

Concept of a quantitative project selection model for PPP projects

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Abstract

Project selection decision-making in construction companies that deal with life-cycle oriented and equity-intensive projects (e.g. Public Private Partnership (PPP) projects) is still dominated by intuition rather than structured rational processes. At the same time, companies from related business fields, like infrastructure investors, have been successfully using quantitative models to support their decision processes for years. Hence, there is room for improvement in the project selection process of construction companies.

This paper proposes the concept of a new quantitative model to guide the project selection process of construction companies, using PPP projects as an example. The introduced PPP project selection model (PPP-PS-model) combines Modern Portfolio Theory (MPT) with multi-objective optimization. The PPP-PS-model is divided into three modules. Each module represents a self-contained part of the overall model. In a first step, the company's current PPP project portfolio is analyzed in order to determine the risk-return profile of every single project. To this end, quantitative parameters for the evaluation of both risks and return need to be identified in advance. Secondly, a target portfolio for the construction firm is calculated by applying MPT. Hence, this module quantitatively describes the future objective of the company's PPP project portfolio. Its evaluation is based on the analysis of the current portfolio (step 1) as well as the corporate strategy and economic constraints. Finally, a multi-objective optimization algorithm is applied. As a result, this algorithm provides a hypothetical optimal PPP project, which reduces the difference between the evaluated current portfolio (step 1) and the calculated target portfolio (step 2) as far as possible. This hypothetical optimal project serves as a reference, in order to select a new PPP project.

The authors are convinced that rational decision-making and project selection processes based on quantitative analyses will improve the performance of PPP project portfolios. As a result, the PPP project portfolios of construction firms will contain a higher number of suitable projects. To this end, the new PPP-PS-model supports construction companies to better meet their commercial goals.

Keywords: decision-making, life-cycle orientation, Modern Portfolio Theory, operations research, project selection.

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1. Introduction

Companies in demand-driven markets need to select the most appropriate projects out of all projects announced to be economically successful. The Public Private Partnership (PPP) market within the construction industry represents such a demand-driven market. Therefore, construction firms dealing with PPP projects rely on appropriate models which ideally support their project selection decisions.

Generally, project selection processes are predetermined by the corporate strategy, which defines e.g. business areas of interest for the company, and by the competitive strategy (Girmscheid (2010)). Nevertheless, decision-makers need to decide in their specific business unit (BU), for which project(s) they would like to apply. This project selection decision is particularly important, if the BU deals with PPP projects. This distinct type of project is characterized by immense bid costs in comparison to ordinary construction projects. In addition, PPP projects offer great potential regarding return on investments next to substantial risk exposure. Due to these facts, it is astonishing that PPP project selection processes in construction companies are still dominated by intuition rather than structured rational processes.

This paper proposes the concept of a new quantitative model to guide the ordinary project selection process of construction companies dealing with a PPP project portfolio.

2. PPP projects – Extended scope of service demands for an improved project selection process

2.1 Problem specification

The European Commission (2012) pointed out, that the “markets of the EU construction sector and the sector itself are highly fragmented...” (p4). Many different competitors with mostly small shares are determining the competitive market especially in traditional business segments (e.g. building construction). Furthermore, the composition of bidders, which are competing for the same contract, is commonly very heterogeneous. Companies of varying sizes and interests frequently applied and (still apply) for the same projects, which regularly leads to competitive disadvantages for bigger companies, as they need to cover higher overhead costs (Girmscheid (2000)). Consequently, many big construction companies both in Switzerland (e.g. Implenia, Marti, Piora) and abroad (e.g. Hochtief, Bilfinger Berger, Strabag, Vinci, Bouygues, Balfour Beatty, ACS, FCC) took actions against the ongoing price competition in the traditional business fields. These companies drift more and more towards becoming total service providers, trying to participate either in several project phases or the whole life-cycle of a building. According to the increasing life-cycle orientation, these companies offer a more comprehensive range of service. This range regularly includes construction, design, operation, maintenance and finance, having a positive impact for both the companies involved and the environment. These positive impacts are confirmed by a current study of the European Commission (2012), which points out that these distinct types of projects have „the potential to contribute to a competitive construction sector and to the development of a resource and energy efficient building stock...” (p12). On the other hand,

the extension of the range of service and the naturally longer contract duration of life-cycle oriented projects (e.g. PPP projects) lead to a significant increase in the magnitude of risks taken by the construction companies involved. As a consequence, construction companies that deal with these “high risk projects” increasingly emphasize considerations regarding risk management (Girmscheid (2007b), Girmscheid (2007c)), risk allocation (Girmscheid (2011a)) and risk diversification (Girmscheid and Busch (2008)) in their portfolio. However, there still is a lack of appropriate, quantitative instruments to support decision makers in selecting those PPP projects, which perfectly complement the risk and return profile of a company’s current portfolio. As a consequence, the actual process of decision-making in PPP project selection is mainly determined by the intuition of the company’s management rather than structured rational processes. Chapter 4 introduces a concept, which aims to improve the current project selection process of construction companies dealing with a PPP project portfolio.

2.2 The importance of an appropriate PPP project selection process

The reasons mentioned below have no claim to completeness, but stress the importance of an appropriate project selection process in construction companies dealing with PPP:

- **High bid costs:** Due to the fact that essential planning services are shifted from the tender authority to the bidders, notable costs arise for the private companies involved. These costs are further increased by the (mandatory) inclusion of several consultants. For instance, seven consultants were commonly mandatory due to specifications of the tender authority or specifications of lenders within the first stage of infrastructure PPP projects (A-models) in Germany. According to Stolze (2008), the average bid costs of all acquired PPP projects within the company Balfour Beatty added up to almost EUR 3,000,000 per project. This average amount can be largely exceeded in case of major infrastructure projects. Therefore, the success rate (i.e. the ratio between tender participations and acquired projects) is of considerable importance for construction companies dealing with a PPP project portfolio.
- **High equity investment:** The construction companies involved in PPP projects (usually) act as sponsors of the project and regularly invest a high amount of equity into a project. According to Weber and Alfen (2010), an “equity ratio (...) between 10 and 30% of the total financing volume of a project depending on its (perceived) risk profile...” (p199) is considered to be normal in this case. Thus, a lot of equity is tied up in one single project and is not available for other investments for a longer period of time.
- **Earnings depend on dividends provided by the SPC:** Usually, a special purpose company (SPC) takes the role of the private partner within a PPP contract. This SPC has to be financially equipped in order to fulfill its “special purpose”. Therefore, it receives debt capital from the lenders as well as equity capital from the sponsors, which are regularly the construction companies involved. If this is the case, the main earnings of these construction companies arise, according to Merna et al. (2010), from their “compensation for equity (which) is dividends (dividends are the amount of

profits paid to the shareholders)...” (p33). Dividends are only distributed, if the SPC makes profit. Furthermore, the debt claims of the lenders must be met, before the sponsors receive money from the SPC. Hence, construction companies that deal with PPP projects need to make carefully considered project selection (i.e. investment) decisions in order to be economically successful.

2.3 State of practice in arranging project portfolios in related business fields

When designing an applicable project selection model, it seems advantageous to make use of “best practice” solutions coming from comparable business areas by adjusting and enhancing the best suited methods to our specific problem. Furthermore, the participation of construction companies in PPP projects goes hand in hand with a broadening of the offered range of service. This offers the opportunity to learn from the experience of companies, which deal (or dealt) with comparable fields of action. Evaluations of related business fields have shown that the financial industry in particular successfully uses Modern Portfolio Theory (MPT) for quite a few years now to support their investment decisions. Furthermore, Wellner (2011) demonstrated that MPT can also be used for real estate investment decisions, which are highly comparable to PPP project investments. Wellner (2011) is convinced that “it is thus possible to implement the findings of the Portfolio Theory in practice and make investment decisions safer and more independent from subjective influences...” (p18). Viezer (2010) even goes one step further and proposes that private equity investors as well, such as construction companies that deal with PPP projects, “may someday find MPT as a useful engine of inquiry...” (p755). These recent findings demonstrate that MPT could contribute to an increase of rationality within the project selection process of construction companies dealing with a PPP project portfolio. Hence, the potential of MPT in construction has to be evaluated with further scrutiny, with special focus on its applicability to the PPP project selection process.

2.4 State of research regarding the applicability of MPT to the project selection in construction companies

The MPT was first developed by Harry Markowitz. Markowitz (1952) stated that the “hypothesis (or maxim) that the investor does (or should) maximize (...) return must be rejected...” (p77). He suggested instead considering both risks and return, where risks should be limited by optimal portfolio diversification. Markowitz’ research concerned the security management in share portfolios and had no ambition of being applicable to other types of investment. Subsequently, most of the research related to MPT focused on implementing the basic findings on various industries and fields. Vergara and Boyer (1977) tried to implement MPT to construction bidding practices and generally stated that “bid decisions can be rationalized...” (p33) by applying this method. Kangari and Boyer (1981) calculated the return of a project by using the net present value (NPV) and compared the portfolio approach with a market model approach. Kangari and Riggs (1988) conducted a “probabilistic approach (...) to show a more realistic approach to the evaluation of correlation” (p168) within the project portfolio. Archer and Ghasemzadeh (1998) introduced a decision support system (DSS) for project portfolio selection, which utilized a computerized project database. Han et al. (2004) focused on big, diversified international construction

companies and provided a practical method based on NPV, return on investment (ROI) and value at risk (VaR) for the selection of new international construction projects. Ravanshadnia et al. (2010) added a fuzzy model, in order to determine the optimal project portfolio of a construction company.

The literature research showed that MPT is applicable for the project selection of construction companies. Nevertheless, two main problems in applying MPT to the project selection in construction companies have been identified. Firstly, the high correlation and therefore the limited diversification in the project portfolio of traditional construction companies have been criticized in several publications. This problem has less influence, if MPT is applied to PPP project portfolios of larger construction firms. The various types of PPP projects (e.g. hospitals, schools, highways, airports) show completely different risk profiles. In addition, the particular risk profile of each project changes over the life cycle. Thus, a PPP project portfolio offers a much bigger potential for diversification than an ordinary portfolio of construction projects. Secondly, many researchers used MPT by adding specific announced projects to the current project portfolio and then compared the risk and return profiles of these various potential future portfolios. These researchers faced the problem of a limited knowledge of the announced projects. The PPP-PS-model presented in this paper uses a completely new approach for identifying an optimal future project. This approach covers the identified problem of limited knowledge and additionally provides a bid strategy.

2.5 Objectives of the new quantitative PPP-PS-model

The objective of this paper is to present a new concept to support the PPP project selection process in construction companies. The PPP-PS-model has to be developed on a quantitative basis, in order to increase the currently limited rationality within the PPP project selection process. Furthermore, the PPP-PS-model aims to achieve the targeted return, while minimizing the risks within the whole PPP project portfolio (and not just for maximizing the return and minimizing the risks of a single PPP project). Therefore, the PPP-PS-model needs to consider the current portfolio and has to determine the specific project that improves the risk-return ratio of this current portfolio as much as possible. To meet this objective, MPT is applied. The practical applicability of MPT is bounded by the limited knowledge of a potential future project. This problem has to be solved by using a new and different approach. Furthermore, the model should provide a bid strategy. In addition, the model needs to include the corporate strategy so to enable a target oriented long-term development of the construction firm.

3. Research methodology

Putting the PPP-PS-model into a broader setting, this specific type of model can be seen as a decision model. Decision models are characterized by evaluating alternatives of action for a specific problem. According to Girmscheid (2007a), the derivation of a decision model follows the constructivist-hermeneutic approach, which has been developed by von Glasersfeld (1996). The quality of decision models is guaranteed by applying the principle of triangulation (Yin (2009)). The application of this principle ensures the (1) viable, (2) valid

and (3) reliable model development. Firstly, the viability of the PPP-PS-model will be guaranteed by designing the model logically deductively. The underlying theory is provided by systems theory (von Bertalanffy (1968)) and cybernetics (Wiener (1992)). Secondly, the validity of the model is ensured by using proven and target oriented mathematical methods such as MPT. Finally, the reliability of the model will be evaluated by conducting both simulations and practical tests.

4. Conception of the new quantitative PPP-PS-model

This new quantitative PPP-PS-model aims for the identification of the specific new PPP project, which achieves the targeted return of a PPP project portfolio while minimizing the risks. To reach this objective, MPT will be applied. Moreover, the practical applicability of MPT in project selection processes will be improved by solving the problem of limited knowledge of new projects at the beginning of the tender stage.

Fig. 1 displays the basic concept of the new quantitative PPP-PS-model. As illustrated, the model consists of three major elements:

1. analysis of the current portfolio,
2. evaluation of the target portfolio and
3. determination of the optimal next project for which a company should apply.

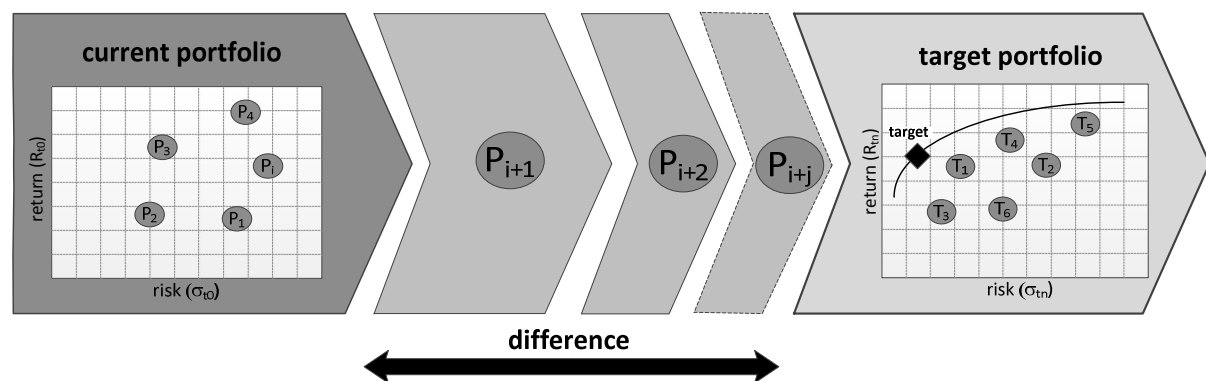


Figure 1: Basic idea of the new quantitative PPP-PS-model

The “current portfolio” symbolizes the actual PPP project portfolio within a construction company. It is characterized by the total return (R_{t0}) and the total risk (σ_{t0}) of every single project. Furthermore, the average percentage of return $R_{t0,m}$ [%] and the average risk $\sigma_{t0,m}$ [%] of the current PPP portfolio as a whole can be calculated.

The “target portfolio” symbolizes the optimal future PPP project portfolio within the same construction company. The target portfolio will be determined by the corporate strategy, taking into account the company’s specific constraints (e.g. risk bearing capacity and the availability of equity). It is characterized by the targeted return of the portfolio (R_{tn} [%]) and the corresponding minimal risk (σ_{tn}) of the PPP project portfolio. The target portfolio will naturally show a better risk-return ratio than the current portfolio:

$$\frac{R_{t0,m}}{\sigma_{t0,m}} < \frac{R_{tn}}{\sigma_{tn}}$$

The determination of an optimal next PPP project ($P_{i+1} = P_{NEW,opt}$), for which a company should apply in a tender procedure, represents the third major element of the model. $P_{NEW,opt}$ is defined as the specific project, which minimizes the difference between the current portfolio and the target portfolio as far as possible. To meet this objective, the following formula needs to reach a minimum, where $R_{t1,m}$ [%] represents the average return and $\sigma_{t1,m}$ [%] the average risk of the PPP portfolio when adding one additional new project:

$$\min \left(\frac{R_{tn}}{\sigma_{tn}} - \frac{R_{t1,m}}{\sigma_{t1,m}} \right)$$

Each of the three major elements forms a separate module within the PPP-PS-model. Subsequently, these three modules are described in further detail.

4.1 Module 1: Analysis of the current PPP project portfolio

According to Busch and Girmscheid (2005), prior to “their acceptance, new risks to be assumed must be aggregated with the already accepted risks from, for example, other projects...” (p784). Consequently, a construction company needs to evaluate the accepted risks before applying for new PPP projects. As MPT constitutes the major instrument in the concept of the new quantitative PPP-PS-model, it is not just the risks that need to be identified but the composition of risks and return (Wellner (2003)). Therefore, every actual PPP project needs to be analyzed regarding its return (achieved + expected) and its associated risks. MPT defines the aggregated risks of every project as variance (σ) of the return. Referring to Girmscheid (2011b), the accumulated risks of a PPP project decrease over the contract period. Furthermore, the accumulated total return (achieved + expected) can be increasingly precisely determined with proceeding contract period because less parameters need to be forecasted (fig. 2). This time-related evaluation of both risks and return of every project allows for the comparison and aggregation of various projects at different stages. This makes MPT increasingly suitable for supporting PPP project selection.

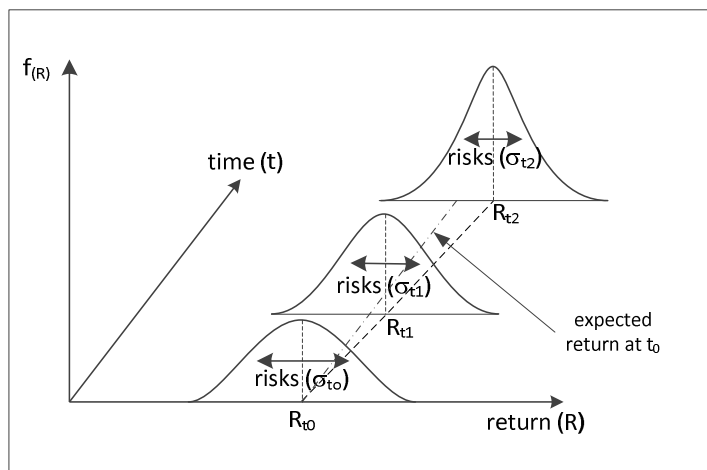


Figure 2: Time-related evaluation of risks and return

Supplementing the aggregated risks and the return (achieved + expected) allows for classifying each project by its current (t_0) risk-return ratio, as displayed in fig. 3.

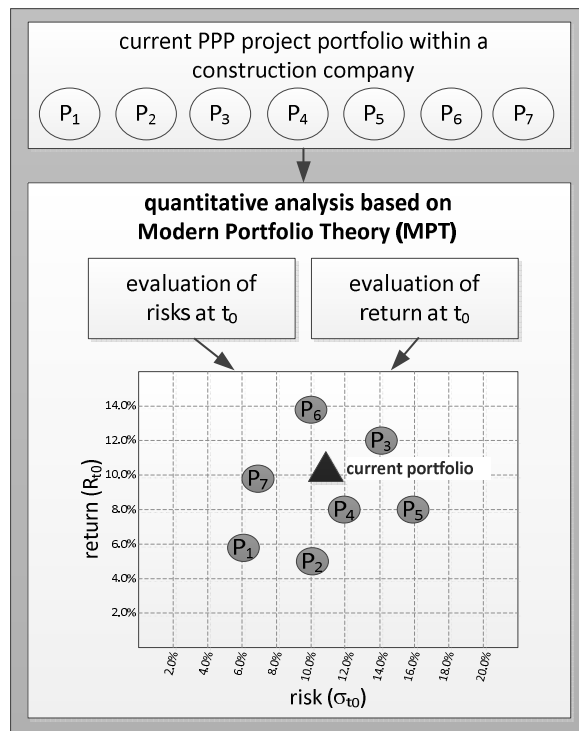


Figure 3: Analysis of the current PPP project portfolio

4.2 Module 2: Determination of an optimal target PPP project portfolio

Module 2 aims to determine an optimal target PPP project portfolio. Therefore, several steps, which refer to the market and to the resource based approach of Girmscheid (2010), need to be conducted. Firstly, the market based view represents the corporate strategy, which is important, due to the “linkage of the company’s strategy and its project selection activities...” (Ravanshadnia et al. (2010), p1083). Developing a target oriented strategy results in the determination of potential target countries and potential types of projects. Secondly, the resource based view leads to constraints, which limit the development of the company in the future. These constraints are, amongst others, the company’s risk bearing capacity, the available equity capital and the company’s technical and economic performance. The market based view, under consideration of the resource based view, allows for the identification of potential fictitious target PPP projects as shown in fig.4. Every identified fictitious project T_n is described by the same characteristic parameters (respectively return and risks) as applied in module 1.

Subsequently, the application of MPT allows for the calculation of an optimal composition of various potential fictitious target PPP projects. To reach this target, an efficient frontier has to be calculated. This efficient frontier represents a curve of all possible compositions of projects that lead to the highest possible return at a specific level of risk (Elton et al. (2011)). The particular point of the curve, which represents the expected average return of the company, is named maximum sharpe ratio portfolio (MSRP). The MSRP represents the specific composition of potential fictitious PPP projects, whose combination bears the

smallest risks in reaching the return objectives. The obtained composition of PPP projects represents the optimal PPP project portfolio of the company.

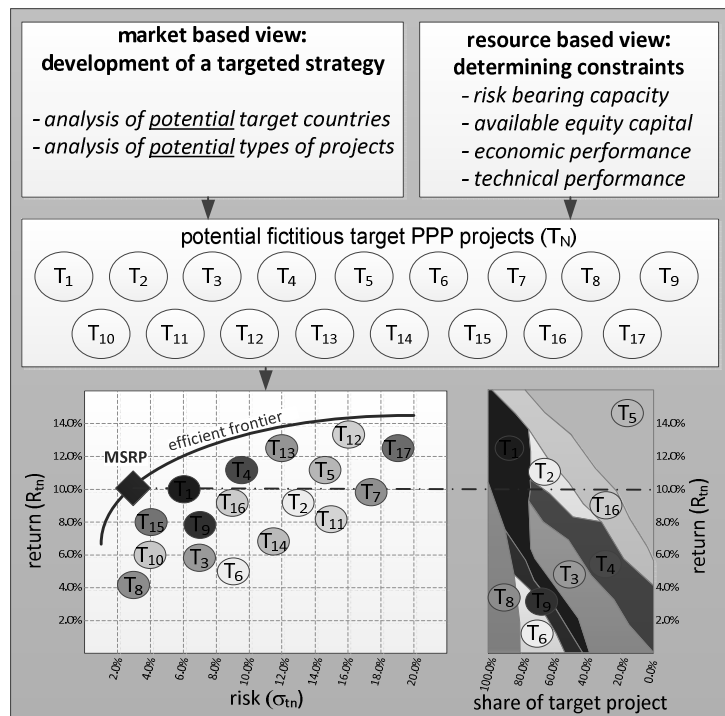


Figure 4: Determination of an optimal target PPP project portfolio

4.3 Module 3: Determination of an optimal new PPP project

Module 3 aims to determine an optimal new PPP project ($P_{NEW,opt}$) and is displayed conceptually in fig. 5. Firstly, the difference between the MSRP and the current PPP project portfolio is calculated. Subsequently, an optimization process based on multi-objective optimization is conducted. This process searches for the fictitious PPP project that reduces the difference between the MSRP and the current portfolio as much as possible. The result obtained is $P_{NEW,opt}$, which signifies the hypothetical next PPP project a company should apply for. Thus, $P_{NEW,opt}$ serves as a reference, in order to select a new PPP project.

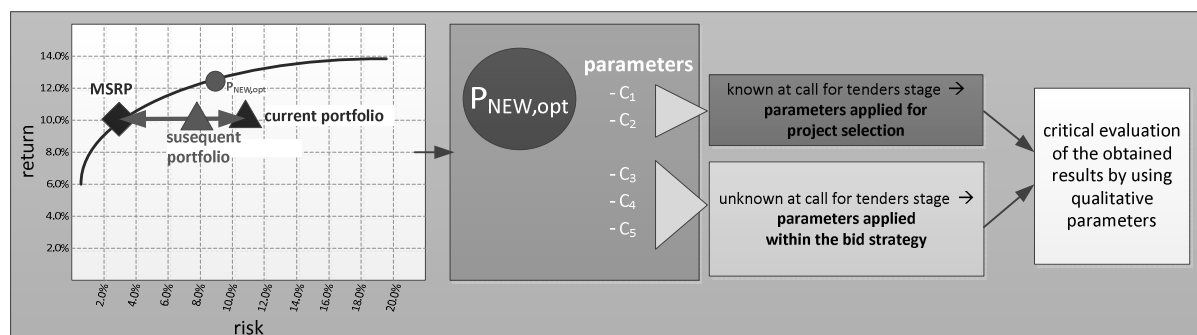


Figure 5: Determination of an optimal new PPP project ($P_{NEW,opt}$)

According to a holistic approach and in order to ensure the quality of the results, the parameters (return + risks), which determine $P_{NEW,opt}$ will be evaluated using qualitative parameters.

To solve the problem of limited knowledge of announced projects at tenders stage, the new PPP-PS-model distinguishes between two groups of parameters that describe $P_{NEW,opt}$:

- **Parameters that are known at call for tenders stage:** These parameters contain project information, which is commonly available when projects are put out for tender. Therefore, these parameters can be used to search for real projects that meet $P_{NEW,opt}$ as closely as possible.
- **Parameters that are unknown at call for tenders stage:** These parameters contain project information, which is commonly not available when projects are put out for tender. Notwithstanding this, these parameters are advantageous for designing and structuring the project in the bid phase. If applied, these parameters ensure that the bid strategy pertaining to the project is in line with the corporate strategy, which has been used to determine the optimal target PPP project portfolio.

5. Conclusion

The realization of this new PPP-PS-model will support construction firms in selecting and structuring highly suitable PPP projects for their specific strategy and their specific current PPP project portfolio. Furthermore, the problem of limited knowledge of projects at tender stage has been solved by following a new approach in applying MPT for project selection. This will allow for a more practicable application of MPT within the project selection process of construction companies dealing with a PPP project portfolio. Therefore, the authors are convinced that the realization of this concept will improve the performance of PPP project portfolios. As a result, the PPP project portfolios of construction firms will contain a higher number of suitable projects. To this end, the new PPP-PS-model supports construction companies to better meet their commercial goals.

The findings in this paper are restricted to large international construction companies that deal with a PPP project portfolio.

The current paper represents the first step of a research project at the Institute of Construction and Infrastructure Management, ETH Zurich. The next steps in the development of the new quantitative PPP-PS-model are the detailed determination of both an appropriate return measure and suitable risks as well as the mathematical formulation of the three modules. Finally, the model's reliability will be evaluated by conducting several simulations and practical tests.

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