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RATIONAL INFORMATION ACQUISITION FOR PPP PROJECTS IN AN ENTREPRENEURIAL CONTEXT

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Risk allocation (RA) for Public Private Partnership projects is crucial for the project's success. There is potential for improvement in decision-making because in practice intuition, habit or opportunism dominate the according decision-making process. One option to achieve rationalization is by quantification. However, a quantitative model is only as good as its input. Therefore, the process of information acquisition (IA) for a quantitative RA model needs to be rationalized, as far as possible. Aspects of decision-making that could be relevant for the optimization of the IA's cost-benefit ratio are elaborated. This study discusses further the allocation of decisions to a strategic or operational entrepreneurial level. The aim is to raise the general awareness for rationality in decision-making. This study exemplifies this abstract matter, where possible, using a process oriented approach as well as methodologies such as the continuous improvement process and the Analytical Hierarchy Process. However, the specific solution depends on the given circumstances and the decision-maker's background. The subject matter presented is relevant for all kinds of projects aiming to optimize resource use and achieve process quality.

Keywords: Project management, Risk, Rationality, Decision analysis, Key performance indicators.

INTRODUCTION

Many national economies are confronted with infrastructure investment needs. To meet these needs, Public Private Partnership (PPP) has become an alternative to traditional public procurement. Finding the optimal risk allocation is of high importance for PPP projects (Andersen and LSE 2000; Jacob and Kochendörfer 2002). Today, risk allocation (RA) takes place mainly in a qualitative way according to intuitive, habitual or opportunistic criteria or bargaining strength (Delmon 2009; Girmscheid and Pohle 2010). The underlying hypothesis of this work is that this kind of RA is suboptimal for PPP projects and that a PPP project's success can be improved by using a more rational approach to RA. Rationality is increased through use of traceable decision-making with clear criteria and quantitative approaches, where possible. The research aim is therefore the development of a quantitative risk allocation model for an "optimal" risk allocation for PPP projects under consideration of the private party's risk-bearing capacity. Quantitative in this context means implementable. Optimal refers to cost minimal according to the economic minimum principle. Risk-bearing capacity is ensured, if the project's risk coverage exceeds the project's risk load at all times. The main elements of the proposed model are displayed in Figure 1. Precondition for a quantitative RA model, and also this paper's subject, is a likewise rational information acquisition (IA) used as input for the quantitative model (see subsystem I, Figure 1).

The IA comprises the following elements: risk identification, risk assessment, risk classification and risk handling. These elements are part of the general risk management process (Girmscheid 2010) and cannot be quantified in an implementable way. This applies in particular to risk assessment and risk handling, as these processes acquire the most important and most sensitive information used in the implementation part of the model (see subsystem II, Figure 1). Risk identification is a preliminary step to risk assessment and important insofar as all relevant risk should be identified, else they cannot be dealt with. Risk classification is an optional but not mandatory step after risk analysis that allows to structure risks according to their importance.

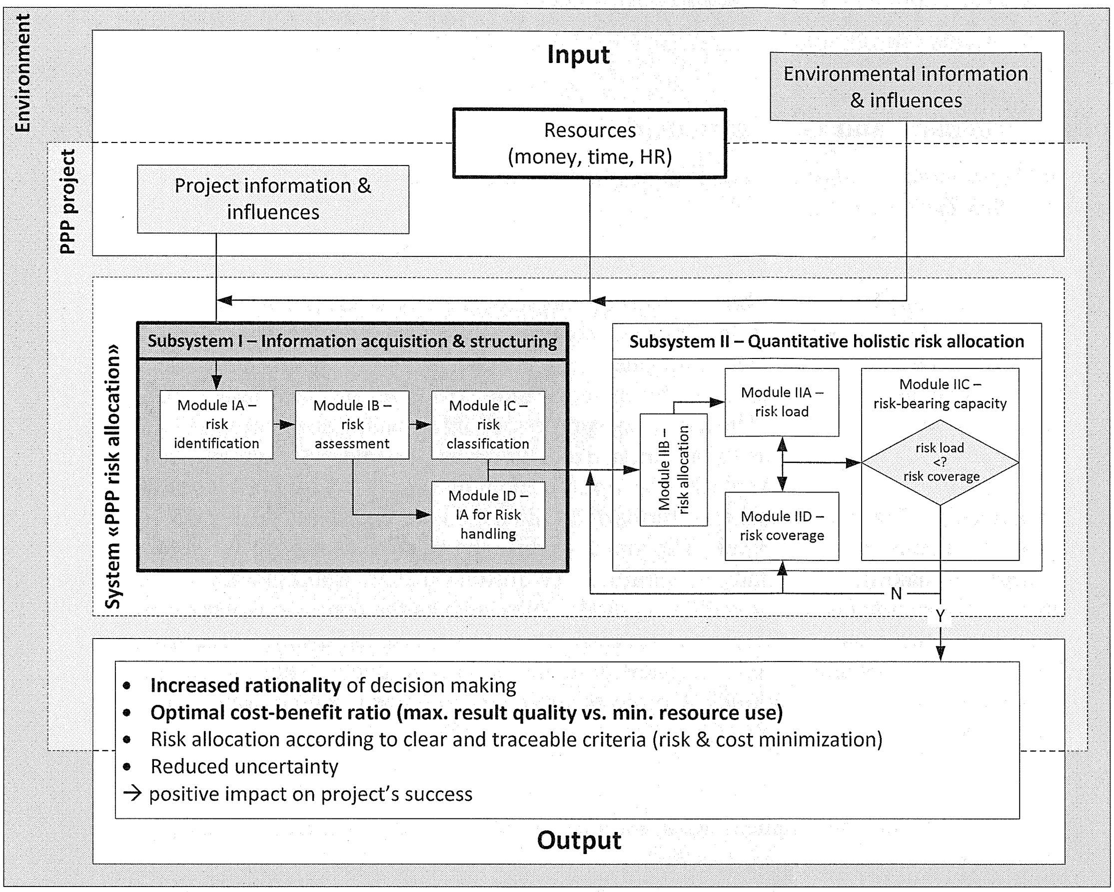


Figure 1: **Concept of a quantitative holistic risk allocation model focusing on rational IA and an optimal cost-benefit ratio**

The paper's objective is to raise awareness for rational decision-making in general and in the context of a PPP project's pre-contract phase in particular. The inherent conflict between the aim of maximizing output quality and minimizing resource use is discussed. Special attention is put on a differentiation of strategic and operation level of decision-making and implementation. Focus is laid on the decision of choosing either internal or external human resources (HR) for team composition in the context of rational IA. Finally, continuous improvement and learning are considered.

GENERAL RESEARCH METHODOLOGY

The presented overall research is based on the research methodology according to Girmscheid (2007). Construction management science lies between engineering and social science and is related to the Third World of Popper's three worlds (Popper 1987). The construction management's processes and models design the socio-technical environment of Popper's Third World according to the hermeneutic research paradigm. The presented research follows a constructivist model development in the tradition of radical constructivism according to Von Glasersfeld (1997). In that context, the objectives of the according problem and the target-means-relationship to solve the problem and achieve the objectives are developed. The model structure is formed according to cybernetic systems theory and the methodological focus lies on the application of quantitative methods, where possible.

RATIONAL INFORMATION ACQUISITION IN AN ENTREPRENEURIAL PROCESS ORIENTED CONTEXT

Motivation and context

To fulfill the requirements of a holistic approach and to achieve a systematic derivation of recommendations, the aimed for rational IA is embedded in an entrepreneurial process oriented context. This is displayed in Figure 2, showing the processes and elements relevant for IA as well as their causal relations. The deployed process oriented approach focuses on value generating performance processes.

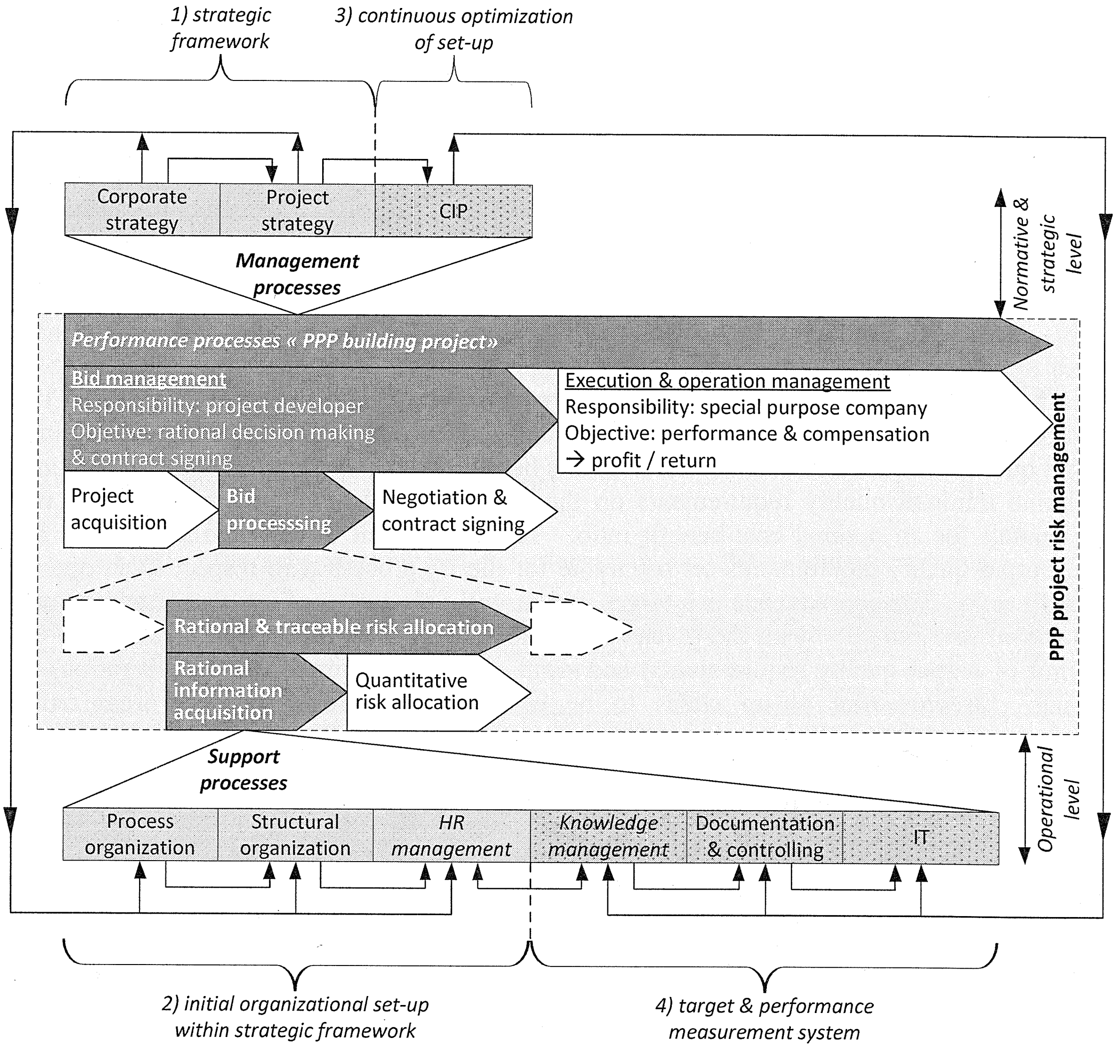


Figure 2: **Information acquisition for a quantitative holistic risk allocation model embedded in an entrepreneurial process system adapted from Girmscheid (2010)**

For a company that manages PPP (building) projects, one can mainly distinguish between the bid process and the contracting process (construction and operation) as performance relevant. Within the bid process, the main sub-processes are: project acquisition, actual bid preparation and contract negotiation as well as signing (adapted from Girmscheid 2010). During bid preparation, the PPP project's risk situation needs to be evaluated and, amongst others, a RA proposal needs to be determined. The input information for a rational and, in this case, quantitative RA model needs to be acquired. The model's requirements of rationality and traceability are thus mandatory not only for the quantitative RA itself, but also for IA representing a pre-stage of a quantitative RA model. However, IA can't be quantified in an implementable way, like it is done for the RA in the presented work, as it depends on subjective expert estimations. A possible statistical determination of risk information out of data is not possible because of the unique character of

PPP projects. Consequently, IA needs to be done by experts by means of subjective estimations and thus, the result quality is vulnerable to bounded rationality and opportunism.

As displayed in Figure 2, the relevant aspects to consider are structured into management and support processes. The management processes on a rather strategic level affect the support processes relevant for IA on a rather operational level, as shown in Figure 2. The corporate and project strategy set the frame for the organizational set-up of how to actually conduct IA (see Figure 3). Over time, a continuous improvement process (Deming 1989) can optimize an organizational set-up of IA, while considering the strategic specifications mentioned above. The most important aspect for achieving continuous improvement is a target and performance measurement system that is integrated into regular controlling and provides relevant indicators for evaluation and further development. These are the aspects discussed in the following sections.

Strategic framework

The following could improve rationality of IA by minimizing cognitive limitations and opportunism and thus maximizing output quality: thorough documentation, data or method triangulation, mix of qualified internal and external experts, use of IT infrastructure as support where possible, enough experts for variety of opinion, independent repetition as well as process audits and reviews.

However, in real life, resources such as money and time are limited. Determining how many resources are to be spent for the achievement of a target and how these resources are to be allocated among processes or projects is an entrepreneurial strategic decision to determine. This needs to be decided on a corporate and on a project level. Hence, if the resources are constrained, the output quality is limited as well. Therefore, it is helpful for the operational implementation of IA to define minimal quality requirements on the strategic level as a further restriction, in a general pursuit for an optimal cost-benefit ratio. The upper limit of resource availability and minimal output quality requirements set the frame for the IA process with respect to an optimal cost-benefit ratio. The consequence is a target system with inherent conflicts that requires trade-offs, as shown in Figure 3. With the given restrictions (upper limit of resource availability and lower limit of output quality requirements) and main objective (optimal cost-benefit ration) the appropriate entrepreneurial set-up needs to be established regarding process organization, structural organization and HR management.

Initial organizational set-up within strategic framework

Figure 4 provides an overview of the main aspects of an IA risk management process organization, differentiated according to modules. The main challenge - because of their dominant cost relevance - is the determination of time and human resources necessary for each process step. This is strongly related to the next two aspects, structural organization and HR management.

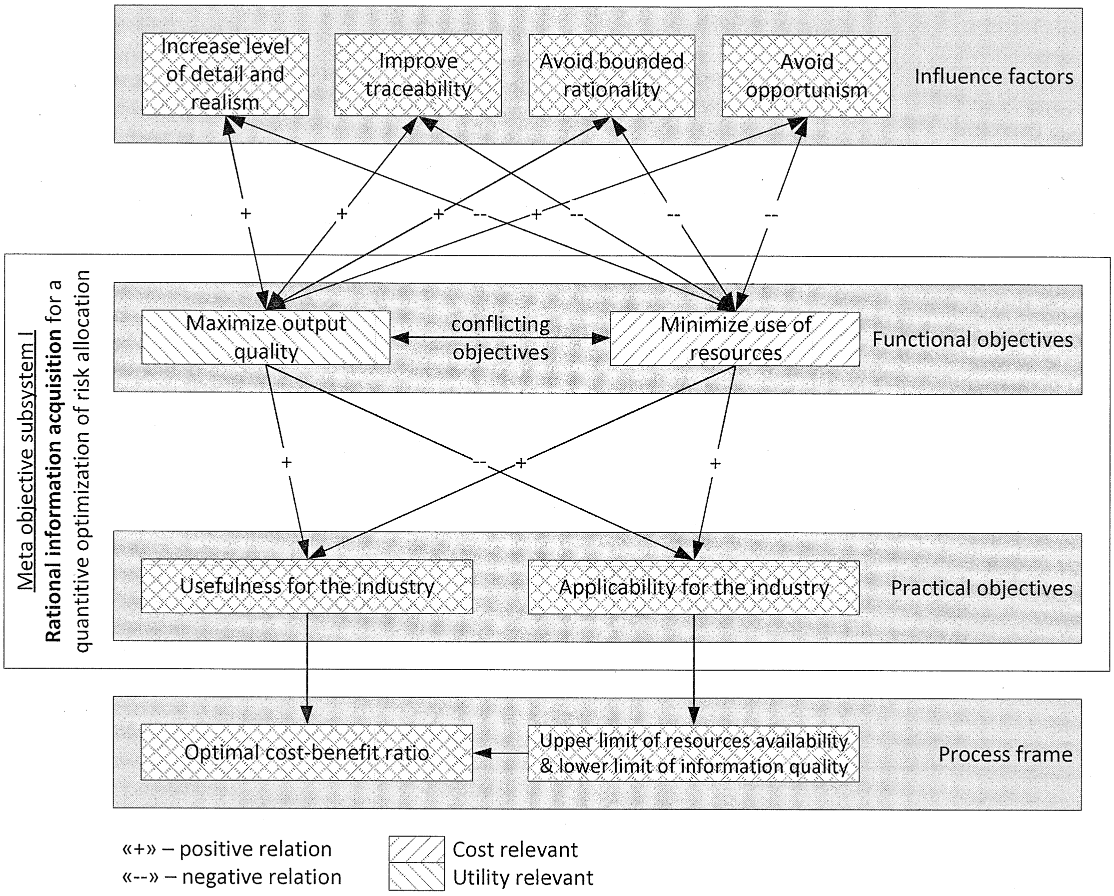


Figure 3: **Target system for rational information acquisition under restrictions**

	Subsystem I: information acquisition			
	Module IA: risk identification	Module IB: risk assessment	Module IC: risk classification	Module ID: risk handling
Objective	Identification of as many risks as possible related to the PPP building project under consideration of the cost-benefit ratio	Assessment of identified risks regarding impact, probability and further characteristics to determine the risk load for a quantitative risk allocation	Classification and structuring of identified and assessed risks regarding their importance relative to risk costs	Identification and assessment of risk handling measures for each risk and player under consideration of measure cost and residual / net risk
Input	• **Specific project information** • **Global environmental information** • Human resources • Other resources	• **Risk accumulation matrix** • Specific project information • Global environmental information • Human resources • Other resources	• **Risk profile A** • Human resources • Other resources	• **Risk profile B** • Specific project information • Global environmental information • Human resources • Other resources
Output	Risk accumulation matrix (cause related risk structuring)	Risk profile A (with qualitative and quantitative characteristics for determination of the risk load) + correlation matrix	Risk profile B = Risk profile A + multi-stage risk classification according to risk costs	Risk profile C = Risk profile B + measure costs, residual / net risk for each risk, player and measure cost
	Documentation, HR qualification check-up, selection and mix of process specific methods			
Process elements	• Determination of risk structuring • Project specific risk analysis • Group size and composition • Stop criterion	• Identification of relevant risk load characteristics • Project specific risk analysis • Group size and composition • Risk attitude and risk strategy		• Identification of relevant risk handling characteristics • Project specific risk analysis • Group size and composition • Risk attitude and risk strategy
Methodical recommendation	• Contract analysis • **Brainstorming** • Risk check lists	Human estimation: • Expert estimation or • Classic round-based Delphi Method or • Modified real-time **Delphi Method**	• **Portfolio analysis** • ABC analysis • Equi-Risk-Contour method • Impact analysis • Sensitivity analysis	• Decision table • Decision tree method • **Utility analysis** • Simulation • and / or risk assessment methods
Threats	• Important risks not identified • Unappropriate resource use	• Unappropriate assessment of risk load characteristics because of bounded rationality, opportunism or subjectivity • Inappropriate resource use	• Non-consideration of important risks because of risk classification results • Interpretation or conclusion mistakes because of bounded rationality, opportunism or subjectivity	• Inappropriate assessment of risk handling because of bounded rationality, opportunism or subjectivity • Inappropriate resource use

Figure 4: **Operational process organization overview for a rational IA process**

Structural organization in the present context describes structural project organization, temporarily formed for the bid management and thus risk related IA of the project. Typically, a bid matrix organization is chosen (Girmscheid 2010) depending on resource availability (upper limit) and output quality requirements (lower limit), strategic HR team composition as well as type, size and complexity of the project. Therefore, it is necessary to set up a budget, task and schedule plan that considers the factors above.

Along with general considerations of HR management, one important aim in the given context is to find the ideal team composition that supports an optimal cost-benefit ratio of IA. As described earlier, differentiating between strategic and operational level is necessary. The strategic framework provides the targets and restrictions. Furthermore, the decision alternatives, decision-making criteria and their weightings need to be determined on the strategic level. The research of the alternative's actual data, the implementation of the decision results as well as the performance control must take place on an operational level. Figure 5 shows the interaction of decision-making between the strategic and operational level for the purpose of a decision result. The main focus of the operational level, after implementation, lies on performance monitoring by means of controlling and thus provides an important element for the continuous improvement process (CIP). CIP is an established concept to improve output quality, without necessarily using further resources. CIP can help to optimize the cost-benefit ratio, starting from an initial set-up within the given strategic framework.

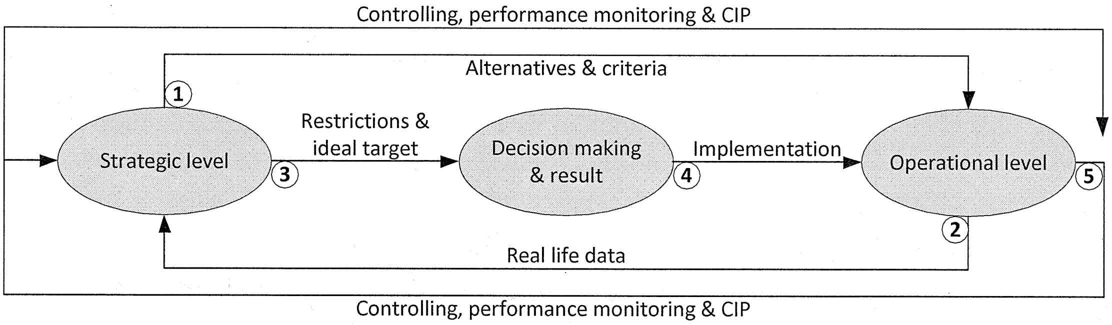


Figure 5: **Interaction between strategic level, operation level and decision-making**

Continuous improvement process (CIP) for rational information acquisition (IA)

Once the process and structural organization is determined and the HR management concept is developed, CIP can be used to further enhance the initial organizational set-up within the strategic framework and thus improve the cost-benefit ratio without necessarily using more resources.

According to Kostka and Kostka (2008), CIP is an executive philosophy and therefore originates in the strategic and/or managerial level of an entrepreneurial system (see Figure 2). It needs to be established on a corporate level and on a project level employing a holistic view of the issues related. As the name states it is crucial to establish a continuous improvement effort in the whole entrepreneurial system in small steps as governing mindset. The focus lies on the reduction of non-value-adding and wasteful activities. Of course, the strategic initialization of CIP strongly influences the operational level and thus the support processes (see Figure 1). The four pillars of CIP are employee and customer orientation, target and result orientation, process and quality orientation as well as transparency and fact orientation.

In this paper's context, the CIP aims for an optimization of the cost-benefit ratio for rational IA. This is achieved by reducing resource use without lessening quality (resource management) and / or by increasing quality without higher resource use (quality management). The responsibility for CIP implementation in this context should be tightly linked to the responsible positions dealing with bid management.

While CIP takes place continuously within the given organizational set-up, the latter needs to be reevaluated regularly, for example on an annual basis. Firstly, it is necessary to check if the strategic restrictions need to be adapted. Secondly, the chosen organizational set-up within the strategic frame itself needs to be reconsidered regularly. This allows, amongst others, for adjustments due to insights gained from controlling results even though the strategic level remains unchanged. Of course, if changes took place in earlier steps (i.e. changed targets), any and all consequences for the CIP need to be considered. This regular evaluation that might lead to reorganization can be seen as potential for a big efficiency step.

Transparency and fact orientation through use of performance indicators

The key to transparency and fact orientation is target and performance measurement by means of adequate indicators. Quantitative and qualitative indicators can be developed that allow monitoring and controlling of process specific targets. The most important aspect is the measurability, which is quite intuitive for quantitative indicators. The intention, scale and responsibility of qualitative indicators need to be considered more thoroughly. Particularly, it should be clear whether the evaluation is done by the participants of the value-adding process (internal evaluation) or whether an additional audit takes place (external evaluation) and what the resulting consequences are. Further, indicators can be aggregated, but the purpose should remain clear while ensuring comparability. Indicators can be differentiated according to several classifications and levels (see Figure 6). On a first level, an indicator stands for itself and is often directly related to a certain action that has been imposed to improve the performance. The measurement of this indicator helps to retrospectively assess the action, if the causal relation is clear and unambiguous. Therefore, such independent indicators compare ex post actual values with ex ante estimations. On a second level, an indicator might be measured to observe development over time, but still within one project. On a third level, indicators help to compare several projects with each other. Because of the project's unique character this requires relativisation and scaling of the indicators to ensure comparability.

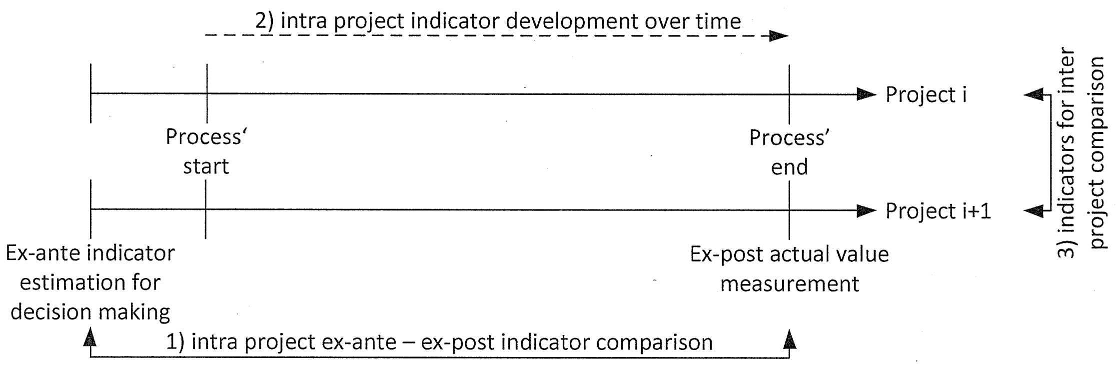
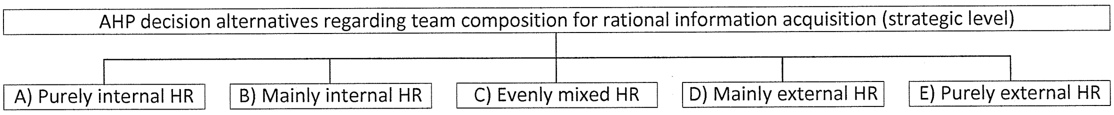


Figure 6: **Indicator categorization for strategic decision-making, e.g. regarding HR team composition for rational information acquisition**

Decision-making regarding HR team composition

The decision problem of whether to use internal or external human resources or a mixture is a multi-criteria decision analysis. To model and process the decision, the Analytic Hierarchy Process (AHP) is used as an example due to the ease with which several criteria as well as ordinal and cardinal criteria scales can be incorporated. Furthermore, it is relatively easy to implement. Figure 6 and 7 show a corresponding AHP problem for strategic decision-making concerning HR team composition. How an AHP works and how it can be solved, is shown in Girmscheid (2011). The exemplary weighting of the proposed three-leveled criteria in Figure 7 is the result of a pair wise comparison of these criteria on each hierarchy level using a common scale from 1 to 9. For example the sub criteria of "competence", which are "special field cover ratio" and "relevant experience", can be weighted 5:4, meaning almost equal importance. The standardized eigenvector of an according matrix leads to a weighting of 55.56 % for the criterion "cover ratio" and 44.44 % for the criterion "relevant experience".

After this step of decision preparation, the actual data for decision-making (v^{abs}_{ijkX}) needs to be researched for each alternative (here: A to E) and each criteria. If quantitative, data for the alternatives will be transformed to a comparative vector through scaling. In case of qualitative data, a relative evaluation is executed for all alternatives. This way a comparable dimension is achieved. Finally a bottom-up aggregation takes place for all criteria (e. g. $\underline{v}^{abs}_{5X} = g^{abs}_{5a} \cdot \underline{v}^{abs}_{5aX} + g^{abs}_{5b} \cdot \underline{v}^{abs}_{5bX}$). On the criteria's top hierarchy level the aggregated relative evaluation of the alternatives is multiplied with the criteria weights to achieve a final score that leads to the final decision ($\underline{b}_X^{tot1} = \underline{g}^{abs} \cdot \underline{V}_X^{abs}$). The chosen alternative is usually the one with the maximal aggregated value ($b_{opt}^{tot1} = \max_X b_X^{tot}$). Alternatively the criteria could by aggregated using $b_X^{tot2} = \frac{v_{1X}^{abs}}{\sum_{i=2}^{4} g_i^{abs} \cdot v_{iX}^{abs}}$ and $b_{opt}^{tot2} = \min_X b_X^{tot}$. The latter alternative would represent an approximation of a cost-benefit ratio for decision-making and of course the minimal aggregated value would be optimal in this case.



AHP Problem	*problem set-up = strategic* *information acquistion for decision problem = operational*	
Objective Optimal HR composition (internal vs. external) for information acquisition of a quantitative holistic risk allocation model for PPP building projects		
Alternatives	*regarding team composition for information acquisition*	expected total HR cost:
A) purely internal; B) mainly internal; C) evenly mixed; D) mainly external; E) purely external		$C_{tot}^{HR} = C_{tot}^{HR,int} + C_{tot}^{HR,ext}$
Criteria		$C_{tot}^{HR,int} = \sum_i c_i^{HR,int} \cdot h_i^{HR,int}$
1) expected total HR cost		
2) expected result quality	*≥ min. quality requirements (strategic restriction)*	$C_{tot}^{HR,ext} = \sum_i c_i^{HR,ext} \cdot h_i^{HR,ext}$
3) competence	*≥ min. competence requirements (strategic restriction)* *= all special fields covered with sufficient experience?*	
3a) special field cover ratio	≥ 1	tot □ total
3b) total relevant years of experience in the group	*≥ min. requirements (for each category)*	HR □ human resource
4) knowhow transfer		int □ internal
4a) transfer external → internal = internal learning potential	*[% benefit plus]*	ext □ external
4b) transfer internal → external = drain threat	*[% benefit loss]*	c □ [$\frac{\text{monetary unit}}{\text{hour}}$]
5) organization		i □ HR no. i, i ∈ □
5a) process organization		restrictions:
5aI) loss of liability for results and consequences	*[% benefit loss]*	$\sum_i h_i^{HR,int} \leq$ available internal HR capacities?
5aII) increased complexity of communication and administration	*[% benefit loss]*	
5b) structural organization		$\sum_i h_i^{HR,int} + \sum_i h_i^{HR,ext} \geq$ minimal HR project requirements?
5bI) increased integration	*[% benefit loss]*	
5bII) increased control	*[% benefit loss]*	$C_{tot}^{HR} \leq$ strategic resource availability?

Figure 7: AHP problem definition for strategic decision-making regarding HR team composition for quantitative information acquisition

				Alternative X	A	B	C	D	E
Explicit description of team composition scenario					purely internal HR	mainly internal HR	evenly mixed HR	mainly external HR	purely external HR
i,j,k	g_i^{abs}	g_{ij}^{abs}	g_{ijk}^{abs}						
1) expected total HR cost	$i=1$ 31.03%			x	v_{1A}^{abs}	v_{1B}^{abs}	v_{1C}^{abs}	v_{1D}^{abs}	v_{1E}^{abs}
2) expected result quality	$i=2$ 27.59%			x	v_{2A}^{abs}	v_{2B}^{abs}	v_{2C}^{abs}	v_{2D}^{abs}	v_{2E}^{abs}
3) competence	$i=3$ 20.69%					$\underline{v}_{3X}^{abs} = g_{3a}^{abs} \cdot \underline{v}_{3aX}^{abs} + g_{3b}^{abs} \cdot \underline{v}_{3bX}^{abs}$			
3a) special field cover ratio		55.56%		x	v_{3aA}^{abs}	v_{3aB}^{abs}	v_{3aC}^{abs}	v_{3aD}^{abs}	v_{3aE}^{abs}
3b) total relevant years of experience in the group		44.44%		x	v_{3bA}^{abs}	v_{3bB}^{abs}	v_{3bC}^{abs}	v_{3bD}^{abs}	v_{3bE}^{abs}
4) knowhow transfer	$i=4$ 13.79%					$\underline{v}_{4X}^{abs} = g_{4a}^{abs} \cdot \underline{v}_{4aX}^{abs} + g_{4b}^{abs} \cdot \underline{v}_{4bX}^{abs}$			
4a) transfer external → internal□internal learning potential		33.33%		x	v_{4aA}^{abs}	v_{4aB}^{abs}	v_{4aC}^{abs}	v_{4aD}^{abs}	v_{4aE}^{abs}
4b) transfer internal → external□drain threat		66.67%		x	v_{4bA}^{abs}	v_{4bB}^{abs}	v_{4bC}^{abs}	v_{4bD}^{abs}	v_{4bE}^{abs}
5) organization	$i=5$ 6.90%					$\underline{v}_{5X}^{abs} = g_{5a}^{abs} \cdot \underline{v}_{5aX}^{abs} + g_{5b}^{abs} \cdot \underline{v}_{5bX}^{abs}$			
5a) process organization		50.00%				$\underline{v}_{5aX}^{abs} = g_{5aI}^{abs} \cdot \underline{v}_{5aIX}^{abs} + g_{5aII}^{abs} \cdot \underline{v}_{5aIIX}^{abs}$			
5aI) loss of liability for results and consequences			*63.64%*	x	v_{5aIA}^{abs}	v_{5aIB}^{abs}	v_{5aIC}^{abs}	v_{5aID}^{abs}	v_{5aIE}^{abs}
5aII) increased complexity of communication and administration			*36.36%*	x	v_{5aIIA}^{abs}	v_{5aIIB}^{abs}	v_{5aIIC}^{abs}	v_{5aIID}^{abs}	v_{5aIIE}^{abs}
5b) structural organization		50.00%				$\underline{v}_{5bX}^{abs} = g_{5bI}^{abs} \cdot \underline{v}_{5bIX}^{abs} + g_{5bII}^{abs} \cdot \underline{v}_{5bIIX}^{abs}$			
5bI) increased integration			*33.33%*	x	v_{5bIA}^{abs}	v_{5bIB}^{abs}	v_{5bIC}^{abs}	v_{5bID}^{abs}	v_{5bIE}^{abs}
5bII) increased control			*66.67%*	x	v_{5bIIA}^{abs}	v_{5bIIB}^{abs}	v_{5bIIC}^{abs}	v_{5bIID}^{abs}	v_{5bIIE}^{abs}
						$\underline{b}_X^{tot1} = \underline{g}^{abs} \cdot \underline{V}_X^{abs}$			

Figure 8: AHP solution template for strategic decision-making pertaining to HR team composition for quantitative information acquisition

For performance measurements regarding the HR team composition decision, corresponding indicators need to be determined. On the first indicator level (see Figure 6) a strong relation to the earlier decision-making with AHP can be considered (see Figure 7 and 8). The AHP criteria of decision-making can be seen as ex ante estimations for the indicators that demonstrate ex post how well the estimations were met in reality based on actual values evaluated after implementation of the decision. For example, the first AHP decision criterion is the estimated expected total HR cost for IA. This can be compared to the actual total HR cost for IA after finishing the process by contract signing. To derive actions from a difference between actual and estimated values, it would be useful to measure the total cost of internal and external HR considering respective man hours and cost per hour and then aggregate the information to the total HR cost. By doing so, the cause for differences can be identified and consequent actions can be taken more easily. Furthermore, an indicators' development can be observed over time, until the final value is reached on the second indicator level. In the given case it might be interesting for example to differentiate HR cost for risk identification and risk assessment. In particular, it might be interesting for the managerial level to compare several projects amongst each other on a third indicator level. To ensure comparability, a viable option could be to compare the difference between actual and estimated HR cost for every project at end of the bid phase and relate the total amount and difference to success in form of contract awarding and the project size. In any case, the chosen indicators must allow feedback, action derivation and action implementation in a reasonable amount of time.

CONCLUSIONS

Rational IA for decision-making is a complex and interdisciplinary task. Because of limited resources, the key to profit maximization is an optimal cost-benefit ratio for the company and / or specific project. In any case, better results can be expected from a systematic evaluation and planning than from a quick and dirty approach. This applies not only to PPP projects or the construction industry, but to rational decision-making in general.

The problem presented could not be solved completely, but was rather discussed to raise awareness for the subject matter. The main conclusion is to allocate the decision aspects to the right entrepreneurial level (strategic or operational). Because of the cost relevance, focus needs to be put on HR organisation in general and the decision regarding HR team composition in particular. The latter pertains to the decision, whether to use external and/or internal resources for IA. The specific organisation, controlling, etc. needs to be determined in correspondence with the respective circumstances. Ultimately, all actions improving the cost-benefit ratio against the background of rational IA must be realized. Although this concept is abstract and difficult to deal with in practice, any responsible person should keep the ideas in the back of one's mind, when making the according decisions. Only business decisions that are based on rational input data can be seen as sound.

Furthermore, Figure 4 provides specific instructions on how to conduct information acquisition in principle, by listing objectives, process elements, methodologies and threats for risk identification, assessment, classification and handling.

The rationally acquired information will be used as input into an implemented quantitative risk allocation model that considers the risk bearing capacity of the private party. The intention is to create a positive impact on PPP project's success through enhanced rationality, reduction of uncertainty as well as risk and cost minimization. The research was co-financed by the Swiss Commission for Technology and Innovation.

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