximize their equity returns (Scannella, 2012) and transfer part of the downside project risk to lenders (Miller & Lessard, 2001), but it does not necessary mean that estimator related risks are transferred to the stakeholder that can best bear it.

The contractual structure of a project is important to allocate risks to the party/parties that can mitigate them best or that can carry them at the lowest cost (Esty, 2004a). The detailed risk typology developed in chapter 3 can serve all infrastructure PF stakeholders as a checklist when evaluating the risks and returns they want to transfer. When choosing a consortium to award the project contract to, specific caution should be taken concerning transferring estimator related risk when companies are small in terms of employee number, were recently founded, incentivize employees heavily over compensation, and provide room for subjective knowledge e.g. through relying heavily on big data.

Companies that are awarded a PF deal should keep in mind several in the following described points when putting together the project team. They should be aware of the phenomenon unrealistic optimism in the assessment of risks and rewards and the causal enhancing and

diminishing factors of unrealistic optimism. Companies need to act cautiously when staffing people with high subjective based knowledge on projects where the correct assessment of risks and rewards is vital, and ensure that each project team has an experienced decision maker when it comes to assessing risks and rewards. Companies should further install a distinctive feedback system for the team that focuses on the speed with which feedback is delivered, the importance their employees place on their colleagues' feedback, as well as the overall feedback culture in the company. Finally, it is recommended that companies install a distinctive incentive system for the team that focuses on how the success of the individual influences their career advancement, as well as on the individuals feeling of accountability for her/his actions. Compensation as incentive system should be thoroughly rethought.

6.2. Outlook

Considering that up to now research in behavioral finance regarding unrealistic optimism covers either its occurrence or its drivers without taking into view the special features of different industries, the field of what remains to be done is wide.

One first step would be to test the general applicability of the developed causal model for individual decision makers in the same industry with different stakeholder groups, in different geographies, in different industry settings, and for different decision situations. On company level, future research should conduct tests with larger samples to build a predictive model, based on the factors described in chapter 5.6.

Further, the generalizability of hypotheses put forward should be tested. In chapter 5.4 it was proposed that the infrastructure industry might attract unrealistically optimistic decision makers - this should be tested using cross industry comparison. In chapter 5.4 it was proposed that more experienced decision makers are better decision makers regarding unrealistic optimism - testing this model in other decision situations can help to confirm this. In chapter 5.4 it was proposed that representative heuristic had no relevance for the risk and reward

assessment in this study because of the infrastructure industry with its singularities - testing this model in other industries can help to confirm this.

Due to the chosen research design, this research was limited to the analysis of cognitive biases, and did not focus on the impact on actual decision making. Future avenues for research could be to lift this limitation both on individual and company level. On individual level, it should be explored if the positive aspects of unrealistic optimism can outweigh the negative aspects.

On company level it should be tested if unrealistic optimism can be linked to company financial performance, and if the company bias effect is just the sum of the individual biases, or if the belonging to a company manages to amplify biases.

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List of abbreviations

CIT	Critical incident technique
ECA	Europe and Central Asia Credit Infrastructure Program
PF	Project finance
PFI	Project Finance International
PPP	Public Private Partnership
RQ	Research question
SPV	Special purpose vehicle

Appendix

Table 22: Risk typology of PF infrastructure projects based on Irimia-Diéguez et al. (2014)

Risk factor category	Risk factor	Stakeholder that typically carries risk					
		Public sector	SPV	Contractor	Investor	Lenders	Consultants
Clients/user/society	Risk of changing customer demand	x	x				
Clients/user/society	Risk of changing customer willingness to pay	x	x				
Clients/user/society	Risks of third party users	x	x				
Clients/user/society	Risk of cultural differences between main stakeholders	x	x				
Clients/user/society	Risk of inappropriate alignment of stakeholders	x	x				
Clients/user/society	Risk of non-involvement of host-community	x	x				
Clients/user/society	Risk of public opposition to projects	x	x				
Clients/user/society	Risk of rate of return restrictions	x	x				
Clients/user/society	Risk of reputation loss due to miscommunication	x	x				
Clients/user/society	Risk of non-compliance of stakeholders	x	x				
Clients/user/society	Risk of user/customer opposition to project	x	x				
Clients/user/society	Risk of changing social profitability	x	x				
Clients/user/society	Risk of changing royalty payments	x	x				
Construction	Chemical risk of construction						x
Construction	Construction logistics risk						x
Construction	Environmental damage due to construction of project						x
Construction	Physical risk of construction						x
Construction	Risk of archeological features in the ground						x
Construction	Risk of change in schedule						x
Construction	Risk of changing ground water level						x
Construction	Risk of contamination						x
Construction	Risk of ground water quality						x
Construction	Risk of historic monument protection						x
Construction	Risk of infidelity and theft						x
Construction	Risk of inadequate scheduling						x
Construction	Risk of inappropriate quality management						x
Construction	Risk of increased equipment costs and delivery lead time						x
Construction	Risk of increased material cost						x
Construction	Risk of infrastructure accessibility						x
Construction	Risk of rework needed due to supply chain quality						x
Construction	Risk of supply chain bottlenecks						x
Construction	Risk of constructability of building ground and subsurface conditions						x
Construction	Risk of unforeseen required site engineering						x
Construction	Risk of bankruptcy of contractor						x
Construction	Risk of bankruptcy of subcontractors						x
Construction	Risk of insolvency/default of subcontractors and suppliers						x
Construction	Risk of double work						x
Construction	Risk of inappropriate executive support						x
Construction	Risk of increasing land acquisition cost and delay						x
Construction	Risk of land acquisition/site availability						x
Construction	Structural engineering calculation risk						x
Construction	Risk of technical failure during commissioning						x
Contractual	Risk of excessive contract variation	x	x			x	
Contractual	Risk of required change due to other contractors	x	x			x	
Contractual	Risk of changed owner's requirements during construction	x	x			x	

Risk factor category	Risk factor	Stakeholder that typically carries risk					Consultants
		Public sector	SPV	Contractor	Investor	Lenders	
Contractual	Risk of change in kind-of-usage	x	x		x		
Contractual	Risk of change of requirements of usage	x	x		x		
Contractual	Risk of non-adherence to owner obligations	x	x		x		
Contractual	Risk of claims/change orders due to contradictions in contract terms	x	x		x		
Contractual	Risk of claims/change orders due to lack of clarity in contract terms	x	x		x		
Contractual	Risk of claims/change orders due to omissions in contract terms	x	x		x		
Contractual	Contractual conflicts	x	x		x		
Contractual	Risk of high bidding cost	x	x		x		
Contractual	Risk of inadequate distribution of responsibilities and risks	x	x		x		
Contractual	Risk of inappropriate award process	x	x		x		
Contractual	Risk of opportunistic behavior of contractual partners	x	x		x		
Contractual	Risk of prolonged negotiation period prior to initiation	x	x		x		
Contractual	Risks due to rights of third party	x	x		x		
Contractual	Risk of inappropriate contract form and handling	x	x		x		
Contractual	Risks of limitation to liability of contractors	x	x		x		
Contractual	Risk of late design changes	x	x		x		
Design	Risk of delay of contract formation	x	x		x		x
Design	Risk of inadequate delivery method	x	x		x		x
Design	Risk of inadequate licensing application quality	x	x		x		x
Design	Risk of inappropriately predicted attrition reserve	x	x		x		x
Design	Risk of scope changes	x	x		x		x
Design	Design approval risk (delayed, denied)	x	x		x		x
Design	Risk of flawed tender documents	x	x		x		x
Design	Risk of procedural shortcomings in tender	x	x		x		x
Design	Risk of design failure	x	x		x		x
Design	Risk of changing technologies during project	x	x		x		x
Design	Risk of lacking flexibility and function ability of design	x	x		x		x
Estimator related risks	Risk of under or over evaluating future revenue		x		x	x	
Estimator related risks	Risk of under or over evaluating construction cost			x			
Estimator related risks	Risk of under or over evaluating construction time			x	x	x	
Financial/economic	Risk of competition from substitutes		x		x	x	x
Financial/economic	Risk of operational revenue below projection		x		x	x	x
Financial/economic	Risk of too small yield/recovery efficiency		x		x	x	x
Financial/economic	Risks of inadequate working funds		x		x	x	x
Financial/economic	Currency risk/devaluation risk		x		x	x	x
Financial/economic	Currency transfer risk		x		x	x	x
Financial/economic	Demographical risk		x		x	x	x
Financial/economic	Funding cost (interest rate) risk		x		x	x	x
Financial/economic	Price index risk		x		x	x	x
Financial/economic	Risk of change in commodity market conditions (availability, price)		x		x	x	x
Financial/economic	Risk of competitive reaction		x		x	x	x
Financial/economic	Risk of currency inconvertibility		x		x	x	x
Financial/economic	Risk of inflation rate volatility (deflation)		x		x	x	x
Financial/economic	Risk of influential economic event (boom/recession)		x		x	x	x
Financial/economic	Risk of limited availability of project funding		x		x	x	x
Financial/economic	Risk of third party tort liability		x		x	x	x
Financial/economic	Risk of change in material market conditions (availability, price)		x		x	x	x

Risk factor category	Risk factor	Stakeholder that typically carries risk					
		Public sector	SPV	Contractor	Investor	Lenders	Consultants
Financial/economic	Counterparty risk		x		x	x	x
Financial/economic	Credit risk		x		x	x	x
Financial/economic	Equity risk		x		x	x	x
Financial/economic	Financial close risk		x		x	x	x
Financial/economic	Liquidity risk		x		x	x	x
Financial/economic	Performance determination risk		x		x	x	x
Financial/economic	Risk of bankruptcy of concessionaire		x		x	x	x
Financial/economic	Risk of default of one party		x		x	x	x
Financial/economic	Risk of default on debt service		x		x	x	x
Financial/economic	Risk of inability to refinance		x		x	x	x
Financial/economic	Risk of inappropriate indexation		x		x	x	x
Financial/economic	Risk of lack of commitment from public/private partners		x		x	x	x
Financial/economic	Risk of lack of creditworthiness		x		x	x	x
Financial/economic	Risk of low financial attraction of project to investor		x		x	x	x
Financial/economic	Risk of smaller than assumed residual value		x		x	x	x
Financial/economic	Risks of inappropriate quantitative demand projections		x		x	x	x
Financial/economic	Risks regarding pricing of product/service		x		x	x	x
Financial/economic	Risk of inappropriate NPV forecast		x		x	x	x
Financial/economic	Risk of misevaluation of bids		x		x	x	x
Financial/economic	Subsidy risk		x		x	x	x
Financial/economic	Risk of lack of tradition of private provision of public services		x		x	x	x
Force majeure	Climate change/natural disasters	x	x	x			
Force majeure	Risk of weather conditions	x	x	x			
Force majeure	Risk of changing standards during projects	x	x	x			
Force majeure	Risk of terror/war	x	x	x			
Force majeure	Risk of unethical behavior	x	x	x			
Force majeure	Risk of vandalism	x	x	x			
Force majeure	Another force majeure type	x	x	x			
Labor	Risk of increased labor rates		x	x			
Labor	Risk of insufficient capability and training		x	x			
Labor	Risk of labor availability and productivity		x	x			
Labor	Risk of inadequate work safety		x	x			
Labor	Risk of slow progress due to unclear/inappropriate incentives		x	x			
Labor	Organization and coordination risk		x	x			
Labor	Risk of problems due to different working methods/know-how between partners		x	x			
Labor	Risk of riots and domestic disturbance		x	x			
Labor	Risk of inadequate experience in PPP		x	x			
Labor	Risk of inefficient use of personnel and resources		x	x			
Labor	Risk of labor disrupts		x	x			
Labor	Risk of inadequate distribution of authority between partners		x	x			
Labor	Risk of (skilled) labor availability and productivity		x	x			
Legal/political	Risk of poor public decision-making process	x	x		x		x
Legal/political	Risk of strong political opposition/hostility	x	x		x		x
Legal/political	Lacking support by public decision makers	x	x		x		x
Legal/political	Risk of arbitration award default	x	x		x		x
Legal/political	Risk of change in tax regulations	x	x		x		x
Legal/political	Risk of changing environment protection regulations	x	x		x		x
Legal/political	Risk of changing norms and regulations concerning contaminants	x	x		x		x
Legal/political	Risk of changing regulations and norms regarding construction	x	x		x		x
Legal/political	Risk of corruption and lack of respect for law	x	x		x		x
Legal/political	Risk of delay in project approvals and permits	x	x		x		x

Risk factor category	Risk factor	Stakeholder that typically carries risk					
		Public sector	SPV	Contractor	Investor	Lenders	Consultants
Legal/political	Risk of expropriation/nationalization of assets	x	x		x		x
Legal/political	Risk of import/export restrictions	x	x		x		x
Legal/political	Risk of inconsistencies in government policies	x	x		x		x
Legal/political	Risk of increasing tariff amounts	x	x		x		x
Legal/political	Risk of inner and outer security	x	x		x		x
Legal/political	Risk of lack of government guarantees	x	x		x		x
Legal/political	Risk of legislation change/inconsistencies	x	x		x		x
Legal/political	Risk of political instability	x	x		x		x
Legal/political	Risks of gaining approval only under certain conditions	x	x		x		x
Legal/political	Risk of other regulatory change	x	x		x		x
Legal/political	Risk of concessional tax rebate	x	x		x		x
Legal/political	Risk of cancellation of concession	x	x		x		x
Operation and maintenance	Risk of expansion and major upgrading costs		x	x			
Operation and maintenance	Risk of faulty construction techniques		x	x			
Operation and maintenance	Risk of inadequate maintenance diagnostic		x	x			
Operation and maintenance	Risk of inadequate operability, integrity, reliability		x	x			
Operation and maintenance	Risk of inappropriate maintenance measures		x	x			
Operation and maintenance	Risk of inappropriate maintenance strategy		x	x			
Operation and maintenance	Risk of increased wear out		x	x			
Operation and maintenance	Risk of insufficient processes, procedures, and systems in operation		x	x			
Operation and maintenance	Risk of interface between construction and operation phase		x	x			
Operation and maintenance	Risk of low operating productivity		x	x			
Operation and maintenance	Risk of maintenance cost higher than expected		x	x			
Operation and maintenance	Risk of maintenance more frequent than expected		x	x			
Operation and maintenance	Risk of operation cost overrun		x	x			
Operation and maintenance	Risk of over aging		x	x			
Operation and maintenance	Risks of approving a deficient state of construction		x	x			
Operation and maintenance	Risk of rework needed due to poor quality of workmanship		x	x			
Operation and maintenance	Risk of increasing consumption cost		x	x			
Operation and maintenance	Risks of overpriced service level agreements		x	x			
Operation and maintenance	Offtake agreement risk		x	x			
Operation and maintenance	Material risk in running operations		x	x			

Table 23: Relevant quotes from expert interviews

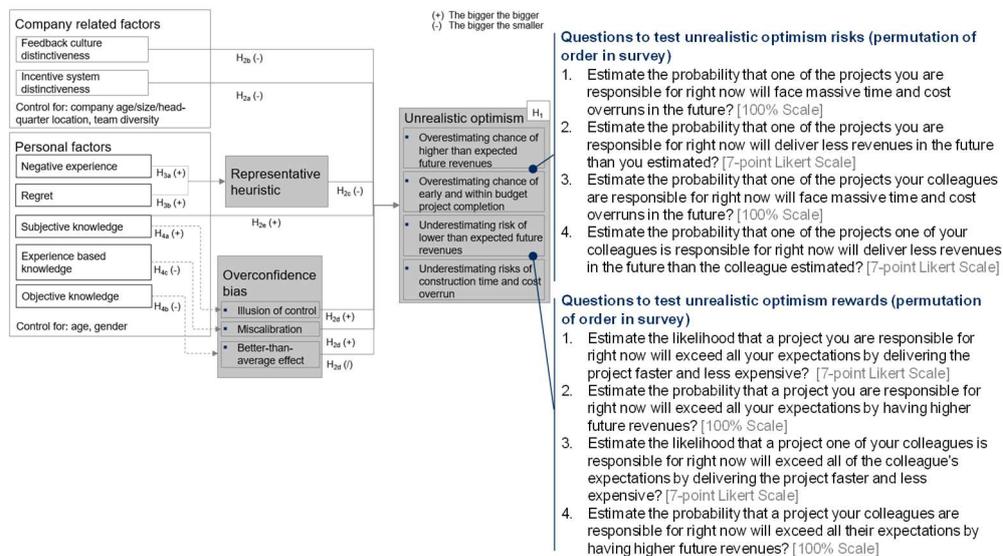
Risk factor category	Quote in original interview language
Clients/user/society	<ul style="list-style-type: none"> - <i>"There is something called outside risk in the [framework], I am not sure which one that is, or at least we had that at [client name]. And then it means if it is obviously not under the direct control of the project director, but he nevertheless has to have some way to managing that through a stakeholder type of management. Sometime, I will give you an example, a large copper project in Mongolia, the government decides to change the way they are going to collect royalties on the mining output, so obviously the poor project manager building the plant can't do much about this but it can really have a detrimental impact on his project once it starts operations so he needs to have that risk responsibility back to someone in corporate that is going to go and essentially going to sit down with the government of Mongolia. That is just an example. So, in a case like that, that would be seen as a we need to identify this as a project risk, because it will impact the NPV. And the control of that is obviously not sitting inside the project team. So, you need to be able to allocate it to someone else." (Consultant I)</i> - <i>"Looking at the typology I would assign risk of changing customer demand and risk of changing customer willingness to pay rather to owner than to contractor." (Consultant I)</i> - <i>"Bei der Autobahn in Ungarn, da hat die Bevölkerung auf einmal festgestellt, dass da überhaupt keine Lärmschutzwand vorgesehen war. Hatten die einfach nicht. Und [da wurde] dann natürlich massiv protestiert, und dann hat der Staat gesagt: naja, gut. Also dann gib noch etwas Geld raus, und dann bauen wir dann noch eine Lärmschutzwand entlang der Dörfer." (Lender III)</i>
Construction	<ul style="list-style-type: none"> - <i>"Organization and coordination risks do belong to execution. For example, if an owner cannot staff his project team, it will impact the execution of the project. Coordination of sub-contractors will also impact the execution." (Consultant I)</i> - <i>"I would add sub-surface conditions that is in the technical category and impacts a lot of projects (metro, light rail, tunnels, etc.) to your typology." (Investor II)</i> - <i>„...Bau eines Protonentherapiezentrum, wunderbare Anlage, Protonen, zum Behandlung von Krebs, von Tumoren. Und da ist dann auch passiert, was Sie sagen, Bauzeitverlängerung eingetreten, das Ding ist nicht recht fertig geworden.“ (Lender III)</i>
Contractual	<ul style="list-style-type: none"> - <i>"Also hier im Hamburg, als zentrales Beispiel, Elbphilharmonie, die eben nicht als Projektvertrag gebracht wurde und wo gewiss von Beginn an gewisse Kostenpositionen offengelassen wurden." (Lender III)</i>
Design	<ul style="list-style-type: none"> - <i>"Gab's mal vor 10 Jahren, oder länger her, ein Projekt für eine Protonen und Ionen Schleuder für das Universitätsklinikum Schleswig-Holstein. [...] Und da hat man damals gesagt, das können wir, man kann eine Protonen/Ionen Schleuder bauen. Das haben [Firmenname] als Projektfinanzierung gemacht, aber die haben dieses neue Technologierisiko nicht genommen als Bank, sondern gesagt [Firmenname] muss selber... Diese Maschine gibt's noch nicht und die haben keinen Beweis, dass es so funktionieren wird. Dieses Risiko müssen die tragen. [...] Und so war es dann auch, die Technologie hat nicht funktioniert." (Lender II)</i> - <i>"Ich kann mich hinstellen und sagen: ich weiß, diese Beinbrüche in Frankfurt im Januar im Durchschnitt passieren und kann das hochrechnen. Das ist ein Risiko. Ich weiß aber nicht, wie viel die Krankenkasse für einen Beinbruch in 50 Jahren zahlen wird, also das ist kein stochastisches Risiko, sondern das ist eine Unsicherheit, und das kann ich z.B. nicht verschieben. [...] wenn es jetzt spezifischer um Krankenhaus, PPP oder Projektfinanzierung geht, können Sie die ganze Hotalleistung der Privaten übertragen. Wir können auch gewisse technische Dinge den Privaten übertragen (wie die Geräte funktionieren), wir werden aber nicht medizinische Risiken, wie viel die Krankenkasse wofür bezahlen wird, in eine Projektfinanzierung packen können." (Lender II)</i> - <i>"Diese Jahr fällt mit spontan ein Thema Energiespeicher, wo jemand von uns große Batteriespeicher finanziert haben wollte, sicher mit Technik, die wir in der Zukunft sogar noch verstärkt sehen werden, aber so wie das Projekt eben konstruiert war, haben wir das dann relativ schnell gesagt: Moment einmal... das Risiko ist zu hoch, obwohl man sich mit einem solchen Projekt deutlich hätte nach außen darstellen können, als Förderer innovativ von Energiesachen und alles, alle die Kriterien hätten toll gepasst, aber da fiel bei der Bank eine relative kühle Entscheidung... sorry... ist... mit hohen technischen Risiko, hohem Marktrisiko, geht es so nicht." (Lender III)</i>
Estimator related	<ul style="list-style-type: none"> - <i>"We've had even in my experience in the last couple years we had a solar project that the costs were lower than the anticipated. In this case, we were skeptical about the engineer's forecast." (Investor I)</i> - <i>"We had a toll road as well that was a merchant bridge and part of it was financial crisis, but that was the scenario, where for instance we kept in a lot of equities in the beginning because the lenders were worried and as it turned out, the traffic was much better than planned." (Investor I)</i> - <i>"On the other side I have been involved in toll roads and ports where the forecast and the numbers were not nearly as strong and therefore, you know, you were offside on your cover ratios and then the scenarios that we looked at were, we're looking at okay,"</i>

Risk factor category	Quote in original interview language
	<p><i>chipping more, chipping in more equity and damming up the dividends, you know, potentially extending the term so that the amortization if it had an amortization facility could be managed a bit.” (Investor I)</i></p> <ul style="list-style-type: none"> - <i>“Wir hatten jetzt zum Beispiel einen Flughafen in [Land] und [Land], die liefen jetzt auch nicht so wie erwartet. In den Gegenden versucht man dann eher das Risiko zu minimieren und dann die Deals eher nicht zu machen. Sondern man steigt in die Märkte rein, wo man sagt, oh das läuft gut, davon ist man überzeugt. Das heißt aber nicht, dass man den Deal grundsätzlich nicht machen würde. Aber man hat eine etwas negativere Einstellung, weil man negative Erfahrung in dem Bereich hatte. Beim Asset oder über die Region halt.” (Lender I)</i> - <i>“Also zu gut bewertet, wo Sie es häufig haben, bei Projekten, die z.B. eben Verkehrsströme wurden häufig viel zu gut bewertet. Also das haben sie in Europa geschafft, sie aber global, dass z.B. ich habe es ja mit dem Herrentunnel geschildert, wissen Sie, dass man einen Tunnel macht und sagt, ist ja ideal für die Stadt. Die Leute werden den sicher super nutzen, und dann feststellt, tatsächlich ist der Verkehrsstrom nur ein Teil, also nicht grad ein Bruchteil, aber doch ein enttäuschender Teil von dem was man angenommen hat.” (Lender III)</i> - <i>“Man muss sich schon täglich oder wöchentlich an die Nase fassen und sich sagen, Moment einmal, wenn ich mich stark für etwas einsetze, liegt es an dem, dass ich natürlich geprägt bin von 20 Jahren. Hat sich die Welt nicht geändert? Aber da sind Sie wie gesagt, also zumindest wenn alle aufmerksam sind... heutzutage kriegt man immer neue Elemente eingespielt... schauen Sie... deshalb, weil wir 20 Jahr Flughäfen gemacht haben, kann ich natürlich nicht sagen alle Flughäfen sind einfach gut und deshalb... und da halte ich daran fest. Umgekehrt sollte man natürlich auch nicht, wenn wir einmal schlechte Erfahrungen mit was gemacht haben, dann immer zu sagen alle sind schlecht. Das erlebe ich natürlich durchaus auch auf der Seite vom Kredit, wenn einmal etwas schwieriger wurde, wird sehr häufig pauschalisiert“ (Lender III)</i> - <i>“Selbstüberschätzung, ja gut dadurch, dass Sie heute kaum mehr was alleine machen, ist es so, dass Sie in einem ganzen Systemraster arbeiten. Früher war es tatsächlich noch so, ich habe noch ein Fall, der übrigens geklappt hat, und den kann ich auch erwähnen. Da wurde ich nach Weihnachten, bin ich nach Portugal geflogen, weil irgendwas nicht geklappt hat... und dann mit dem Anruf bei meinem Bereichsleiter und einem Anruf beim zuständigen Vorstand sollte ich da eine große Kreditsumme unterschreiben, und dann die retten. So etwas wäre heute unmöglich- ich wüsste gar nicht wie das funktionieren sollte. Würde sich auch kein Mensch mehr drauf einlassen. Kein Vorstand, gar niemand mehr.“ (Lender III)</i> - <i>“Wissen Sie, natürlich muss ein Investor, wenn der zu mir kommt, von seiner Sache voll überzeugt sein. Der muss auch eine optimistischere Einstellung haben, weil, sonst würde er das nie machen. Sein Vorteil ist natürlich, dass wenn die Sache gut geht, er hoffentlich damit auch deutlich besser verdient. Ich als Banker, schauen Sie, ich hab ja nur eine Marge von 1 bis 2 Prozent, davon muss ich Kosten decken, davon muss ich Eigenkapitalvorsorge treffen, und dann muss ich das Risiko abfedern und da sehen Sie schon, wenn ich jetzt sage das ist ein gutes Prozent, dann bleibt vielleicht ein halbes Prozent übrig, das können Sie sich vielleicht ausmalen, wie lange ich das halbe Prozent verdienen muss, wenn ich bei meiner Kreditsumme nur 30 Prozent Verlust habe. In der Infrastruktur haben wir ja zum Glück wenig Komplettausfälle, aber mit dem halben Prozent, da geht das 60 Jahre bis ich das ausgeglichen habe.“ (Lender III)</i>
Financial/ economic	<ul style="list-style-type: none"> - <i>“We financed a port with one of the German banks and it was right pre-financial crisis and therefore all the forecast of EBITDA growth and all the rest... because it was sort of financed pretty exact at the multiple... because the view was that the business would continue to grow and that would work. There were... some of the first assumptions, just did not pan out and therefore you had an underperforming loan.” (Investor I)</i> - <i>“Greenfield is particularly tough, because those are clearly based on just assumptions, if it is new then it’s a question of selling the story that there be increase of production for whatever reason, you get back to a port or an airport, you get more traffic because you had a different marketing strategy or they were macrodynamic factors in play, you know, and clearly macrodynamic factors will have a role. So, when you have a great financial crisis, the first boom in infrastructure was followed by 2006, 2007 and top liquidity and lenders were looking at even, you know, GDP related assets as being very stable and when we had a recession of one of these assets, I know I had a 10% decrease as opposed to 5 or 10% increase in EBITDA, and when some of these projects were being borrowing at 10 or 15 or even 20 times EBITDA you are way off your company targets.” (Investor I)</i> - <i>“I would add foreign currency exposure to your typology (market).” (Investor II)</i> - <i>“It is actually interesting so it happened the same with ethane crackers. In 2011 and 2012 there were a lot of ethane crackers in South America and with the event of shell gas in the US they actually moved all those million-dollar projects from Chile to Huston...” (Consultant III)</i>

Risk factor category	Quote in original interview language
	<ul style="list-style-type: none"> - <i>"Toll Roads haben wir früher auch gemacht, da wurde dann festgestellt, dass das Verkehrsrisiko doch schwieriger einzuschätzen ist, als wie das gedacht ist. Heutzutage machen die meisten noch Toll Roads wenn existierender Verkehr besteht, aber nicht mehr bei neuen Straßen."</i> (Lender II) - <i>"Dann haben Sie Flughäfen, da können Sie die Verkehrsrisiken auch gut einschätzen."</i> (Lender II) - <i>"Wo es halt schiefgelaufen ist, war immer, also oft bei Mautstraßen, oder bei dem Maut-Tunnel und Herrentunnel... in Deutschland, da waren einfach die Verkehrsprognosen zu optimistisch, das Ding wurde in der Zeit gebaut, zu dem Preis und so weiter und das war... nicht das Problem, einfach die... das Verkehrsaufkommen wurde überschätzt. Und das finden Sie in Portugal, das finden Sie in Spanien und in anderen Ländern auch. Also wie viel Straße ist sehr, sehr schwierig einzuschätzen, deswegen macht das heute auch kaum noch einer... Die Sponsoren haben eine Verkehrsprognose, wir als Bank habe dann meistens einen viel konservativeren, tieferen Base Case... und hinterfragen dann die Annahmen, aber dennoch trotz allem, waren Verkehrsstudien viel zu optimistisch."</i> (Lender II) - <i>"Lübeck, der Herren Tunnel. Bauzeit perfekt gelaufen mit dem Tunnel. Kein Problem. Kosten eingehalten. Alles. An was hat es gefehlt? Der Verkehrsfluss war enttäuschend. Also musste man die Kredite restrukturieren..."</i> (Lender III) - <i>"Chicago Highway bei einer, und die andere war die große Verbindungsstraße da von Chicago sozusagen an die Ostküste, alle Banken begeistert gemacht, oder viele Banken, mit entsprechende Sponsoren, und dann kam Amerika in die Wirtschaftskrise, der Verkehr ist massiv eingebrochen."</i> (Lender III)
Force majeure	<ul style="list-style-type: none"> - <i>"I was working in a project. We were in a JVs with [company name] doing a refinery in [country]. Because we have a mine already there. So, the site is there. They are mining for decades, it is going well but the hurdle rate, the internal hurdle rate that they would put into the NPV was based also on the country risk and this was pre-Ebola right. This was 2012, 2013..."</i> (Consultant I)
Labor	/
Legal/political	<ul style="list-style-type: none"> - <i>"I would add changes in the law, and risk of concessional tax rebate ending to your typology. This is if delays expire the tax rebates for any reason (delay in startup, etc.)."</i> (Investor II) - <i>"Law können wir nicht beeinflussen. Kann vielleicht der öffentliche Part eines Projektes beeinflussen, dann sollte er dieses Risiko nehmen, aber sicher nicht der Private."</i> (Lender II)
Operation and maintenance	<ul style="list-style-type: none"> - <i>"I would add (for power plants) risk of fuel availability, off taker agreement risk (credit worthiness of the off taker) to the typology."</i> (Investor II) - <i>"Wir hatten ja auch mal, so eine Art von Müllverbrennungslage vor ein paar Jahren finanziert, es war keine richtige Verbrennung durch Feuer, sondern, ich kenn mich nicht so ganz aus, aus irgendwelchen Bakterien, oder sowas. Die haben dann halt nicht so schnell den Müll weggefressen wie es sein sollte... Also bei Müllverbrennungsanlagen kommt es extrem darauf an, wie viel Müll wird angeliefert. Dann erzeugen die halt auch Energie. Du weißt halt nie wie viel Müll da wirklich kommt. Das ist schwierig vorherzusagen..."</i> (Lender I) - <i>"Wind können Sie auch relativ gut messen und einschätzen, wie die Kapazität da ist. Energie mit Langfristverträgen, Lieferverträgen und Abnahmeverträgen, immer, wenn Sie langfristige Abnahmeverträge haben, können Sie über Projektfinanzierung nachdenken."</i> (Lender II) - <i>"Dann haben Sie natürlich Öl und Gas, auch seit vielen, vielen Jahren, Spezialisten, die halt feststellen oder sich zutrauen zu sagen, wie viel Ölvorkommen in einem Ölfeld drin sind und daraus dann auch abstellen."</i> (Lender II) - <i>"We did one for a steel company in the US and... This was to install new melting capacity for pipes for oil and gas, right? And you know there is like no revenue. There is like no projection that this thing is going to run more than fifteen percent at the time. So, from the utilization standpoint it makes no sense. We just turned it off."</i> (Consultant II)

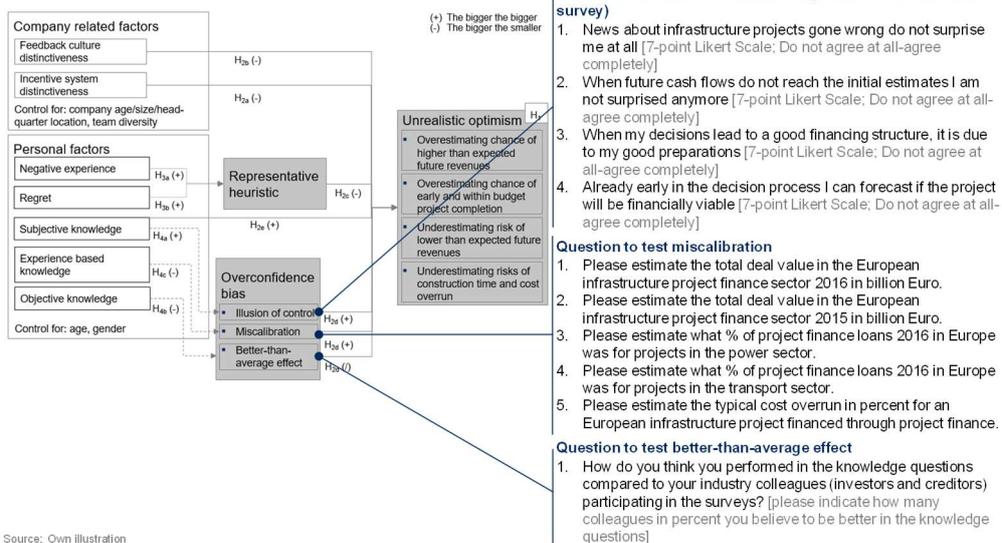
Survey about cognitive biases in decision making

Figure 23: Survey - measurement of unrealistic optimism



Source: Own illustration

Figure 24: Survey - measurement of overconfidence bias



Source: Own illustration

Figure 25: Survey - measurement of representative heuristic

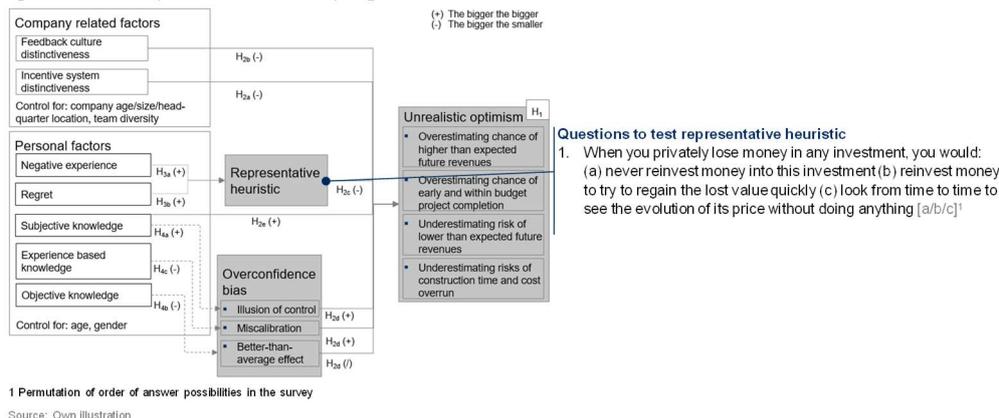


Figure 26: Survey - measurement of company factors

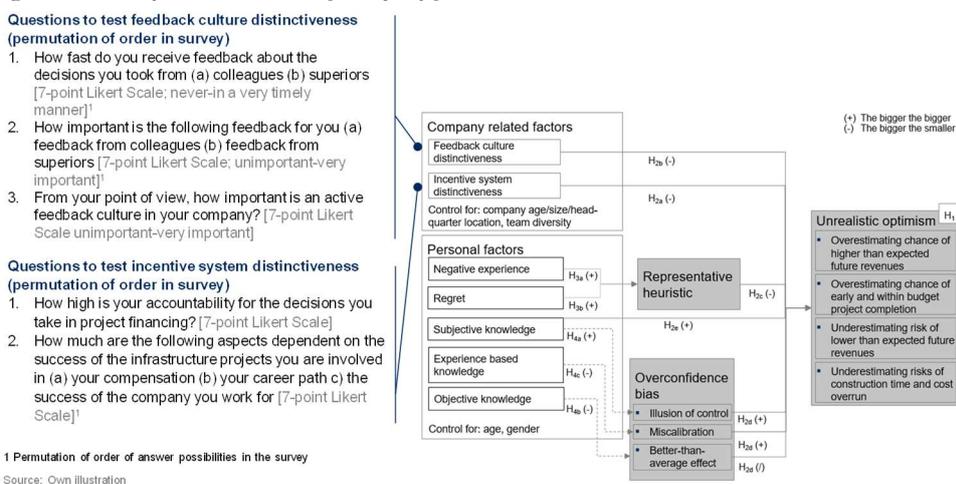


Figure 27: Survey - measurement of personal factors (1/2)

Questions to test prior negative experience

1. Have any projects you were involved in turned out below your expectations (lower rate of return, later completion date, lower revenue stream)? [7-point Likert Scale; never-often]
2. Do you know of projects of colleagues or industry peers that turned out below their expectations (lower rate of return, later completion date, lower revenue stream)? [7-point Likert Scale; none-many]

Question to test regret about previous decisions

1. Do you regret any project financing related decisions you have taken in the past? [7-point Likert Scale; not at all-yes definitely]

1 Permutation of order of answer possibilities in the survey
Source: Own illustration

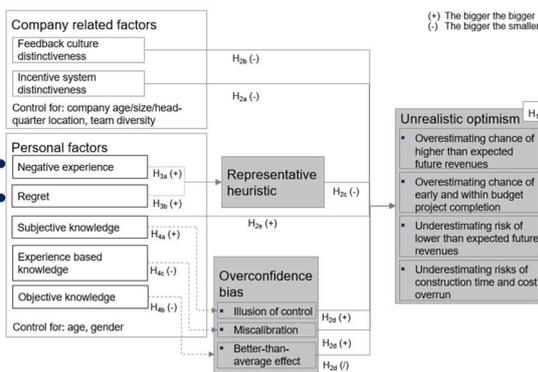


Figure 28: Survey - measurement of personal factors (2/2)

Question to test subjective knowledge

1. How do you rate yourself in the following dimensions in comparison to other decision makers (lenders and investors) involved in infrastructure project finance: (a) skills (b) performance (c) success [7-point Likert Scale, much worse than average-much better than average]

Question to test experience based knowledge

1. On which hierarchy level are you in your company? [analyst/associate, lower management, middle management, senior management]
2. How many years of job experience do you have in total? [Free field]
3. How many years of job experience do you have in the area of infrastructure project finance? [Free field]
4. How many years of job experience do you have in making and being responsible for project financing decisions? [Free field]

Question to test objective knowledge

1. Please estimate the total deal value in the European infrastructure project finance sector 2016 in billion Euro.
2. Please estimate the total deal value in the European infrastructure project finance sector 2015 in billion Euro.
3. Please estimate what % of project finance loans 2016 in Europe was for projects in the power sector.
4. Please estimate what % of project finance loans 2016 in Europe was for projects in the transport sector.
5. Please estimate the typical cost overrun in percent for an European infrastructure project financed through project finance.

1 Permutation of order of answer possibilities in the survey
Source: Own illustration

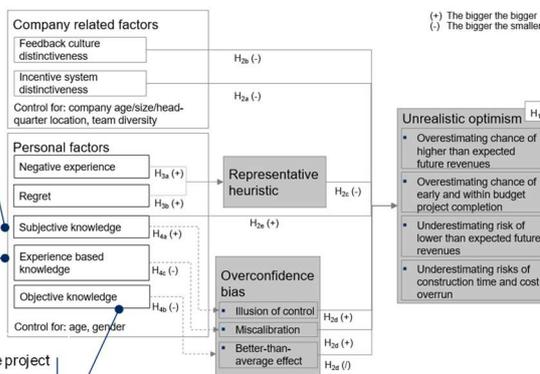


Figure 29: Survey - measurement control factors

Question to test appropriateness of participants

1. Have you ever been involved in financing decisions concerning a large infrastructure/energy project (>75 million Euro) through a special purpose vehicle (project finance)?
2. To which stakeholder group do you belong to when it comes to the financing of infrastructure projects? Lender (credit risk management), lender (credit risk sales), investor (public), investor (private), other

Questions to test company related controls

1. How diverse is your team regarding job experience, age, academic background, cultural background? [7-point Likert Scale]
2. How high is the percentage of males in your team? [100% Scale]
3. Please indicate how many employees the company you work for has globally.
4. When was the company you work for founded?
5. Where does the company you work for have its headquarter?

Question to personal related controls

1. Please indicate your gender.
2. How old are you?

Source: Own illustration

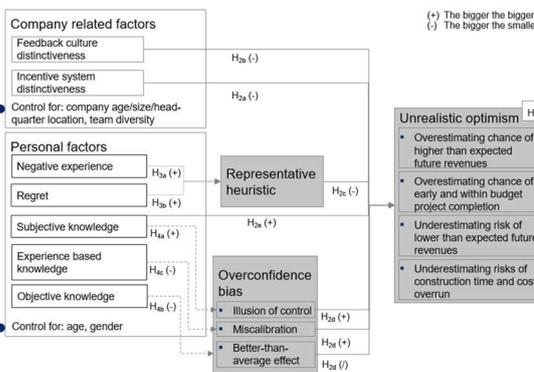


Table 24: Expert interview relevant quotes to reduce causal model on individual decision maker cognitive biases

Category	Quote in original interview language
Unrealistic optimism	<ul style="list-style-type: none"> - <i>“You do have institutional bias as well as, what I would say is, just the fundamental risk of human being not wanting to admit a mistake and take a write off so in certain cases and I’ll use an example, you know, port, we financed a port with one of the German banks and it was right pre-financial crisis and therefore all the forecast of EBITDA growth and all the rest... cause it was sort of financed pretty exact at the multiple... because the view was that the business would continue to grow and that would work. There were... some of the first assumptions, just did not pan out and therefore you had an underperforming loan, you are outside your covenant and I think the first inclination is the banks will want to work with you because no one wants to come and go into a default situation, no one wants to go and write down their loan, so the first bias will be to try taking, you know, a sober but optimistic view that things will get better, i.e., this is the last of the construction overrun, this is the last of the delays, the growth is slow but it eventually will go back, and therefore in those cases you might, you know, the bank will put pressure on the lender on equity owners to get them more equity but the equity owners at the same time will put pressure on the bank, say, okay, can we do, can we extend, can we have waived off the covenant - things like that, so, so, so that is certainly something that I would say is probably the most common scenario is that whether willfully or just to try avoiding the messy scenario of a default, that there will be accommodation on the lender side.” (Investor I)</i> - <i>“We’ve had even in my experience in the last couple years we had a solar project for which the costs were lower than the anticipated. In this case, we were skeptical about the engineer’s forecast, so we, as owners, and we are a public company so we didn’t want to leverage into the hills, as owners we put less debt in than the developers were suggesting because we assumed we would get less production and then after a couple of years, the plants were doing better than planned, so we, you know, we increased the leverage, increased the term, lowered the interest rates and you know, pulled out the capital. We had a toll road as well that was a merchant bridge and part of it was financial crisis, but that was the scenario, where for instance we kept in a lot of equities in the beginning because the lenders were worried and as it turned out, the traffic was much better than planned, so right now I think they are about to do a refinancing, I am no longer involved in the project, but they will be able to increase leverage financially.” (Investor I)</i> - <i>“I mean for basic ones, though sometimes it’s just cost, cost estimates are too high or they are delayed, but if it’s a volume driven deal either because of production or traffic then it could be that your forecasts were wrong including... greenfield is particularly tough, because those are clearly based on just assumptions, if it is new then it’s a question of selling the story that there be increase of production for whatever reason, you get back to a port or an airport, you get more traffic because you had a different marketing strategy or they were macrodynamic factors in play, you know, and clearly macrodynamic factors will have a role, so when you have a great financial crisis, the first boom in infrastructure was followed by 2006, 2007 and top liquidity and lenders were looking at even, you know, GDP related assets as being very stable and when we had a recession of one of these assets, I know I had a 10% decrease as opposed to 5 or 10% increase in EBITDA and when some of these projects were being borrowing a 10 or 15 or even 20 times EBITDA you are way off your company targets.” (Investor I)</i> - <i>“Wo es halt schief gelaufen ist war immer also oft bei Mautstraßen, oder bei dem Maut-Tunnel und Herrentunnel... in Deutschland da waren einfach die Verkehrsprognosen zu optimistisch, das Ding wurde in der Zeit gebaut, zu dem Preis und so weiter und das war... nicht das Problem, einfach die... das Verkehrsaufkommen wurde überschätzt. Und das finden Sie in Portugal, das finden Sie in Spanien und in anderen Ländern auch. Also wie viel Straße ist sehr, sehr schwierig einzuschätzen, deswegen macht das heute auch kaum noch einer... Die Sponsoren haben eine Verkehrsprognose, wir als Bank habe dann meistens einen viel konservativeren, tieferen Base Case... und hinterfragen dann die Annahmen, aber dennoch trotz allem, waren Verkehrsstudien viel zu optimistisch.” (Lender II)</i> - <i>“Also zu gut bewertet wo Sie es häufig haben, bei Projekten die, z.B. eben Verkehrsströme wurden häufig viel zu gut bewertet. Also das haben sie in Europa geschafft, sie aber global, dass z.B. ich habe es ja mit dem Herrentunnel geschildert, wissen Sie, dass man ein Tunnel macht und sagt, ist ja ideal für die Stadt. Die Leute werden den sicher super nutzen, und dann feststellt tatsächlich ist der Verkehrsstrom nur einen Teil, also nicht grad ein Bruchteil, aber doch ein enttäuschender Teil von dem was man angenommen hat.” (Lender III)</i> - <i>“Mir ist es z.B. mal passiert Bau eines Protonentherapiezentrum, wunderbare Anlage, ...Protonen, zum Behandlung von Krebs, von Tumoren. Damals hat ein direkter Freund in der Bank Hirntumor gehabt, und ich hab gedacht Mensch wie kann man dem Kerl helfen. Da kannst du das doch mal machen. Selbst ich war... die technische Idee war toll. Gab aber schon welche in Amerika mit der Technik. Die die hier anbieten wollten, gab es aber noch nicht. Und da ist dann auch passiert, was Sie sagen, Bauzeitverlängerung eingetreten, das Ding ist nicht recht fertig geworden, hat eigentlich... ich glaub man kann sagen selbst bis heute nie richtig funktioniert, war also von dem her enttäuschend. Und da</i>

Category	Quote in original interview language
	<i>muss man sagen, wenn man das nur ganz kühl entschieden hätte, hätten wir das wahrscheinlich nicht angehen dürfen.“ (Lender III)</i>
Representative heuristic	<ul style="list-style-type: none"> - <i>“Wenn man solche Projekte hat, die dann halt nicht so gut laufen, dann sind wir intern bei Banken schon negativen eingestellt. Dann machen wir solche Projekte eher nicht, oder sind weniger kompromissbereit, wenn man halt schlechte Erfahrungen hat.“ (Lender I)</i> - <i>“Beispiel, wir hatten ja auch mal, so eine Art von Müllverbrennungslage vor ein paar Jahren finanziert, es war keine richtige Verbrennung durch Feuer, sondern, ich kenn mich nicht so ganz aus, aus irgendwelchen Bakterien, oder sowas. Die haben dann halt nicht so schnell der Müll weggefressen wie es sein sollte. Das war halt schlecht, entsprechend ist die Bank dann jetzt eher anfälliger wenn die Projekte hat, die da irgendwo waren, dass sie es ungern wieder finanziert.“ (Lender I)</i> - <i>“Wir hatten jetzt zum Beispiel einen Flughafen in [Land] und [Land], die liefen jetzt auch nicht so wie erwartet. Und den Gegenden versucht man dann eher das Risiko zu minimieren und dann die Deals eher nicht zu machen. Sondern man steigt in die Märkte rein, wo man sagt, oh das läuft gut, davon ist man überzeugt. Das heißt aber nicht, dass man den Deal grundsätzlich nicht machen würde. Aber man hat eine etwas negativere Einstellung, weil man negative Erfahrung in dem Bereich hatte. Beim Asset oder über die Region halt.“ (Lender I)</i> - <i>“Man muss sich schon täglich oder wöchentlich an die Nase fassen und sich sagen, Moment einmal, wenn ich mich stark für etwas einsetze, liegt es an dem, dass ich natürlich geprägt bin von 20 Jahren. Hat sich die Welt nicht geändert? Aber da sind Sie wie gesagt, also zumindest wenn alle aufmerksam sind... heutzutage kriegt man immer neue Elemente eingespielt... schauen Sie... deshalb, weil wir 20 Jahr Flughäfen gemacht haben, kann ich natürlich nicht sagen alle Flughäfen sind einfach gut und deshalb... und da halte ich daran fest. Umgekehrt sollte man natürlich auch nicht, wenn wir einmal schlechte Erfahrungen mit was gemacht haben, dann immer zu sagen alle sind schlecht. Das erlebe ich natürlich durchaus auch auf der Seite vom Kredit, wenn einmal etwas schwieriger wurde, wird sehr häufig pauschalisiert.“ (Lender III)</i>
Overconfidence	<ul style="list-style-type: none"> - <i>“Selbstüberschätzung, ja gut dadurch, dass Sie heute kaum mehr was alleine machen, ist es so, dass Sie in einem ganzen Systemraster arbeiten. Früher war es tatsächlich noch so, ich habe noch ein Fall, der übrigens geklappt hat, und den kann ich auch erwähnen. Da wurde ich nach Weihnachten, bin ich nach Portugal geflogen, weil irgendwas nicht geklappt hat... und dann mit dem Anruf bei meinem Bereichsleiter und einem Anruf beim zuständigen Vorstand sollte ich da eine große Kreditsumme unterschreiben, und dann die retten. So etwas wäre heute unmöglich- ich wüsste gar nicht wie das funktionieren sollte. Würde sich auch kein Mensch mehr drauf einlassen. Kein Vorstand, gar niemand mehr.“ (Lender III)</i>
Difference between lenders and investors cognitive biases	<ul style="list-style-type: none"> - <i>“Wir haben interne Rating Tools, wo wir dann halt Zahlen eingeben müssen und dann halt auch qualitative Faktoren, sowie Standort, glauben wir da dran, Kosten Controlling, Management Qualität, da kann man so zwischen sehr gut und mangelhaft eingeben. Und diese qualitativen und quantitativen Faktoren ergeben dann am Ende eine Rating Note.“ (Lender I)</i> - <i>“Wir wollen natürlich den Kredit rausgeben, weil wir haben natürlich auch unsere Ziele, je mehr wir rausgeben an Krediten, desto besser ist es für die Marktseite.“ (Lender I)</i> - <i>“Also marktseitig darf man natürlich nie voreingenommen sein, weil du halt ja versuchst möglichst viele Kredite zu machen. Das ist ja auch deine Zielvorgabe. Das ist ja dann jetzt egal ob es dann 100% läuft oder nicht, aber du musst halt deine Ziele auch irgendwie erreichen.“ (Lender I)</i> - <i>“Wissen Sie natürlich muss ein Investor, wenn der zu mir kommt, von seiner Sache voll überzeugt sein. Der muss auch eine optimistischere Einstellung haben, weil sonst würde er das nie machen. Sein Vorteil ist natürlich, dass wenn die Sache gut geht, er hoffentlich damit auch deutlich besser verdient. Ich als Banker, schauen Sie, ich habe ja nur eine Marge von 1 bis 2 Prozent, davon muss ich Kosten decken, davon muss ich Eigenkapitalvorsorge treffen, und dann muss ich das Risiko abfedern und da sehen Sie schon, wenn ich jetzt sage das ist ein gutes Prozent, dann bleibt vielleicht ein halbes Prozent übrig, das können Sie sich vielleicht ausmalen, wie lange ich das halbe Prozent verdienen muss, wenn ich bei meiner Kreditsumme nur 30 Prozent Verlust habe. In der Infrastruktur haben wir ja zum Glück wenig Komplettausfälle, aber mit dem halben Prozent, da geht das 60 Jahre bis ich das ausgeglichen habe.“ (LenderII)</i> - <i>“I think the bankers would have a different bias [than investors]. If the price is higher, barring better cash flows, additional debt will reduce the credit metrics and worsen the riskiness of the loan. An equity investor may be more willing to take a lower equity return to either reduce financing risk of get the project. So, I would believe that there would be different biases.“ (Investor I)</i>

Statistical tables

Table 25: Pearson's correlations for unrealistic optimism regarding risk of construction time and cost overrun and control variables

Variable	Unrealistic optimism risk time/cost overrun	Gender	Age	Company age	Company size
Gender	-0.124				
Age	-0.144	0.013			
Company age	0.039	0.016	0.138		
Company size	-0.001	-0.091	-0.023	-0.210	
Team diversity	0.094	-0.023	0.103	0.157	-0.172

Note: *= statistically significant at $p < 0.05$ level

Table 26: Pearson's correlations for unrealistic optimism regarding risk of lower than expected future revenues and control variables

Variable	Unrealistic optimism risk revenues	Gender	Age	Company age	Company size
Gender	-0.058				
Age	-0.078	0.013			
Company age	0.145	0.016	0.138		
Company size	0.021	-0.091	-0.023	-0.210	
Team diversity	-0.040	-0.023	0.103	0.157	-0.172

Note: *= statistically significant at $p < 0.05$ level

Table 27: Pearson's correlations for unrealistic optimism regarding chance of early and within budget completion and control variables

Variable	Unrealistic optimism chance early/within budget completion	Gender	Age	Company age	Company size
Gender	0.085				
Age	0.037	0.013			
Company age	-0.250*	0.016	0.138		
Company size	0.172	-0.091	-0.023	-0.210	
Team diversity	-0.015	-0.023	0.103	0.157	-0.172

Note: *= statistically significant at $p < 0.05$ level

Table 28: Pearson's correlations for unrealistic optimism regarding chance of higher than expected future revenues and control variables

Variable	Unrealistic optimism chance revenues	Gender	Age	Company age	Company size
Gender	0.016				
Age	0.169	0.013			
Company age	-0.019	0.016	0.138		
Company size	0.150	-0.091	-0.023	-0.210	
Team diversity	0.019	-0.023	0.103	0.157	-0.172

Note: *= statistically significant at $p < 0.05$ level

Table 29: Pearson's correlations for hit rate and control variables

Variable	Hit rate	Gender	Age	Company age	Company size
Gender	-0.179				
Age	-0.121	0.013			
Company age	0.047	0.016	0.138		
Company size	-0.067	-0.091	-0.023	-0.210	
Team diversity	-0.019	-0.023	0.103	0.157	-0.172

Note: *= statistically significant at $p < 0.05$ level

Table 30: Pearson's correlations for illusion of control and control variables

Variable	Illusion of control	Gender	Age	Company age	Company size
Gender	0.059				
Age	0.023	0.013			
Company age	0.156	0.016	0.138		
Company size	-0.151	-0.091	-0.023	-0.210	
Team diversity	0.161	-0.023	0.103	0.157	-0.172

Note: *= statistically significant at $p < 0.05$ level

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