Risk Allocation Decision-Making Concept for PPP Projects

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Risk Allocation Decision-Making Concept for PPP Projects

Jennifer Firmenich

Abstract
Risk allocation is crucial for the success of a Public Private Partnership project. The paper presents a rational and efficient decision-making approach for a PPP building project’s risk allocation. A differentiation between a qualitative and quantitative decision-making approach is made. The first qualitative step considers insurability and quantifiability of the identified risks as well as the influence possibilities of the potential risk sender and the potential risk recipient. It is shown how risks that are quantifiable and can be influenced by both parties can be allocated according to minimal cost under consideration of both parties’ holistic cost-oriented risk mitigation options. The proposed causalities are set in context of a research project that ensures rational information acquisition for decision-making and the private party’s risk-bearing capacity as well.

Keywords: Public Private Partnership, risk allocation, risk mitigation, rationality of decision-making, risk quantification, risk influence.

1. Introduction

Many national economies are confronted with infrastructure investment needs. To meet the needs, Public Private Partnership (PPP) has become an alternative to traditional public procurement. Finding the optimal risk allocation is of high importance for a PPP projects’ success (Andersen, Enterprise LSE, 2000). Today’s risk allocation takes place mainly in a qualitative way according to intuitive, habitual, and opportunistic criteria or bargaining strength (Delmon, 2009; Girmscheid, Pohle, 2010). A current research project at ETH Zurich aims for a rational risk allocation as a transparent and traceable decision-making approach with clear criteria. Aside from being cost minimal, the risk allocation is considered optimal, if the resulting private party’s risk load does not exceed the according private party’s risk coverage and thus risk-bearing capacity is ensured at all times. Both aspects will be integrated

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in named research project. The presented work is based on the risk allocation model developed by Girmscheid (2011) and Girmscheid (2013).

The overall research project is presented in Figure 1. The first part of the risk allocation model (submodel I) covers rational information acquisition as precondition for a rational decision-making approach (Firmenich, Girmscheid, 2013b). The modules of the risk allocation model’s first part follow the typical steps of the risk management process: risk identification, risk assessment, risk classification and risk mitigation. The second part of the risk allocation model (submodel II) contains the rational decision-making: risk allocation in the context of risk mitigation, risk load determination, risk coverage estimation and risk-bearing capacity test. The paper’s subject and contribution to the overall research project is a practical approach for rational risk allocation as a precondition for the derivation of the PPP project’s risk load (Firmenich, Girmscheid, 2013a). The presented approach aims to improve the current standard of risk allocation by providing an efficient and thus practical decision-making concept based on clear criteria that allows to determine a rational and project specific risk allocation for PPP projects. This should contribute to the maximization of the PPP project’s value for money.

Figure 1: Concept of a quantitative holistic risk allocation model under consideration of the private party’s risk-bearing capacity with focus on risk allocation
2. State of Practice and State of Research

State of practice and state of research regarding risk allocation are extensive and multi-sided. In general, the state of practice is represented by reports, guidelines and other documents from public or other PPP-focused institutions (see HM Treasury, Treasury Task Force, House of Commons, National Audit Office, etc. in UK for example). Usually, the main concepts and principles of PPP in general and risk allocation in particular are explained. Often these publications provide examples and proposals for PPP risk allocation, but without explanation of project specific derivation and the actually criteria used. This does not allow the actors to develop a rational project specific risk allocation and to manage the risks professionally themselves. The state of research consists either of descriptive analysis regarding actual PPP projects or the theoretical solution of very specific problems with certain methodologies like real options, fuzzy theory, neural networks, stochastic processes, etc. The Glasgow Caledonian University and the University of Manchester were identified as PPP research think tanks in the UK. Many contributions originate from Akin Akintoye, Abdelahlim Boussabaine, Bing Li and Anthony Merna, to name a few. Unfortunately, the theoretical solution proposals remain abstract and are often not embedded in a bigger context that would allow for a transfer to the industry. Additionally, a systematic review of the research communities regarding PPP risk allocation in general and PPP risk allocation criteria in particular has shown that no consensus could yet be achieved (Firmenich, 2011).

3. Research Methodology

The overall research presented is based on the research methodology according to Girmscheid (2007). In general, the development of construction management processes and models is supposed to shape the socio-technical environment (see the “Third World” in Popper (1987)). The presented research follows the radical constructivism paradigm according to von Glasersfeld (1997). In that context, the objectives based on the underlying problem and the “target-means-relationship” to solve the problem and achieve the objectives are developed. The decision model’s structure is developed according to cybernetic systems theory and the methodological focus lies on the application of methodologies that enhance rationality. Research quality will checked regarding viability, validity and reliability (based on Yin (2009)).
4. Risk Allocation in the Context of Risk Mitigation

The risk allocation for PPP contracts needs to be seen in the context of a risk mitigation concept. The transfer of risk is one of several risk mitigation alternatives as demonstrated in Table 1. The underlying assumption is that all risks are taken by the Client by default (potential risk sender). The PPP contracts are a tool to transfer the risks to the other contract parties (potential risk recipients). If the transfer takes place, the price for the contracted service rises.

Table 1: Overview risk mitigation alternatives
(based on Girmscheid & Busch (2008) and Schierenbeck (2003))

<table>
<thead>
<tr>
<th>Risk mitigation alternative</th>
<th>Risk consequence</th>
<th>Net risk consequence</th>
<th>Financial consequences for sender</th>
<th>Differentiation</th>
<th>Risk type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoidance</td>
<td>PO = 0</td>
<td>Gross risk eliminated</td>
<td>Risk mitigation cost</td>
<td>Cause oriented</td>
<td>Active</td>
</tr>
<tr>
<td>Reduction, via:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• HR;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• technical;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• organisational; measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer (e.g. insurance)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer (contract parties):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 1. level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 2. level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptance</td>
<td>Risk coverage necessary</td>
<td>Gross risk cost</td>
<td>Gros risk cost</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ PO = \text{Probability of occurrence} \]

In theory, the risk mitigation alternatives have to be analysed for every single risk and a risk mitigation concept for all relevant players needs to be developed. If this is done for the potential risk sender and the potential risk recipient, the parties’ risk mitigation situation and according cost can be compared and the risk should be beared by the party who can handle the
risk cheapest under consideration of potential residual risk. The elements of a risk mitigation analysis and their relations are displayed in Figure 2.

For a PPP project at least two risk transfer levels have to be considered assuming that the public Client is the default risk bearer. The first risk transfer level relates to the decision what risks should be transferred from the public Client to the private PPP joint venture in general. The joint venture’s representative and main contact of the Client is the special purpose vehicle (SPV). The more risks the public Client transfers, the higher the price the risk sender has to pay to the risk recipient because the resulting risk load of the risk recipient need to be covered. Those risks transferred to the SPV can be allocated in a next step to the players within the private PPP joint venture which is the second risk transfer level. This concept of several risk transfer levels is visualized in Figure 3.

Figure 2: Elements and relations of a risk mitigation concept
Figure 3: Recursion problem with regard to a rational risk allocation for PPP projects

5. Qualitative and Quantitative Risk Allocation

Girmscheid (2013) proposed an approach to allocate risks quantitatively according to minimal cost under consideration of the player’s risk mitigation options. On the one hand does the inherent logic of a quantitative approach serve the aimed for rationality. On the other hand does a cost oriented optimization represent an acceptable criteria to achieve value for money. This approach is rather intense however and requires a lot of resources because the many information needed and the many risk mitigation alternatives that need to be analyzed. This approach is only reasonable if the single risk is quantifiable and the risk sender as well as the risk recipient can influence the single risk. In fact, most risk allocation decisions can be made qualitatively based on the following criteria:

- Risk insurability
- Risk quantifiability
• Risk influence ability of the private PPP joint venture
• Risk influence ability of the public Client

Mainly due to reduction of uncertainty it is advised to insure every insurable risk. The premium will be paid directly by the private PPP joint venture and indirectly by the public Client via the availability fee. The management of the insurance contract can be delegated to the private PPP joint venture. If the risk is uninsurable the next question is whether the risk is quantifiable for estimation and assessment of probability of occurrence and impact.

Unquantifiable risks shouldn’t be transferred to the private PPP joint venture. Due to the according uncertainty, those types of risks can be shared at most between the public Client and the private PPP joint venture including a risk cap for the private party. Finally, it needs to be considered if the risk can be influenced by the potential risk sender and/or the potential risk recipient. The most important causalities are proposed as follows:

• If the risk is uninsurable, quantifiable, and only influenceable by one party, it should be taken by this party.
• If the risk is uninsurable, quantifiable, and influenceable by both parties, this requires further analysis and leads to a quantitative decision-making approach based on comparison of the parties’ risk mitigation situation.
• If the risk is uninsurable, quantifiable, and no party can influence the risk, it should be shared (without cap).
• If the risk is uninsurable, unquantifiable, and the private PPP joint venture cannot influence it, the risk should be taken by the public Client.
• If the risk is uninsurable, unquantifiable, and the private PPP joint venture can influence it, the risk should be shared with a risk cap for the private PPP joint venture.

The described causalities are visualized in Figure 4. This analysis is advisable for every identified single risk. However, it is of strong influence how those identified risks were aggregated and structured. A practical solution should be found by experienced project participants.
This qualitative approach of risk allocation has the benefit of being applicable more efficiently to the identified risks in comparison with the quantitative approach because a less information is required for the decision-making. On the downside it is less obvious why the proposed criteria are rational and how they benefit the project’s value for money. The qualitative criteria were selected based on thorough literature review and the experience of the industry partner. The application to typical risks relevant for a PPP project shows reasonable results (see demonstration). Given the contracted party’s acceptance of the decision criteria, the contribution to value for money will stem from that acceptance leading to faster contract design and less disputes and consequently to efficiency.

The risk allocation has in any case cost consequences for the risk bearer that lead to a risk load as shown in Table 2. The risk load of the private party leads to certain requirements for the project equity and the profit margin or return. The higher those numbers, the higher the availability fee needs to be, given that the project should be set up with an appropriate risk coverage for the private parties. The net risk cost depends on the estimated probability of occurrence and the estimated risk impact of potential residual risk after risk mitigation, the risk mitigation cost of the chosen risk mitigation measures and premiums for risk transfer.
The risk mitigation cost of the private PPP joint venture should be less than the risk mitigation cost of the public Client to justify the risk transfer. On a single risk perspective, the transfer premium to be paid by the risk sender to the risk recipient should amount to the lower risk mitigation cost for the risk recipient. On a project perspective, the availability fee consists of a compensation for cost of construction, operation, maintenance, etc. and compensation for risk-taking. The deterministic costs are derived from estimation and assessment that results in a base scenario. This base scenario is uncertain, however. The other part of the availability fee should cover for possible variations of the base scenario that can be derived using probabilistic methodologies. In total, the availability fee should be high enough to cover certain risk load confidence levels that can be derived from an according Monte Carlo Simulation (see (Firmenich & Girmscheid, 2013a)). The risk load is a consequence of base scenario variations that leads to higher cost and certain risk events with extra cost.

### Table 2: Monetary consequences of risk allocation

<table>
<thead>
<tr>
<th>Deterministic risk cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$RC_{i,gross} = PO_i \times E(I_i)$, with</td>
</tr>
<tr>
<td>$RC_{i,gross}$: deterministic gross risk cost of the single risk $i$</td>
</tr>
<tr>
<td>$PO_i$: probability of occurrence of the single risk $i$</td>
</tr>
<tr>
<td>$E(I_i)$: expected impact of the single risk $i$</td>
</tr>
</tbody>
</table>

The deterministic net risk cost of single risk $i$ is calculated as  $RC_{i,net} = PO_i^* \times E(I_i^*)$ with $PO_i^* \leq PO_i$ and $E(I_i^*) \leq E(I_i)$.  

<table>
<thead>
<tr>
<th>Risk mitigation cost in case of no transfer of single risk $i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the public Client keep the single risk $i$, then the according player specific risk mitigation cost $RHC_i$ are as follows:</td>
</tr>
<tr>
<td>$RHC_{i,Red} = MC_{i,Red} + RC_{i,Red}^{PC} + IP_i^{PC} + MC_{i,Avo}$ and $RHC_{i,Avo} = 0$, with</td>
</tr>
<tr>
<td>$MC_{i,Red} &lt; (RC_{i,gross} - RC_{i,net}^{PC}) \iff 0 &lt; RC_{i,net}^PC &lt; RC_{i,net}$: measure cost “reduction”</td>
</tr>
<tr>
<td>$RC_{i,Red}^PC \in {RC_{i,gross}; RC_{i,net}^{PC}}$: risk cost public Client</td>
</tr>
<tr>
<td>$IP_i^{PC} &lt; RC_i \Rightarrow RC_{i,Red}^PC = 0$: insurance premium</td>
</tr>
<tr>
<td>$MC_{i,Avo} &lt; RC_{i,gross} \Rightarrow RC_{i,Red}^PC = 0$: measure cost “avoidance”</td>
</tr>
</tbody>
</table>
**Risk mitigation cost in case of transfer of single risk i**

Is the single risk i transferred to the private PPP joint venture, then the according player specific risk mitigation cost RHC are as follows:

\[ RHC^{\text{nc}}_i = TP_i \quad \text{and} \quad RHC^{\text{JV}}_i = RHC^{\text{nc}}_i - TP_i, \]

\[ RHC^{\text{JV}}_i = MC^{\text{JV}}_{i,\text{Red}} + RC^{\text{JV}}_i + IP^{\text{JV}}_i + MC^{\text{JV}}_{i,\text{Avo}} \]

\[ MC^{\text{JV}}_{i,\text{Red}} < (RC^{\text{JV}}_{i,\text{gloss}} - RKC^{\text{JV}}_{i,\text{net}}) \leftrightarrow 0 < RC^{\text{JV}}_{i,\text{net}} < RC^{\text{JV}}_{i,\text{gloss}} \quad \text{measure cost “reduction”} \]

\[ RC^{\text{JV}}_i \in \{RC^{\text{JV}}_{i,\text{gross}}, RC^{\text{JV}}_{i,\text{net}}\} \quad \text{risk cost PPP joint venture} \]

\[ IP^{\text{JV}}_i < RC^{\text{JV}}_i \Rightarrow RC^{\text{JV}}_i = 0 \quad \text{insurance premium} \]

\[ MC^{\text{JV}}_{i,\text{Avo}} < RC^{\text{JV}}_{i,\text{gloss}} \Rightarrow RC^{\text{JV}}_i = 0 \quad \text{measure cost “avoidance”} \]

\[ TP_i \quad \text{transfer premium single risk i} \]

**6. Demonstration**

The presented concept will be exemplified with a selection of risks. The quantification usually takes place via subjective expert estimation if not stated otherwise. Emphasis is put on uninsurable and quantifiable risks because those will be considered in a Monte Carlo Simulation for the derivation of the private party’s risk load as a precondition for a risk-bearing capacity test. An example for an unquantifiable risk is conflicts between the contracted parties. It can be influenced by both parties and therefore should be shared with a cap for the private PPP joint venture. Only a few single risks were identified that actually justify a detailed quantitative analysis. Examples are an inappropriate user behaviour and the change of contact persons on the Client’s side.

- **SPV administration during construction**
  The risk that the actual cost for project administration through the SPV differs from the base cash flow scenario is uninsurable, but quantifiable. This risk can be influenced by the private PPP parties but not by the public Client. Accordingly, the risk should be taken by the private PPP joint venture. Following the influence argument, the SPV should take that risk within the joint venture.

- **Periodic operation cost, e.g. maintenance, cleaning and catering**
  The risk that the actual periodic cost of operation differs from the base cash flow scenario is not insurable, but quantifiable. If at all, this risk aspect can be influenced
by the private PPP parties only and not by the public Client. The development of energy costs and wages, for example, cannot be influenced by any party and should be considered separately during risk management. The periodic operation costs are a good example that the risks should be structured in an appropriate way to allow for ideal risk management. Those parts of the risk that can be influenced should be taken by the private PPP joint venture. Following the influence argument, the operator should take the parts of the risk it can influence within the joint venture.

- **Cost and time variation replacements**
The risk that the cost for replacements differs from the base cash flow scenario either regarding amount or time is not insurable, but quantifiable. This risk can be influenced by the private PPP joint venture but not by the public Client. Accordingly, the risk should be taken by the joint venture in general and the operator in particular because of the influence argument.

- **Ground risk**
The management of this risk is substantially connected to survey reports. The risk can be quantified and estimated on the basis of survey reports that specify and limit the risk. It is not insurable, but can be influenced regarding it’s potential impact by the private PPP joint venture depending on the chosen construction methods. It cannot be influenced by the public client. Accordingly, the risk should be taken by the private PPP joint venture in general and the main contractor in particular following the influence argument. Any risk events going beyond the surveyed situation should be taken by the public Client.

- **Operation performance with penalty consequence**
The risk that insufficient operation performance within the joint venture responsibility leads to increased cost or to penalties and reduced income cannot be insured, but is quantifiable. The risk can be influenced regarding probability of occurrence and impact by the private PPP joint venture, but not by the public Client. Accordingly, the risk should be taken be PPP joint venture in general and the operator within the joint venture in particular following the influence argument.

- **Change of contact persons on Client’s side**
The risk that changing contact persons on the Client’s side leads to higher costs of administration for the SPV is not insurable, but quantifiable. This aspect can be influenced by the private PPP joint venture regarding the impact and by the public Client regarding probability of occurrence and impact. As the risk is quantifiable and
can be influenced by both players, a more detailed analysis for quantitative decision-making is justified. In case of limited resources, the risk can still be shared as an easy solution. If the private PPP joint venture takes on the risk or parts of it, the SPV should take the risk because of the influence argument.

- **User behavior**
  The risk of inconvenient user behavior that leads to extra cost or maybe even penalties is not insurable and only quantifiable with further investigation like scenario analysis. The user behavior can be influenced by the private PPP joint venture in the context of operation and by the public Client in the context of the employees using the building facility. As the risk is quantifiable and can be influenced by both players, a more detailed analysis for quantitative decision-making is justified. In case of limited time or other resources the risk can still be shared. If the private PPP joint venture takes on the risk or parts of it, the operator should take the risk because of the influence argument.

- **Insolvency of operator**
  The risk that the operator becomes insolvent during the operation phase is not insurable and quantifiable via scenario analysis and other analyses methods. The risk can be influenced by the private PPP joint venture, but cannot be influenced by the public Client. Accordingly, the risk should be taken by the PPP joint venture. The organizational structure forces the SPV to take this risk within the joint venture if the back-to-back contract regulations fail because of the operator’s default.

### 7. Conclusion, Discussion and Outlook

The presented work is based on an intense analysis of existing research results and strong cooperation with an industry partner. The analysis results were combined logically to the presented holistic decision-making concept for a rational, efficient and project specific PPP risk allocation. The main achievement is the holistic identification and consistent structuring of risk allocation criteria. By differentiating between a qualitative and quantitative decision-making approach, resources can be used economically. The resource-intensive quantitative approach that analyzes the risk mitigation situation of the potential risk sender and the potential risk recipient is only processed if justified. With given causalities, every project’s risk situation can be approached specifically and practically. The proposed structure allows
for transparency, traceability and a sound discussion basis for mutual decision-making and contract design regarding the PPP project’s risk allocation.

The public Client’s purpose for risk transfer when contracting a PPP project is to benefit from the industry’s experience and thus reduce cost. Appropriate risk-taking can be used furthermore to create the chance for profit and/or return for the PPP joint venture. The challenge is consequently to transfer the right risks and the right total amount of risks. In general, the risk should be allocated to the party best able to manage it in accordance to the economic minimum principle. Inappropriate risk transfer reduces the project’s efficiency. If this or a comparable holistic and logical approach could be implemented as a standard for contract design, the communication between the parties and the project related decision-making process would improve, become easier and less costly. Conflicts could be reduced and the rationality enhanced. This should contribute to the project’s success for all participants and thus contribute to the project’s value for money as well.

The presented proposal was applied to a fictive but plausible project data set developed with the industry partner to check viability, validity, and reliability. However, a real life application is still missing. Even if the presented causalities are used for contract development, it will take a typically long lasting contract period for retrospective assessment. Theoretically, the given principles could be applied to other life-cycle oriented infrastructure projects or even pure construction projects as well. This might make it more easy to actually test the practicability in real life.

Based on the presented results, further research derives the PPP joint venture’s risk load and applies a risk-bearing capacity test to ensure that the risk coverage exceeds the risk load at every point of time with a certain probability under consideration of different scenarios. This way it can be ensured that the equity share and the availability amount to a sound relation with the transferred risk. This has been applied to a detailed project data set as well.

8. Acknowledgements

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