Chair of Economic- and Business Management

Master's Thesis

Management system based decision-making process for the use of multidimensional risk factors

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Management-System basierter Entscheidungsprozess für den Einsatz mehrdimensionaler Risikofaktoren

Implementierung unter besonderer Berücksichtigung der Bias-Mitigation

Masterarbeit
von
DI Nina Romich, BSc.

eingereicht am
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Scope of Thesis

To Mrs. **Nina Romich** the topic

Management system based decision-making process for the use of multidimensional risk factors

is given for elaboration in a master thesis.

The first part of the thesis has to cover the theory foundation for developing a sound risk factor determination process. A conceptual approach based on system theory has to be developed to come up with an improved process for risk factor determination. Relevant tools from the business process re-engineering methodology shall be identified for process optimization and for alignment with the concerned stakeholders. Additionally the most important cognitive biases related to the involved decision making need to be elaborated and the appropriate de-biasing tools have to be defined. Those theoretical considerations shall be based on an extensive literature research as well as on expert interviews.

Target for the practical part of the thesis is an optimized process for risk factor determination that increases efficiency, raises the transparency of decision making in line with improved acceptance of the results and overcomes the most relevant biases related to those decisions as far as possible. Therefore, the existing process has to be analyzed in detail under system theoretical considerations and shall be captured via a structured task analysis. A major input for this analysis as well as for improvement considerations has to come from structured expert interviews with the major stakeholders of this process. Based on that analysis the optimized process shall be developed with business process re-engineering tools and a focus on de-biasing of the decisions involved. The result shall be an optimized process that can be readily implemented by management and is already aligned with the major stakeholders.

Leoben, July 2019

o.Univ.Prof. Dr. Hubert Biedermann

Lehrstuhl für Wirtschafts- und Betriebswissenschaften

Gleichheitsgrundsatz

Aus Gründen der Lesbarkeit wurde in dieser Arbeit darauf verzichtet, geschlechtsspezifische Formulierungen zu verwenden. Es wird ausdrücklich festgehalten, dass die bei Personen verwendeten maskulinen Formen für beide Geschlechter zu verstehen sind.

Danksagung

Ich möchte mich an dieser Stelle bei allen bedanken, die mich bei der Erstellung dieser Masterarbeit unterstützt haben.

Besonders herzlich möchte ich mich bei meinem Betreuer Herrn PD DI Dr. Wolfgang Posch für seine hilfreichen Anregungen und seine fortwährende Unterstützung bedanken. Ich konnte sehr von den zahlreichen konstruktiven Gesprächen und dem übermittelten Wissen profitieren.

Außerdem bedanke ich mich bei allen Teilnehmerinnen und Teilnehmern der OMV internen Befragungen für die interessanten Inputs und Informationsbereitschaft.

Abschließend möchte ich mich bei meinem Partner, meiner Schwester und meinen Eltern bedanken, die für mich eine wichtige Stütze während der Erstellung dieser Arbeit, aber auch während meines gesamten Studiums waren.

Kurzfassung

Die Festlegung eines Risikofaktors in Umgebungen mit großer Unsicherheit sind naturgemäß von einem hohen Grad an subjektiven Einschätzungen geprägt. Sobald Entscheidungen von Menschen mit variabler und schwer feststellbarer Expertise getroffen werden, ist ein Einfluss von kognitiven Verzerrungen („Biases“) sehr wahrscheinlich. Biases schränken die rationale Argumentation ein und resultieren aus unterschiedlichen Umständen. In dieser Arbeit wird ein Fokus auf Informations-, Motivations- und soziale Biases gelegt. Informationsbiases beeinflussen wie Informationen gesammelt und verarbeitet werden. Motivationsbiases resultieren aus einem Interesse am Ergebnis und dem Bestreben, den Risikoparameter in eine gewisse Richtung zu manipulieren, um in weiterer Folge das Ergebnis zu beeinflussen. Soziale Biases sind hauptsächlich das Ergebnis von Gruppendiskussionen mit Teilnehmern unterschiedlicher hierarchischer Ebenen oder besonders starker Persönlichkeit. Ein Entscheidungsprozess innerhalb eines Unternehmens muss daher sicherstellen, dass ein umfassendes Risikoverständnis unter Einbeziehung der Meinungen und Sichtweisen aller beteiligter Personen ermöglicht wird.

Die sorgfältige Ausarbeitung eines implementierfähigen Prozesses, der eine höchstmögliche Objektivität sicherstellt, erfordert eine gewissenhafte Analyse bestehender Prozesse, Schwächen im Prozess sowie den Einbezug aller Stakeholder des Prozesses. Zahlreiche Stakeholder-Interviews sowie Interviews mit internen Experten wurden durchgeführt, um ein umfassendes Bild der derzeitigen Lage zu erhalten und Verbesserungspotenziale zu identifizieren. Des Weiteren helfen systemtheoretische Überlegungen bei der Identifikation von Sub-Systemen und den vorhandenen und notwendigen Interaktionen dieser Systeme zur Sicherstellung eines optimalen Prozessablaufes.

Schlussendlich werden drei mögliche Prozessabläufe präsentiert, wobei der erste Prozess die umfassendsten Ansätze zur Bias-Mitigation enthält und daher eine klare Präferenz dieses Prozesses besteht. Nichtsdestotrotz werden zwei weniger umfangreiche Alternativen angeboten, die bei weniger komplexen Projekten mit geringerem Budget Anwendung finden können und eine schnellere und mit weniger Aufwand behaftete Festlegung des Risikofaktors ermöglicht. Alle Prozessschritte werden detailliert beschrieben und die angewendeten Prozessoptimierungsmaßnahmen werden hervorgehoben. Bei sorgfältiger Durchführung der einzelnen Prozessschritte (besonders für den ersten Prozess) kann dem Management ein fundierter, weitgehend objektiver Risikofaktor präsentiert werden. Durch den Nachweis der sorgfältigen Umsetzung des Prozesses und der Maßnahmen zur Bias-Entschärfung sollte die Akzeptanz im Management erhöht werden und im besten Fall eine Annahme des Risikofaktors ohne weitere Diskussionen erreicht werden.

Abstract

Determining a risk factor in a low-validity environment is naturally characterized by subjective judgements. As soon as humans with variable and hardly identifiably expertise make decisions, they are in some way very likely influenced by cognitive biases. Biases are a deviation from rationality that limit rational argumentation and result from various circumstances.

This work focuses on information, motivational and social biases. Information biases influence how information is gathered and evaluated. Motivational biases result from an interest in the result and the desire to manipulate risk parameters in a certain direction to influence the outcome. Social biases mainly result from group discussions, particularly if people are from different hierarchical levels and have powerful characters.

The process has to make sure that a comprehensive understanding about project-related risks, including opinions and perspectives of all individuals involved, is reached.

A careful elaboration of a ready-to-implement process, which ensures a highest possible objectivity, requires a careful analysis of the current process, of weaknesses of the process as well as the involvement of all stakeholders of the process. Several stakeholder-interviews and interviews with internal experts were conducted to gather a comprehensive picture of the actual situation and to identify improvement potentials. Furthermore, system-theory related considerations help to identify sub-systems and necessary interactions of these systems to ensure an optimal process flow.

Finally, three possible process sequences are presented, whereas the first process includes the most comprehensive approaches for bias-mitigation, which leads to a clear preference of this process. Nevertheless, two less comprehensive alternatives are offered, which can be applied to less complex projects with lower project budgets. These alternatives allow a faster and less time-consuming determination of risk factors.

All process steps are explained in detail and applied de-biasing measures are highlighted. In case of a careful treatment of all process steps (especially for the first proposal) a well-founded, extensively objective risk factor can be handed over to management. By proofing the diligent execution of the process and the application of de-biasing actions, acceptance in management should be improved and in the best-case approval of the proposed risk factor without further discussion is achieved.

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Abbreviations

BPR	Business Process Reengineering
CC	Chance Committee
CFO	Chief Financial Officer
CoM	Chance of Maturation
CoMm	Chance Committee
DM	Decision Making
e.g.	for example
etc	et cetera
E&P	Exploration and Production
E-D	Department Project Delivery & Assurance
E-G	Department Governance
E-P	Department Performance, Portfolio & Planning
E-T	Department Exploration, Development & Production
ET-X	Department Exploration & Appraisal
ExCom	Exploration Tollgate Committee
IGR	Independent Gate Review
MEFS	Minimum Economic Field Size
Mn	Million
Pg	Geological Chance of Success
Phc	Hydrocarbon Chance
PR	Project Representatives
Prc	Recovery Chance
ROI	Rate of Return
SVP	Senior Vice President
TC	Tollgate Committee
TG	Tollgate
TGC	Tollgate Committee
TGLC	Tollgate light Committee
TQM	Total Quality Management
VP	Vice President

1 Introduction

Making good and well-founded decisions is crucial for companies to succeed in long-term. Especially under conditions of uncertainty and in low-validity environments decision-making is a difficult task and needs carefully conducted preliminary work. Applying approaches to mitigate influences of cognitive biases and heuristics is necessary to enable an objective determination of risk factors for projects. A well-considered and detailed guideline for determining risks and uncertainties that could affect the project outcome helps to reach comprehensive understanding of all possibilities that might have a positive or negative impact. Extensive literature reviews were conducted to evaluate opportunities available to mitigate subjectivity in decisions. Afterwards appropriate approaches were identified and in consideration of opinions of the most important stakeholders, an improved risk factor determination process was developed that addresses the issues of unconscious biases.

1.1 Starting Position and Presentation of Problem

It is not possible to comprehensively free decisions from intuitive feelings that influence the way situations are framed, options are chosen, which people are consulted and how data is collected. Nevertheless, it is definitely doable to identify situations where decision-makers are likely to be biased. By increasing awareness of possible biases in the process, decisions can be strengthened.

Risk factor determination in OMV already follows a sound process including some de-biasing approaches. However, there is still a lack of acceptance in management and lengthy discussions come up in tollgate meetings that clearly indicate improvement potentials in the determination process. More extensive de-biasing actions and enhanced coordination meetings in front of tollgate meetings are necessary to increase awareness of uncertainties and risks related to the project and finally objectiveness of the risk factor. Developing a process that addresses the issues of lacking acceptance in management and negative influences of biases on the risk factor is urgently needed to ensure a more efficient procedure.

1.2 Objective and Research Issue

The goal of this thesis was to provide ready-to-implement proposals for a risk factor determination process. The process should ensure extensive bias mitigation approaches and involvement of all necessary stakeholders to determine a risk factor that correctly represents project related risks and uncertainties. Furthermore, the process needs to be efficient and must not include any unnecessary reviews and steps that only lead to an elongation of the decision-making procedure but not to any quality improvements.

1.3 Methodical Procedure

A conscientious review of state-of-the-art principles for bias mitigation was performed. A deeper look was taken on decision analysis principles, coordination tools, process optimization tools and system-theory considerations to capture relevant issues for developing the new process. A main part of this thesis was to perform numerous stakeholder interviews to reveal weaknesses of the current process and improvement potentials that should be considered. Based on those findings a new, improved process was developed. As the complexity of projects and project-related risks and uncertainties strongly differ from project to project, three possible approaches for the risk factor determination are provided. They vary in the extent of de-biasing measures and furthermore in time and effort needed to undergo the process.

1.4 Structure of Thesis

The thesis starts with a theoretical introduction to relevant issues for the practical part. Principles of systems theory, coordination instruments, decision theory, biases as well as de-biasing actions are explained in detail to provide a theoretical basis. The practical part starts with the analysis of the current process based on interviews and internal documents. Afterwards results of expert interviews are summarized and evaluated. Based on all findings the new process is developed and each step is explained in detail. De-biasing measures are chosen according to the beforehand identified biases affecting the determination process and introduced to the new, improved process for projects with different degrees of complexity.

2 Theoretical Part

This part of the thesis covers the theoretical background that is required to develop a sound risk factor determination process. First, a short introduction to systems theory is provided, as the whole risk factor determination process is based on interacting sub-systems that follow a common goal. System theory considerations are later on applied to identify and enhance interactions among different committees and teams. Next, an overview about coordination tools and a classification according to Leavitt is provided. Those coordination tools will find application in the improved process. Afterwards, the theoretical background regarding process optimization is examined to provide a basis for the development of the new, improved risk factor determination process. The next sub-chapter covers the main principles of decision theory and describes how decision quality is improved by decision analysis. An important part of this thesis is the description of possibly influencing biases on the risk factor determination process. Biases were grouped into information, motivational and social biases. Further, de-biasing approaches provided by literature are described in detail. These theoretical approaches were evaluated and the best fitting ones will find application in the new risk factor determination process. Finally, a short summary of the PDCA cycle closes this chapter to point out the importance of a continuous improvement of the process.

2.1 Systems Theory

System theory was developed in the 1950s to have a set of systematically theoretical constructs to discuss the empirical world.[1] System theory is applicable in various different disciplines and can be seen as a macro-level theory to understand biological, physical or social systems.[2]

The key concept behind systems theory is to demonstrate dynamic relationships and interdependence between components of the system and is established based on the relationships emerging from interactions among them. All components are interdependent with one another in the system, which means that one component is not able to function without the support of other components. The components of the system can either be tightly or loosely coupled dependent on the strength of the connection between them. The main process always consists of an input (resources, information etc.), a throughput (processes within the organisation) and an output (products, services etc.). Another crucial element is the feedback, which can either be negative (need to correct errors to maintain the state of the system) or positive (change system through improvement or growth). Further, the exchange with the environment is an important aspect, which is needed for the system to develop capacity.[3]

[1] Compare Boulding (1956)
[2] Compare Kast & Rosenzweig (1972)
[3] Compare Lai & Sapphire (2017)

A broad range of application of systems theory is to analyse organizational conflicts and problems. Problems should be diagnosed and solutions need to be prescribed. The complete consideration of the system (including structure, functions, processes and environment) helps to solve organizational problems. Looking at an organisation as a whole could enhance the problem-solving abilities of the management. Furthermore, the importance of communication, including internal, external and inter-organizational communication, with all stakeholders of the system, to achieve optimum organizational effectiveness is highlighted. This includes several feedback mechanisms to achieve a state of equilibrium within the system.[4]

2.2 Coordination Tools

In order to solve sophisticated tasks in a company it is unavoidably necessary to share them between employees. This leads to an increase of complexity due to the creation of subunits. The goal of coordination tools is to summarize and adjust those sub-tasks. Coordination instruments that aim to improve the information-processing capacity of an organization can be grouped (according to Leavitt, 1964) into person-oriented, technocratic and structural coordination mechanisms (as shown in Figure 1).[5]

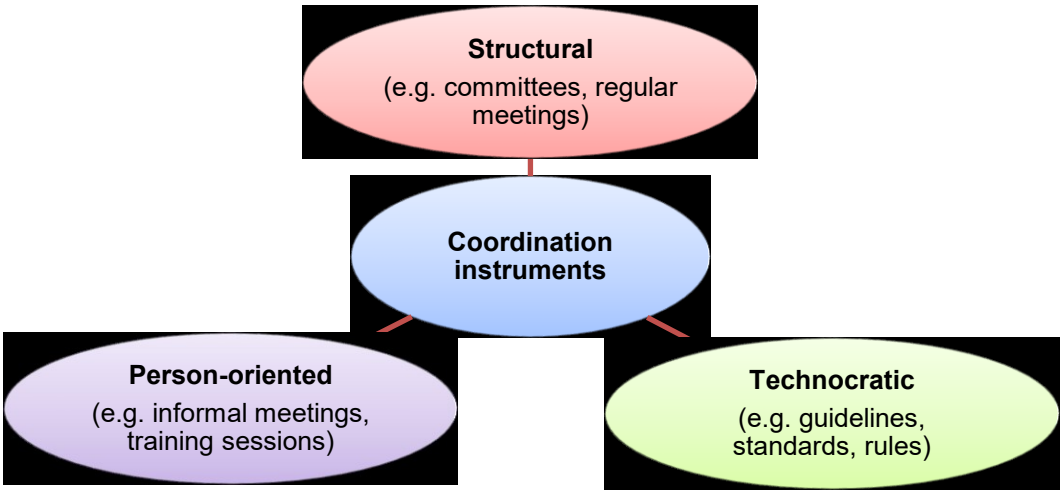

Figure 1: Coordination instruments after Leavitt (1964)

Person-oriented coordination mechanisms mainly focus on the distribution of competencies. Personal relations and arrangements between different disciplines result from person-oriented coordination mechanisms.[6] Person-oriented tools use human interaction and communication and allow for an exchange of social information.[7] Open forums for problem solving and allowing an exchange of social information are characteristics of person-oriented coordination instruments. These coordination

[4] Compare Lai & Sapphire (2017)
[5] Compare Schmidt (2010)
[6] Compare Posch (2011), S. 229
[7] Compare Hakanson & Zander (1986)

instruments are best suited for dealing with non-routine situations where solutions are not readily available or creative attempts are required.[8]

Issues that may arise from person-oriented coordination mechanisms are the unpredictable development due to social interaction as information is loosely constrained and not clearly specified. Further, they are comparably expensive as they rely on personal interactions.[9]

Technocratic coordination mechanisms focus on standardizing and formalizing. Personal interactions are hereby replaced by "managerial technology".[10] Measures are independent from humans. Process fixes, goals, plans or rules are examples for technocratic coordination tools. Especially processes that come up frequently should be standardized to decrease variety.[11] Technocratic coordination instruments, in comparison to person-oriented instruments, have a significantly lower information processing ability and restrict flexibility. Technocratic coordination instruments are very useful if problems reoccur and decision situations are similar and predictable.[12]

Structural coordination involves all coordinating aspects of primary and secondary organizations. Whereas primary organization focuses on structural organization and secondary organization on the creation of timely constrained committees or project teams. Structural coordination instruments are typically planned occurrences like regularly held meetings or permanent teams. Structural coordination instruments improve information flow between organizational subunits. Interactions typically follow a formal agenda within a framed setting. [13]

Technocratic and structural coordination are independent of the individuals involved, whereas person-oriented coordination mechanisms are dependent of the individual and are based on individual influence. [14]

For the risk factor determination process, structural coordination mechanisms are applied to organize project teams, chance and tollgate committees, independent gate review teams and regular meetings of these teams.

Technocratic coordination is performed by planning risk portfolios, reviewing proposed risk factors by certain parties and by checking and evaluating past performances.

Person-oriented coordination is necessary when personal influences become important and when individuals need to share their knowledge and opinions. Especially during group discussions, these coordination mechanisms become increasingly important.[15]

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[8] Compare Van de Ven (1989)
[9] Compare Verbeke et al. (2014), p. 103
[10] Compare Verbeke et al. (2014), p. 103
[11] Compare Posch (2011), S. 229, Schmidt (2010)
[12] Compare Khandwalla (1973)
[13] Compare Verbeke et al. (2014), p. 104
[14] Compare Posch (2011), p. 229
[15] Compare Posch (2011), p. 288

2.3 Process Optimization

The general idea behind process optimization is to analyze old business processes and optimize them to enhance efficiency. It is critical that before a process can be optimized, it is necessary to document and analyze the current process in detail. A careful documentation of all steps, parties involved and tools applied is a prerequisite for a proper analysis. During the process analysis, weaknesses and improvement potentials of the process should be identified. After completing those tasks several approaches for process optimization exist. Those approaches are mainly differentiated by the way they are implemented. Successive, softer methods (e.g. 5S-methode[16], Kaizen, TQM) avoid destroying implemented and efficient structures. They only aim to make small but effective adjustments on the process to enhance workflow efficiency. Whereas approaches that are more drastic revise all processes of a company and avoid an isolated improvement. That could lead to job cuts and extensive adjustments on the individuals working procedure. Often employees react with resistance and disconcertion. Furthermore, caution has to be taken during the implementation of radical approaches. Mistakes in this phase often lead to a complete failure of the whole project. The danger to fail miserably is much higher than for softer process optimization approaches.[17] Business-Process-Reengineering (BPR)[18] is one example for a very radical method to optimize processes. Processes are changed fundamentally and therefor this optimization method is very time-consuming, expensive and risky. The goal is to identify processes that are inefficient and subpar and figure out how to get rid of them or how to change them. Especially for corporations with implemented and fixed structures BPR is a tricky task. Nevertheless, BPR is highly relevant in rapidly changing environments and provides useful guidance in increasing efficiency of corporations.[19]

After implementing changes, it is crucial to monitor the process performance and continuously fine-tune it. The necessary steps for process optimization are summarized in Figure 2.

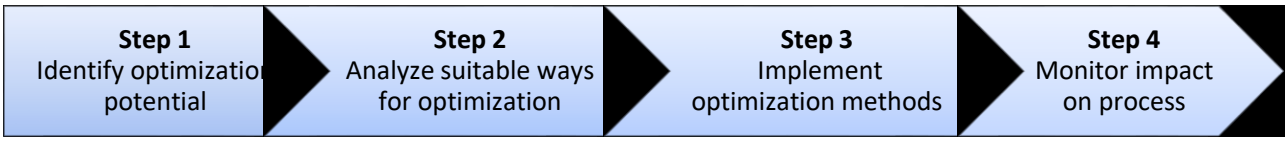

Figure 2: Process optimization steps[20]

Process optimization in case of the risk factor determination process, focuses on soft optimization approaches. Only relatively slight (but effective) changes will be applied to simplify the implementation of the new process.

[16] Compare Liker, Braun, Meier (2008), p. 101
[17] Compare Kothari (tallyfy.com/business-process-optimization/, Accessed 05/09/2019)
[18] Compare Hammer, Champy (1995)
[19] Compare Sonia Pearson (tallyfy.com/business-process-reengineering/, Accessed 05/09/2019)
[20] After Kissflow.com (Accessed 05/09/2019)

2.4 Decision Theory

The principle of decision theory started with Neumann's and Morgenstern's Expected Utility theory[21] and underwent a long way since then. In simple words, the term decision theory describes an approach to determine how decisions are made if there are several unknown parameters and an uncertain decision environment framework. Decision theory brings together several disciplines like psychology, statistics, philosophy and mathematics to analyze the decision-making process.[22]

All theories are based on a mathematical background and can be distinguished by three main directions:[23][24]

- **Normative studies**: to model fully rational decisions (do not allow for psychological factors – not adequate for real decision problems).
  Normative decision theory provides a guidance to make decisions with a given set of values.
- **Descriptive theories**: more realistic (account for uncertainty and imperfect nature of decision environment)
  Descriptive theory evaluates how irrational human beings make decisions.
- **Prescriptive theories**: combine theoretical basis with influential factors in real-world decisions.
  Prescriptive decision theory provides guidelines to make best possible decisions if an uncertain decision-making framework is given.

All existing theories have certain limitations but still provide a useful guideline for rational decisions. The assortment of methods and techniques applying utility theory to real-world decisions is known as decision analysis.

2.4.1 Decision Analysis

Decision analysis is concerned with finding effective and practical ways to implement decision theory. It describes processes to organize and translate a decision problem into a structure that is analyzed applying a collection of related analytic techniques to that structure. Elements of this decision structure are possible courses of action, potential outcomes from each course of action, probabilities and eventual consequences (costs and benefits).

Decision analysis is useful in project portfolio management as it provides a framework for analyzing project selection decisions and specific methods to quantify project values and address project risks. Formal decision making involves several steps: problem definition, information collection, risk assessment, identification and screening of alternatives, evaluation and selection of alternatives and communication and implementation of decisions. Decision analysis can be seen as a toolbox for decision-making. Various tools are applied, e.g. to model uncertainty (probability, sensitivity

[21] Compare Neumann, Morgenstern (1944)
[22] Compare Investopedia (Accessed 07/2019)
[23] Compare Aliev (2016), p. 1-2
[24] Compare Investopedia (Accessed 07/2019)

analysis), structure preferences (risk aversion, utility analysis, value functions) and to represent and solve decision problems (decision trees, influence diagrams).

Furthermore, decision analysis methods draw on fields of psychology of judgement and choice, as errors in decision making often arise from people's inability to make rational, objective decisions. Those errors are usually referred to as "Judgement Errors". Biases are the main reason for judgement errors and therefor de-biasing decisions is of high importance in decision-making processes.[25]

A decision analysis cycle that was developed at the Stanford Research Institute can provide a useful guideline for decision analysis (See Figure 3).

This cycle recommends a first "deterministic" phase were variables that affect decision outcomes should be identified. A sensitivity analysis to assign values and sensitivities of decision outcomes to the variables needs to be performed.

In the second phase, the "probabilistic" phase, experienced experts should determine probabilities to these variables. Furthermore, a course of action regarding uncertainty should be developed and an assessment of risk preference should be defined.

In the third, the "informational" phase, results of the previous two phases, are synthesized. For this reason a calculation of the value of eliminating uncertainty over each uncertain variable is performed. The desired outcome of this phase is a monetary value that needs to be paid to have perfect information to decide whether it is worth to buy additional information or to accept uncertainty. Afterwards a course of action should be defined.

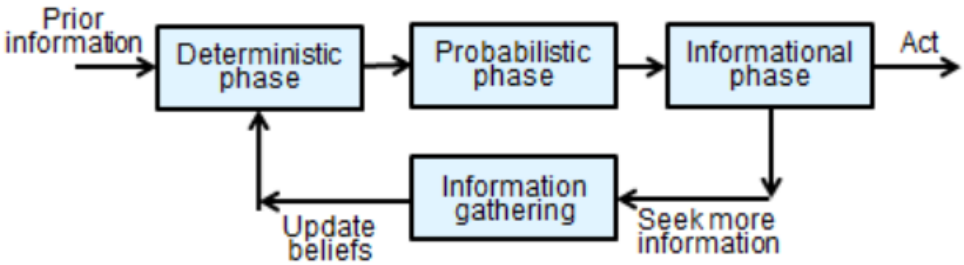

Figure 3: Decision analysis cycle[26]

In the end a decision that considers all possible alternatives (at least those that are available to the decision maker), accounts for potential consequences of each alternative and is consistent with the preferences of the decision-maker.
In simple words, a good decision requires knowledge of what can be done, what the decision maker believes in and what he wants to do.

[25] Compare prioritysystem.com (Accessed 07/2019)
http://www.prioritysystem.com/glossaryd.html#decisionanalysis
[26] Compare prioritysystem.com (Accessed 07/2019)
http://www.prioritysystem.com/glossaryd.html#decisionanalysis

2.4.2 Decision Quality

Decision quality is an extension of decision analysis that provides a framework for defining a good decision. One very important aspect of decision quality is that a high-quality decision could result in a poor outcome and on the other hand, a poor-quality decision can luckily produce a good outcome. Therefore, it is necessary to assess the quality of a decision by evaluating how choices were reached. The six considerations shown in Figure 4 provide guidance to evaluate decisions.

Figure 4: Decision quality[27]

[27] Compare prioritysystem.com (Accessed 07/2019)
http://www.prioritysystem.com/glossaryd.html#decisionanalysis

2.5 The Influence of Biases

Cognitive biases are a deviation from rationality that cause people to make irrational decisions (See Figure 5). They have various different effects and can either lead to minor issues (like forgetting details of past events), but can also have a much more detrimental impact (e.g. decisions about medical treatments). Generally, cognitive biases can influence how new information is perceived and interpreted or how past events are remembered. All humans experience the influence of biases, because they occur due to the way our basic cognitive system works. Various background factors like age, personality type and general cognitive ability affect the degree of influence of biases on people and to which degree their rationality is bound. Those circumstances lead to the fact that people's decision-making ability is constrained by the limitations of their cognitive systems.

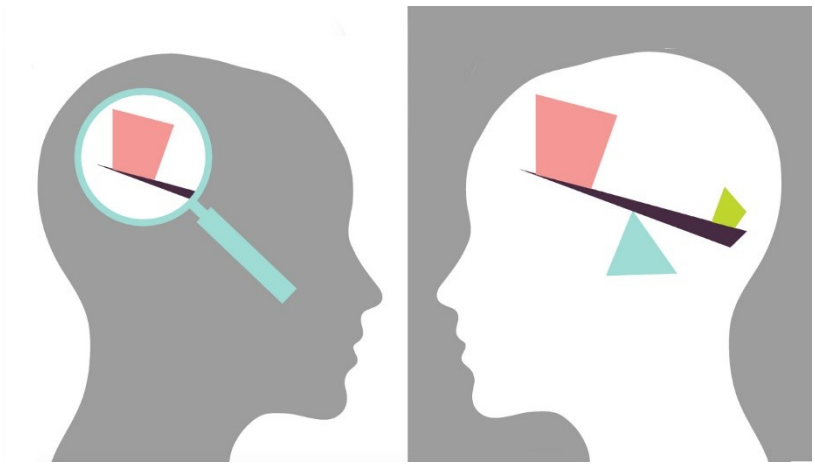

Figure 5: Illustration bias influence

(https://www.vision.org/critical-thinking-checking-the-bias-2982)

Highly biased decisions are often made if only limited time is available to process high amounts of or very complex information. Problems are not solved optimally if there is not enough time to think about the solution. Finding a solution that is "good enough" in a limited amount of time is in this case of higher importance than finding the optimum solution.[28] Unfortunately, those vastly intuitive decisions are often wrong as they are colored by biases without the decision maker even noticing it. Biases and heuristics have a negative impact on decision-making and very likely result in a loss of productivity.

This chapter deals with the issues in determining risk factors for petroleum exploration or development projects that arise because those factors are commonly based on and modified by subjective expert opinions. Subjective judgements are very likely inconsistent and inaccurate and in uncertain situations even very experienced people are influenced by numerous factors. Those factors can be objective (hard data, laws of probabilities), subjective (interpretations, assumed models, motives) and caused by influences on the thinking on the subconscious level (heuristics, biases).

[28] Compare Effectiviology – Science and philosophy you can use (Accessed 07/2019)

Four sources can be determined that promote subjectivity in decision-making[29]:

1. **The influence of heuristics (intuitive judgement, "rule of thumb")**

People have the intention to assess information quickly and to reach a conclusion without dealing with background information. Therefor they make use of representative heuristics.

2. **Limited cognitive capacity**

Biases that arise from limited cognitive capacity might cause that people quickly forget information that is easily accessible somewhere (e.g. Google effect). Usually it is easier to remember where information is stored than to remember the actual information.

3. **Noisy information processing**

How information is processed can be influenced by various background factors. E.g. when information is perceived as humorous it is remembered more easily than non-humorous information (humor effect). Media could highly influence people's opinion and what they keep in mind just by the way how content is presented.

4. **Social influence**

In addition, social influences cause several biases. A popular example is the "outgroup homogeneity bias" which causes people to view members of outside groups as being more similar to each other than members of the group they are a part of.

A distinction between hot and cold biases can be very useful. Hot biases always involve various emotional considerations. The desire of people to have a positive self-image or to make decisions that are ethically justifiable. Cold biases on the other hand arise from emotionally neutral processes. For example, it might arise from the desire to make quick decisions.[30]

Literature reports a vast amount of different biases that might affect people's decision-making ability. The most important ones for the risk factor determination process can be assigned to three groups as shown in Figure 6. Afterwards an explanation of those biases is provided.

[29] Compare Effectiviology.com (Accessed 07/2018)
[30] Compare Effectiviology.com (Accessed 07/2018)

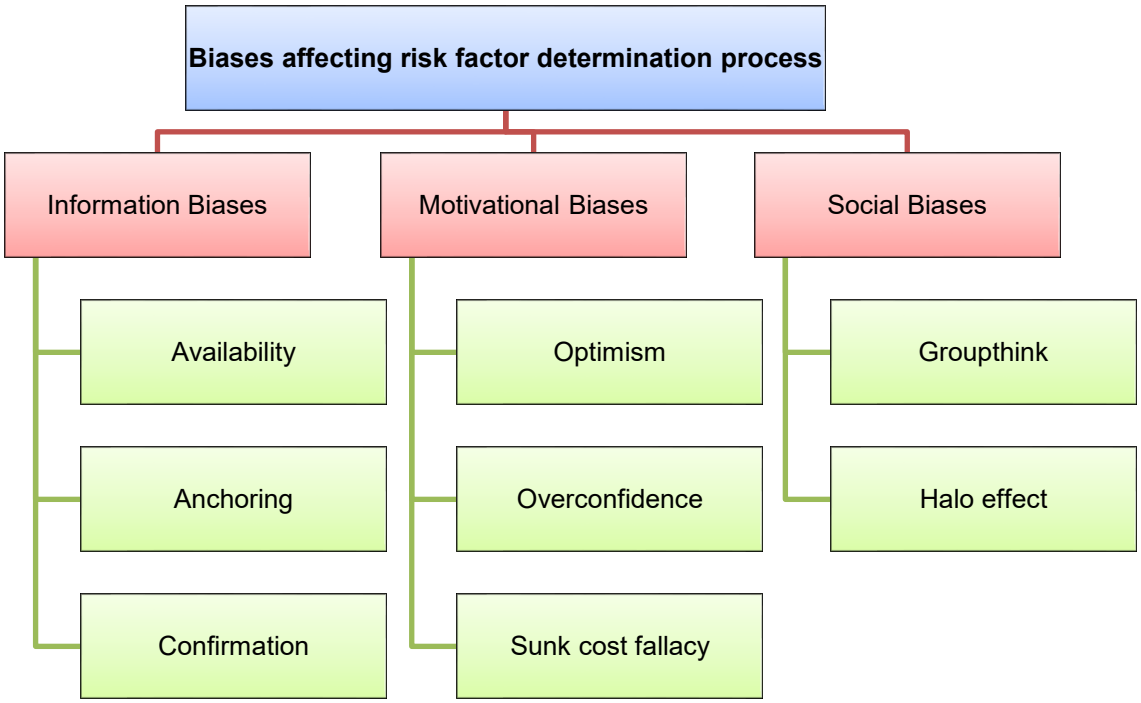

Figure 6: Important biases for risk factor determination process

2.5.1 Information Biases[31]

Biases of the informational type influence how information is acquired or processed. An example for this bias is the tendency of people to reject explanations that seem complex to them (overkill effect). People tend to prefer information that is easy to process from a cognitive perspective. Availability, anchoring and confirmation biases can be assigned to the group of information biases.

Availability Bias [32] [33] and Familiarity Heuristic[34]

The availability bias belongs to the group of information biases and describes people's tendency to overestimate the probability of events with greater availability in memory. Events, that charged our emotions more than others are more likely to be remembered and more easily recalled when it comes to decision-making. Decisions are influenced more by personal experiences than by objective data and so the simplicity of how easily a certain information comes to an expert's mind dedicates his/her decision.

In the petroleum industry, experts that are specialized in a certain type of oilfields tend to oversee risks in oilfields that are not so familiar to them. This means that people tend to interpret data in a way that fits their dominant expertise and knowledge.

The familiarity heuristic is a popular example for availability biases. Familiarity with information clearly influences people's decision. Especially in situations where subjects

[31] Compare Effectiviology.com (Accessed 07/2019)
[32] Compare Tversky & Kahneman (1974)
[33] Compare Rouse (2019)
[34] Vgl Shefrin (2007)

try to save time and make fast decisions, heuristics very likely influence judgements. However, this might be highly misleading as situations are not always comparable and heuristics decrease objectivity and hence weaken decision quality.[35]

An easy way to mitigate this bias is to work intentionally with people who think differently and have different expertise and experience.

Anchoring Bias[36]

This bias describes the tendency of people to regard one piece of information more intensively than the rest. Often estimations are pushed towards average or popular values. The decision-maker loses objectiveness as soon as such an anchor is set.

In the risk factor determination process an anchor that is set by the first proposal of the project team very likely influences the judgement of experts and harm their objectiveness in the reviewing process. This circumstance needs to be kept in mind during the development of the process.

Confirmation or Self-Serving Bias[37][38][39]

Another bias that belongs to the group of information biases is the confirmation bias. It describes the tendency of people to search for and recall information that confirms their preexisting beliefs. Those beliefs can include certain expectations in a given situation and predictions about a particular outcome. On the other side, information that contradicts the preconception is ignored, rejected or undervalued. In other words, people have already reached a conclusion beforehand and only shape the evidence, either knowingly or unknowingly, to make it fit. This bias is sometimes referred to as “Ostrich effect”[40]. Apparently, it adversely affects the objectiveness of decision-making. Especially for decisions about issues that are highly important or self-relevant for the decision maker, the confirmation bias is very likely to have an influence on the outcome. The confirmation bias is quite familiar to the self-serving bias (evaluate information in a way that is beneficial to own interests).[41] In petroleum exploration projects it might happen that people that are especially interested in realizing a certain project, unconsciously back-calculate risk values in their favor. Biased portfolios can then harm a company’s long-term performance. [42]

[35] Compare psynso.com/familiarity-heuristic (Accessed 02/09/2019)
[36] Compare Tversky & Kahnemann (1974)
[37] Compare Oswald & Grosjean (2004), Shefrin (2007)
[38] Compare Rouse (2019)
[39] Compare Casad, 2019
[40] Compare howtogetyourownway.com (Accessed 07/2019)
[41] Compare AAPG Risk and Uncertainty Forum (2019), p. 46
[42] Compare Merckhofer (1987)

2.5.2 Motivational Biases

Motivational biases are defined as influences on judgements due to the desirability or undesirability of events, consequences, outcomes or choices.[43] Below some examples of motivational biases are described:

Optimism and Pessimism Bias[44]

Those biases describe the tendency to overestimate favorable or pleasing outcomes or to exaggerate the likelihood of negative outcomes. This bias is present in a variety of fields and very likely companies unintentionally engage excessive optimism e.g. if their existence depends on favorable forecasts. Apparently, E&P projects are highly endangered to be valued under the influence of optimism biases.

Overconfidence Bias[45]

This bias arises from people's subjective excessive confidence in their own judgement and their overestimation to perform well. People might oversee the limits of their professional skills and knowledge. When subjects do not have a real accountability and "suffer" from their bad predictions later on, they might tend to be overconfident with their forecasts. In addition, managers who think they know more than they really do are often overly confident in their own abilities and avoid searching for help in making important decisions. Wrong decisions based on erroneous justifications are very likely to result from this bias.

Sunk Cost Fallacy[46][47]

Sunk costs are expenses that have already been incurred and cannot be recovered to any significant degree. Sunk cost fallacy describes the case that if significant amounts of effort and money are already spent on a certain project, the probability of success might be estimated higher than justified by data. Previous investments become a reason to carry on with a project, even if the outcome is very likely to be poor. Lending more weight to costs that have already incurred rather than the costs to come is a widely spread fallacy beyond managers which needs to be assessed urgently.

[43] Compare Montibeller, Winterfeldt (2015)
[44] Compare Baron (2007), Alexander & Lohr (1998), Hersh (2007)
[45] Compare Hoffrage (2004), Shefrin (2007)
[46] Compare Arkes & Ayton (1999), Whyte (1986)
[47] Compare De Barros Teixeira (2019)

2.5.3 Social Biases[48]

This group of biases deals with influences of cognitive biases on social perception and behavior. Two famous representatives of social biases are the groupthink bias and the halo effect:

Groupthink Bias[49]

The groupthink bias is a popular example linked to social biases. It deals with the loss of independent thinking in groups where unanimity is regarded as too important. The motivation to consider alternative views might get lost, which apparently leads to weaker decisions. The bandwagon effect is a type of groupthink bias. It arises from the feeling of a need to conform and act in accordance with others.

Halo Effect[50]

The halo effect is a type of cognitive bias in which our overall impression of a person influences how we feel and think about his or her character. It refers to the habitual tendency of people to rate attractive individuals more favorably for their personality traits or characteristics than those who are less attractive. The halo effect is also known as the physical attractiveness stereotype and the "what is beautiful is good" principle. Overall, it describes the fact that feelings generally overcome cognitions when we appraise others. In group-discussions arguments from experts “with a halo” (because they have a natural charisma, good presentation skills, connections to the top manager etc.) might be trusted more, even if they are less knowledgeable than others are.

[48] Vgl Effectiviology.com (Accessed 07/2019)
[49] Vgl Effectiviology.com (Accessed 07/2019)
[50] Compare Rosenzweig (2007)

2.6 Debiasing Decisions

Biases are often difficult to detect and it is a tricky task to decrease their influence. They adversely affect business decisions and should be avoided whenever possible. A McKinsey study by Lovallo and Sibony (2010) revealed that the 25% companies best at de-biasing actions had a higher ROI by 5.3% (ROI 6.9%) in comparison to the 25% companies worst (ROI 1.6%). This underpins the importance of de-biasing strategies.[51]

Especially in situations where business success depends on avoiding decision errors, a strong focus should be set on reducing mistakes to a minimum. Some carefully targeted interventions against the most critical biases can highly enhance decision-making quality. Using neutral fact bases, distressing exercises or encouraging employees to scrutinize decisions will in long-term lead to greater confidence in the process and well-founded, successful projects.[52]

Research[53] shows that team members avoid to bring up problems as it can be seen as obstructive or disloyal. Even if feedback is requested, people tend to hold back criticism to protect political, organizational or personal interests. So, to ensure that projects get the scrutiny they need to perform well, de-biasing techniques should be implemented in the decision-making process. [54] De-biasing techniques are applied to reduce and remove biases that influence important judgements and decisions. Those techniques should support organizations in learning how to de-bias and to obtain better performing project portfolios. [55]

Wilson and Brekke (1994)[56] provided a view of the formation of biases and the reasons why it could be difficult to remove them (See Figure 7). They concluded that people could only de-bias their decision if they are aware of the erroneous mental processes they use. Nevertheless, people will not correct biases, if they are not motivated to do so, even if they are aware of them. To de-bias, people need understanding of the bias that may affects them as well as the error that results from the bias. Furthermore, there has to be an effective strategy for removing the bias.

[51] Compare Lovallo, Sibony (2010)
[52] Compare Baer, Heiligtag, Samandari (2017)
[53] Compare Klein (2007)
[54] Compare Klein, Koller, Lovallo (2019)
[55] Compare Fischhoff (1982)
[56] Vgl Wilson & Brekke (1994)

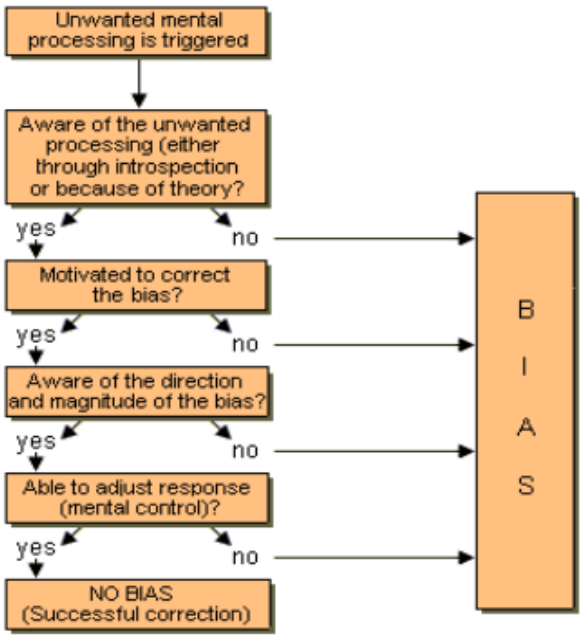

Figure 7: General strategy for debiasing (After Wilson & Brekke 1994)

Debiasing approaches are often related to D. Kahnemans (2011) System 2 thinking. Therefor a short explanation of this principle is provided below:

Table 1: Distinction System 1 and 2 according to D. Kahneman (2011)

Two main cognitive systems after D. Kahneman (2011)	
System 1	The cognitive system 1 is mainly responsible for intuitive processing and is fast, automatic and effortless. Processes on this system run in parallel (multiple fronts can be engaged simultaneously) and outcomes are strongly influenced by emotional considerations.
System 2	This system is responsible for conscious reasoning and is in contrast to system 1 slow, controlled and effortful. Processes run in a serial way, it is only possible to focus on one thing at the same time. No emotional considerations have an influence on decisions of this system.

Successful de-biasing promotes System 2 thinking, which means applying cognitive effort, rationalizing, slowing down, using tools and aids and bringing more information and facts to the decision-making process.[57] There exist several approaches to accomplish this, e.g. incentives, nudging, training, policy fixes and tools (See Figure 8).

[57] Compare Kahnemann (2011)

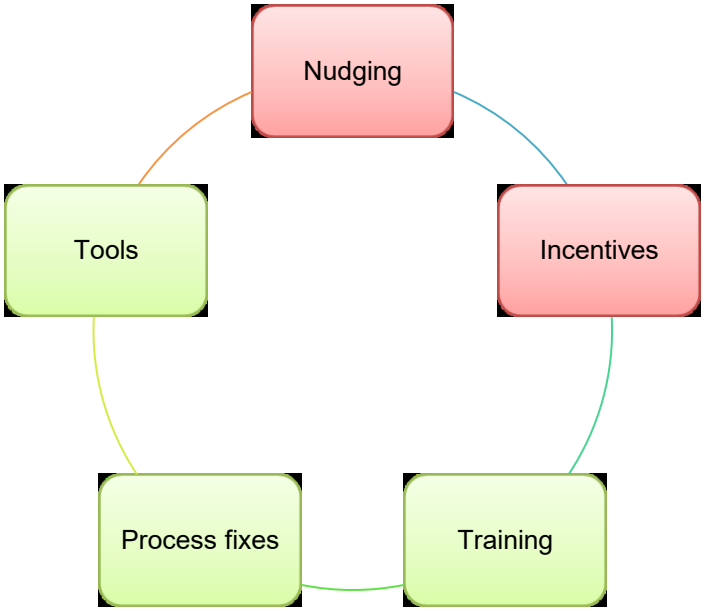

Figure 8: Debiasing approaches [58]

2.6.1 Nudging

Nudging, or optimizing choice architecture, includes framing decisions and providing helpful information to decrease decision-maker's tendency to make poor decisions under the influence of biases. Good choices should be easy choices. Nudge strategies should change people's behavior without restricting their options or changing their incentives.[59]

This can be achieved in several forms, e.g. by manipulating the structure of decisions, presenting choice options in certain ways, providing additional information or by setting default options. Whereas presenting decision options and relevant information to make sure everything is understood properly, is the most obvious nudge. Nevertheless, decisions should not appear more complicated than they actually are, just by giving too much choices or information.[60]

Nudging is currently applied in communicating information to influence customer behavior. There are not too many effective applications of nudging to business decisions and furthermore nudging does not address the causes of biased decisions. In addition, concerns were raised that nudging is a way to manipulate people's decisions. [61]

2.6.2 Incentives

Increasing motivation to perform well, improves the quality of decisions. If individuals spend more effort on reflection and calculation, system 2 thinking will override the emotional, intuitive system 1 thinking. Related to that, it is useful to make people more

[58] Compare prioritysystems.com (Accessed 07/2019)
[59] Compare Thaler & Sunstein (2008)
[60] Compare Bhargava & Loewenstein (2015)
[61] Compare prioritysystem.com (Accessed 07/2019)

accountable for their decisions.[62] People intuitionally want to make a positive impression and avoid embarrassment.[63] Overly extreme positions are limited by enhancing accountability and going on records can encourage people to be more careful in their logic. Furthermore, the fear of being proved wrong helps to mitigate over-optimism. Having in mind that the decision needs to be justified to others helps to decrease flaws in arguments.[64]

Nevertheless, the usage of incentives has to be treated with caution. If people do not have the ability to apply better decision-making approaches, increasing incentives could lead them to apply flawed heuristics. Therefor increasing incentives is not always effective in improving decision quality. Experiments showed that incentives can even have a detrimental effect on some biases, especially for overconfidence, supporting evidence and framing bias.[65] The exception in this case is anchoring, where incentives have a positive influence on avoiding anchors in some situations.[66]

In any case, incentives need to be easily understandable, viewed as fair and aligned with company objectives to drive unbiased decisions effectively in the interest of the organization. As long as decision-makers have the tools and ability to asses project value, incentives and accountability help in creating better project selection decisions. Nevertheless, it is crucial that managers are rewarded based on the quality of the decision itself and not so much on the project outcome, as the outcome is not always correlated with the quality of decisions.[67] “Reward skill, not luck” should be kept in mind. Although this is not an easy task as companies have to understand whether the causes of particular successes and failures were controllable or not and have to eliminate the role of luck when project managers are rewarded. Projects that are executed well, even if they fail due to anticipated, uncontrollable factors, should be rewarded. On the other hand project managers that manage projects poorly, but succeed due to lucky circumstances, should be disciplined. Even if gathering this information might be quite cumbersome, it is the only way to use incentives as a bias mitigation measure in a fair way.[68]

2.6.3 Training

As mentioned earlier, understanding biases is a prerequisite to avoid them. So obviously, educating people about biases will help in reducing them. Fischhoff[69] provided four strategies in reducing biases:

(1) Warning subjects about the potential for biases
(2) Describing the likely direction of biases
(3) Illustrating biases to the subject
(4) Providing training, feedback and coaching about biases

[62] Compare Lerner & Tetlock (1999)
[63] Vgl Aczel et al. (2015)
[64] Compare Larrick (2004)
[65] Compare Arkes (1991)
[66] Compare Epley (2004)
[67] Compare prioritysystems.com (Accessed 07/2019)
[68] Compare Koller, Lovallo, Williams (2012)
[69] Compare Fischhoff (1982)

Nonetheless, Fischhoff concluded that these strategies only lead to moderate and short-term improvements in decision-making. [70]

One explanation for the little effect of education is that people often do not feel personally affected by biases. [71] In this case, it could be helpful to improve cause-effect understanding of situations and processes. Training on recognizing patterns and applying appropriate responses can help experts to make decisions that are more accurate. Being able to apply System 2 thinking by teaching people statistical reasoning and decision-making rules has been shown to reduce some biases. [72]

De-biasing training was proven to be effective in **medical decision making** by a study conducted with undergraduate psychology students in West Virginia. They concluded that educating students about framing effects and by forcing them to provide a rationale after decision making (e.g. advantages and disadvantages about different treatments), decision quality was greatly enhanced. It could be proven that framing effects could be diminished by requesting a rationale. This shows that simple interventions taught during short training sessions are highly effective.[73]

Another interesting experimental evaluation of how effective de-biasing training could be was performed in seven countries with 410 software developers from Brunel University in London.[74] They particularly looked into diminishing anchoring bias by providing a 2-3 hours workshop training. Without training, they observed a huge influence of anchors upon the judgement of experts in software development about how long it would take to finish a certain task. Even irrelevant and misleading anchors highly influenced expert's judgements. After the workshop was conducted, where participants were informed about the influence of cognitive biases to increase their awareness, it could be determined that the likelihood of the influence of anchoring biases could be significantly reduced (but not eliminated). Figure 9**Error! Reference source not found.** shows an interaction plot of the relation between anchor and de-biasing. The diminishing effect of the workshop is particularly strong for the high anchor. Although this study did not look into long-term effects and probably follow-up work would be useful, it clearly showed the advantageous effect of training people to enhance their decision-making abilities.[75]

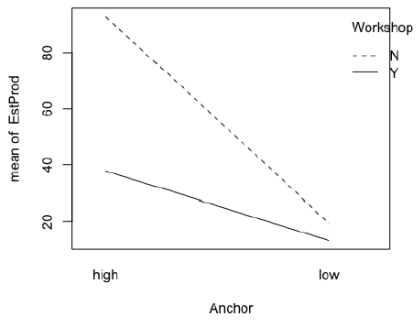

Figure 9: Interaction plot of anchor and de-biasing Intervention (Shepperd et. al. (2018))

[70] Compare Fischhoff (1982)
[71] Compare Wilson & Brekke (1994)
[72] Compare Nisbett et al. (1987)
[73] Compare Almashat et al. (2008)
[74] Compare Shepperd et al. (2018)
[75] Compare Shepperd et al (2018)

Welsh and Begg (2007) from the University of Adelaide conducted another study that proofs the benefit of awareness-style training for bias mitigation. They mainly focused on overconfidence bias in the **oil and gas industry**, which describes the tendency of people to give too narrow bounds when asked to set a range that they are certain to some stated level of confidence that a value will fall within. In the oil and gas industry, it is widely accepted that repeated feedback is the best option to reduce overconfidence bias. Nevertheless, they showed that also awareness training of overconfidence bias helps to reduce it. Pre and post-training results showed that although people tended to be too confident even after the training session, the overconfidence effect could be reduced by 21%.[76]

2.6.4 Process Fixes

Process fixes are modifications on the organizational policy with the intention to reduce the likelihood of decision errors and important biases. A common process to reduce decision errors is to build an independent review board, where decision-makers authorize groups to provide advice and feedback to decisions. The goal is to increase the awareness of the decision maker about relevant issues in question.[77]

An interesting approach that can be assigned to the group of process fixes is to encourage decision makers to take an “outside view” on the project instead of only considering the specifics of the case at hand (“inside view”). “Outside view” in that terms means building a statistical view of the project based on a reference class of similar projects. Obviously, it is critical to identify the reference class of projects and companies might think it is too exhausting and time-consuming to find it. However, research shows that using the correct reference class can reduce estimation errors by 70 percent.[78] So learning from others’ experiences can definitely be as useful as learning from own experiences.[79]

Another idea that offers a vast amount of benefits compared to low costs and effort is a so-called “premortem” (summarized process see Figure 10). In short, this technique works backward by considering that a project has failed and thinking of reasons that could have caused this failure. It helps to raise awareness of possibilities and to enrich the planning.[80]

In such “premortem”-sessions decision-makers should surround themselves with trusted experts in advance of major decisions, whereas the primary job of the experts is to present negative arguments against the preferred choice.[81] “Premortems” can also be quite effective inside project teams to encourage team members to review the plan and anticipate threats and hurdles.[82]

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[76] Compare Welsh and Begg (2007)
[77] Compare Jackson (2010)
[78] Compare Flyvbjerg et al. (2009)
[79] Compare Koller, Lovallo (2019)
[80] Compare Serrat (2017)
[81] Compare Kahnemann (2011)
[82] Compare Klein, Koller, Lovallo (2019)

Especially, in strong hierarchical systems there is a high danger that people are reluctant to express doubts about the workability of a plan. Team members do not want to oppose their bosses and therefor keep their mouths shut. “Premortems” can help to bring up reasons for failure that would not have been mentioned for fear of being impolite. Tasking a team to imagine that a plan has been implemented and failed miserably increases the ability of team members to identify reasons for negative future outcomes. Getting team members away from the position of defending their plan opens new perspectives and enables them to search for faults. [83]

As mentioned earlier, “premortems” are low cost and effort, but high valuable process fixes. One way to organize such “premortems” would be to imagine a future situation (in months or years, whenever it should be known whether a plan was well formulated) and to ask each team member to write down thoughts on why the project had failed and share their reasons with the group. For highly sensitive issues it might be better to make an anonymous collection of ideas. Finally, multiple ideas should be recorded and everyone in the team has the possibility to raise his/her opinion. After identifying project vulnerabilities, it might also be useful to prioritize the comprehensive list of reasons. Finally, the team should think about ways to mitigate the issues to strengthen the plan. In the end, a stronger plan and a project team that is more aware of the potential challenges will come up. “Premortems” offer a very effective way for team members to speak out uncomfortable truths without repercussion but with gratitude for courage and cleverness.[84][85]

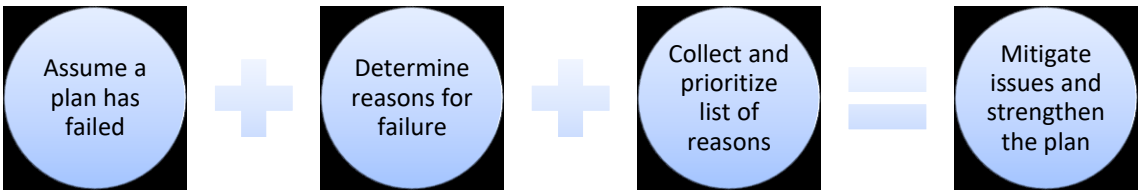

Figure 10: Summarized “premortem” process

A study conducted by the University of Colorado in 1989 proofed that premortem-sessions could increase the ability to identify future reasons for outcomes by 30%. Furthermore Gary Klein documented that military air-campaign planners successfully used this process fixes to strengthen their plans. [86]

Nevertheless, there exist two main limitations for the usage of process fixes. First, the organization must accept the required change in policy as a good thing before the implementation can take place. Secondly, the organization has to enforce adherence to the new process and must be willing to adopt the new policy. [87]

[83] Compare Serrat (2017)
[84] Compare Klein, Koller, Lovallo (2019)
[85] Compare Serrat (2017)
[86] Compare Klein (2007)
[87] Compare Jackson (2010)

2.6.5 De-biasing Tools

Numerous tools intended to aid decisions exist and all of them are useful in some way to reduce distortions caused by errors and biases. A common characteristic of all these decision aids is to add structure to the decision-making process and to force decision makers to rely less on System 1 intuition and emotion and to rely more on System 2 deliberate thinking. The idea behind is to replace intuitive reasoning by a formal and analytical process.[88]

Debiasing tools can be grouped into five categories:[89]

(1) Checklists for promoting a quality based decision process
(2) Thinking aids intended mainly to improve perspective
(3) Models and optimization methods for recommending choices
(4) Aids for promoting group consensus
(5) Voting methods

An example for the first category is shown in Figure 11, which is a checklist aid to score the decision-making process.

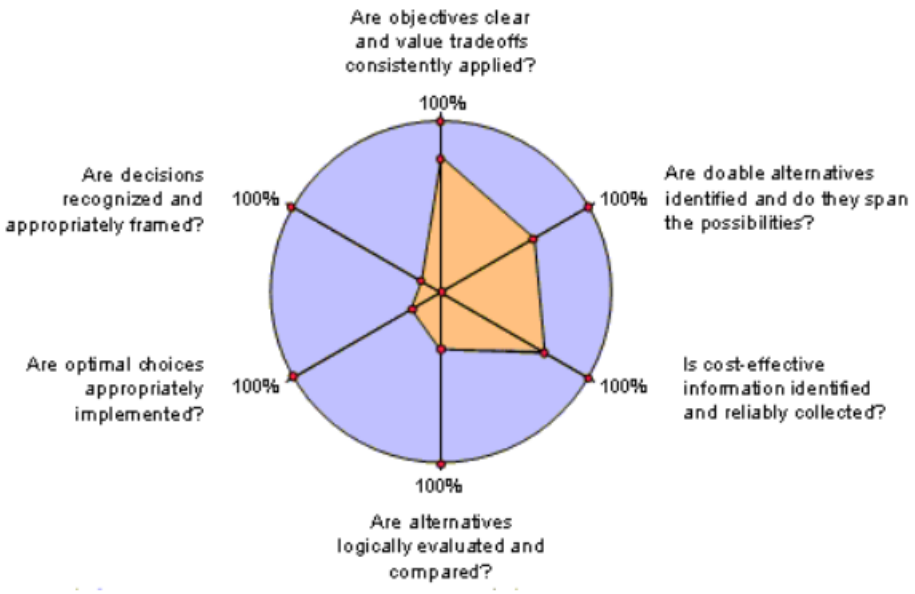

Figure 11: Checklist evaluate deficiencies in DM process[90]

Models and analytic processes turned out to be very effective in reducing the impact of biases. E.g. in situations where past data is available, simple statistical methods like regression analysis can highly improve the decision-making process. Models (even if they were imprecise and without accurate inputs) have been proven to provide better and more reliable decisions than people in a wide range of fields and even very simple models highly improve estimates and encourage better decisions.[91] In addition, decision analysis provides a very effective tool to avoid biases and improve decision quality.[92]

[88] Compare prioritysystems.com (Accessed 07/2019)
[89] Compare Howards (1999), Chapter 3
[90] Compare Howard (1999)
[91] Compare Jagacinski & Flach (2003)
[92] Compare Larrick (2004)

2.6.6 Summary of De-biasing Approaches

In Table 2 a list of advantages and disadvantages of the explained de-biasing approaches is provided.

Table 2: Summary of De-biasing Approaches, Pros & Cons

	PROS	**CONS**
Incentives	Increase motivation to spend effort on reflection and calculation	People have no ability to apply better decision-making approaches; incentives lead them to apply more flawed heuristics
		Can even reinforce biases (overconfidence, framing bias)
	Increase accountability (encourage people to be more careful in their logic, mitigate over optimism)	Hard to implement a fair process (honour good decision quality and not project outcome)
		Hard to judge if events were success/failure based on controllable or uncontrollable factors
Nudging	No restriction of options	Not many effective applications for business decisions
	Decision maker receives important information	Do not address the causes of biased decisions
		Danger of manipulating decisions
Training	Educating people to be aware of influence of biases is prerequisite to avoid them	Could only lead to short-term improvement
	Teaching people statistical reasoning was proven to reduce biases	People often do not feel personally affected by biases (also not after training)
Process Fixes	Increase awareness of project team about relevant issues (risks, vulnerabilities)	Additional effort in process: time (expenses)
	Encourage people to raise opinions (no repercussion)	Organization must accept change in policy
	Record multiple ideas and identify project vulnerabilities	Organization has to adopt new policy in long-term
	Extension: think about mitigation strategies	
Debiasing Tools	Decrease intuitive decision making	Additional effort in process: time (small)
	Promote conscious reasoning	Organization must accept and adopt new techniques
	Models and analytic processes are proven to be effective in reducing biases and enhancing quality	

2.6.7 Supporting Approaches from Project (Risk) Management[93]

When it comes to project management, it is of high importance to overcome biases to maximize the project outcome. E.g. during risk management, biases can highly affect people's judgement on the severity and probability of risks. Project management training should enable people to assess risks from a more objective dimension.

Low impact levels tend to be widely tolerated, but as soon as the risk impact overcomes a certain "tipping point", the perceived impact dramatically reduces risk tolerance and it could result in an exaggerated cure that is worse than the potential of the disease. Biases can have detrimental effects in such situations as people focus too much on specific details ("anchoring bias") and tend to oversee the rest. If, during risk assessment, lower impact risks with high probabilities may affect the project repeatedly adversely and lead to high losses. Three possible ways to deal with natural biases in risk management are described below:[94]

(1) Unbiased risk facilitator
The project manager should not be the risk workshop leader at the same time. An independent leader can more easily identify negative groupthink and biases.

(2) Once bitten, twice shy
Low impact, high probability risks should be regarded as carefully as high impact, low probability risks. Both can substantially affect a project outcome and therefor need to be assessed with the same accuracy.

(3) Step back to gain perspective
Evaluating the risk portfolio once again after the risk assessment section has ended could also help to identify whether sufficient effort has been spent on all risks (and not only on high impact risks). Often a separate session to address low impact risks with high probabilities can be useful.

2.6.8 Quick Test of Possible Influence of Biases in Decision-Making Process

The before mentioned System 1 is responsible for intuitive decisions that rely on a "gut instinct". It is important for decision-makers to know when they should trust their gut instincts and when those instincts might be misleading. Fully avoiding the influence of gut instincts on decisions is unrealistic, but identifying situations that are specifically endangered by the influence of biases is helpful to strengthen the decision-making process.

An easy way how decision-makers can proof the quality of their decisions is to ask themselves the following four questions:[95]

Have we frequently experienced identical or similar situations? (Familiarity test)

To judge if decisions are sound it is important to proof if there are enough "appropriate" experiences available on which decisions are based on. Care has to be taken to make

[93] Compare Bondale (2019)
[94] Compare Bondale (2009)
[95] Campbell & Whitehead (2010)

sure that those experiences are indeed representative as they might be misleading in case of different framework conditions. Examining the main uncertainties and evaluating whether sufficient experience is available to make sound judgements about them is in this case crucial.

Did we get reliable feedback in past situations? (Feedback test)

To make sure that previous experiences really increase quality of decisions it is essential to proof that they rely on decisions were comprehensive feedback was available. Otherwise, it might be misleading to rely on past decisions, as the outcome of former judgements is not known.

Are the emotions we have experienced in similar or related situations measured? (Measured-emotions test)

Judgements might be greatly unbalanced if situations bring highly charged emotions to mind. Decision makers should be aware of misleading past experiences that bias judgements in an emotional way. If people are emotionally charged in a specific decision making situation (positively or negatively), it is usually not a good idea to rely on their opinion.

Are we likely to be influenced by any inappropriate personal interests or attachments? (Independence test)

Personal attachments or interests always adversely affect decision quality and should be avoided whenever possible. Making sure that decision-makers are extensively free from any inappropriate personal preferences is critical to allow for objective and sound decisions.

Decision processes need to be strengthened if a situation fails one of these four tests. Unfortunately, there is no universal safeguard available. Nevertheless, combining some safeguards in the process and making sure decision-makers keep in mind that although their gut instincts might be useful in most of the situations they can also have a negative impact and they should be aware of these issues, highly enhances decision quality.[96]

2.6.9 Bias Mitigation in Petroleum Exploration

Mitigating biases in petroleum exploration portfolios is of high interest for oil and gas companies. Therefore, it is crucial to first assess each prospect consistently to be able to compare, contrast and rank them relative to each other. As all human beings are susceptible to various biases and logical fallacies, this is a tricky task in practice.

Especially in the early period of exploration projects, influences of biases are very likely. In many cases, when a promising exploration is found, signs that indicate a success are much more highlighted than signs that show the contrary. Negative indications might be dismissed as exceptions or special cases and not enough attention is paid to them. Furthermore, risk factors that may terminate a project are dismissed too quickly as economic targets would be adversely affected. In addition, biases to risks that were

[96] Compare Campbell & Whitehead (2010)

already identified and to information that was first available might cause issues in petroleum exploration.

One possibility to increase objectivity and consistency and to remediate cognitive biases in the risking process is to provide regular training in risk assessment. Another possibility is the usage of risk tables to reduce subjectivity and biases to improve the consistency of risk assessment by different experts and teams. Especially in low-validity environments, it is recommended[97] to use simple algorithms instead of individual judgements. The reason is that experts try to be comprehensive in their minds with complex combinations of data and interpretations, but this often simply does not work in low-validity environments. They tend to become overconfident, suffer from various biases and do not want to admit that they have a lack of knowledge in certain areas. Many experts are less knowledgeable than they think and are prone to harmful judgement heuristics, biases and mistakes. Often they interpret the same data differently in a second run, even if no new information was added. All those issues in low-validity environments can be mitigated by applying algorithms, as they always return the same result when giving the same input. [98]

[97] Compare Kahnemann (2011), p. 51-60
[98] Compare Effectiviology – Science and philosophy you can use (Accessed 07/2019)

2.7 Continuous Improvement of Processes

The key to sound decision-making is learning from experiences and continuously improving the process for future decisions. This applies for the negative influence of biases as well as for many other deficiencies in the process. A useful approach to develop and improve a management system is the widely recognized PDCA cycle that is utilized by the ISO 27001. PDCA stands for Plan-Do-Check-Act and represents a dynamic model where the end of one turn directly flows into the start of the next and therefor continuous improvement is achieved. The cycle was devised by W. Shewhart in the 1920s and further developed by W. E. Deming, therefor the cycle is sometimes referred to as “Deming cycle”.[99]

In Figure 12 the four stages of this management cycle are visualized. The specific tasks of each step can be generalised as follows[100]:

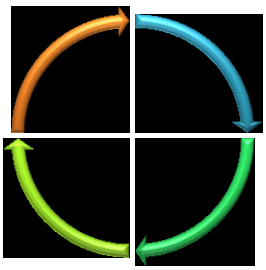

Figure 12: PDCA cycle

Plan
1. Identify business objectives
2. Obtain management support
3. Select proper scope of implementation
4. Define method of risk assessment
5. Rank assets according to risk classification (based on risk assessment)

Do
- Manage and treat risks
- Set up procedures to control risks
- Allocate resources and staff

Check
- Compare data to expected outcomes
- Monitor implementation

Act
- Improve process
- Corrective and preventive actions

To ensure a continuous improvement of the risk factor determination process the PDCA cycle has to be periodically applied. It is regarded as an overarching process to the risk factor determination process. Mainly members of the chance committee are responsible for a continuous improvement of the process. Nevertheless, all stakeholders of the process should support the chance committee with feedback and ideas to improve the process.

[99] Compare http://www.17799central.com/pdca.htm, Accessed 07/2019
[100] Compare https://www.isaca.org/Journal/, Accessed 07/2019 (Pelnekar, 2011)

3 Practical Part

The practical part of this thesis starts with an explanation of the risk factor that is mainly applied in OMV, which is the “CoM – Chance of Maturation”. Afterwards, an application of system theory considerations on the risk factor determination process is presented. Interacting sub-systems of the actual process were identified and visualized. Interactions between the project team and various committees are shown. Afterwards an analysis of tasks and structure of the process was performed to make sure that no steps are overseen. The current risk factor determination process was analysed in detail. Arguments in favour and against a standardized procedure for the determination process are provided. The second sub-chapter captures the opinions of OMV internal experts and stakeholders of the current process. These expert views were gained by performing numerous interviews. The goal was to identify pitfalls in the current process and to find out reasons for the lack of acceptance of the current risk factor in top management. All those findings were considered when finally the new, improved process was developed. Three different processes, depending on the complexity of projects and the project budget are developed.

3.1 Current Risk Factor Determination Process

A major task of this thesis was to provide a suggestion for a coordinated decision making process for the determination of a risk factor. Therefore, it was necessary to analyse the current process in detail to be able to improve the process later on.

3.1.1 Chance of Maturation - CoM

The currently applied risk factor for E&P projects in OMV is the Chance of Maturation (CoM). The CoM is a percentage value that expresses the probability of the success case. The CoM consists of four sub-categories that cover different aspects of the project.

The chance of maturation was implemented in OMV to provide a consistent approach in assessing the risk exposure of the company’s portfolio. Projects of different types and maturity levels should become better comparable to ensure that investment is directed to projects with the best value.

The CoM changes with each iteration of assessment and always represents the chance of the currently defined business case. The four sub-categories of the CoM are shown in Figure 13. Generally, the first two sub-categories focus on subsurface risks (Phc and Prc) whereas the third and fourth sub-category deal with projects related technical, legal and stakeholder interaction risks.

Figure 13: Four quadrants of chance of maturation

The overall CoM value is calculated be multiplying the values of the four sub-categories. It has to be pointed out that commerciality risks and country risks are not included in the determination of the CoM. Most of the CoM values can be assessed using a standardized framework with pre-defined correlations. Exceptions are always possible, but they need to be explained and documented.

The CoM becomes 100% as soon as the project is in the producing state and delivers hydrocarbons. It has to be kept in mind that in spite of the clear definitions and guidance the CoM remains a subjective figure that is based on personal views, experiences and intuition. As soon as new information comes up, the CoM needs to be updated continuously to finally ensure that investments are directed to targets with reasonable chance of realization.

3.1.2 Main Stakeholders of the Process

Identifying all relevant stakeholders was a pre-requisite for a comprehensive analysis of the process. The most important parties for the process are project representatives, chance and tollgate committee. Members of the tollgate committee are dependent on the project characteristics. For exploration projects up to and including tollgate 0 the members of the ExCoM are present at the TG-meeting. Post tollgate 0 the participants are dependent on the project budget. Below 20 mn EUR the “Tollgate light” and above the “Tollgate” committee is present at the meeting. In Table 3, a list of all important stakeholders of the current process is provided. The IGR Committee is also mentioned here, although the independent gate review is not performed by default for CoM values in the current process. Nevertheless, in some instances IGR-teams already evaluated CoM values if they were available in front of the review.

Table 3: Main Stakeholders of the Process

Project Team	**Chance Committee**	**Further stakeholders**
• Project Owner • Project Manager • Asset Development Manager • Development Manager • General Manager • Region Manager	• Central Risk Coordinator • PE & Development • Technical Assurance • Exploration • Engineering • Commercial • Project Services	• IGR Committee • Geologists (Explorationist) • Risk Committee
ExCoM	**Tollgate Committee**	**Tollgate Committee light**
• VP ET-X • SVP E-T • SVP of Hub • Divisional CFO • VP E-P • Senior Expert EP-G • Head of Corp. Dev. E&P • Head of Portfolio Mgmt. • Project team	• E&P Board Member • SVP E-T • SVP E-D • SVP of Hub • Divisional CFO • VP E-P • Senior Expert EP-G • VP ET-X • Head of Portfolio Mgmt. • Team leader IGR • Project team	• Hub SVP • SVP E-T • SVP E-D • SVP of Hub • Divisional CFO • VP E-P • Senior Expert EP-G • Team leader IGR • Project team

3.1.3 Systems Theory Considerations

Ideas of system theory were applied to understand the different sub-systems that interact in the defining process. The whole decision-making process takes place using secondary organization committees and teams (project team, chance committee, tollgate committee). Figure 14 shows the hierarchical level where those secondary organization teams are normally located in the primary organization.

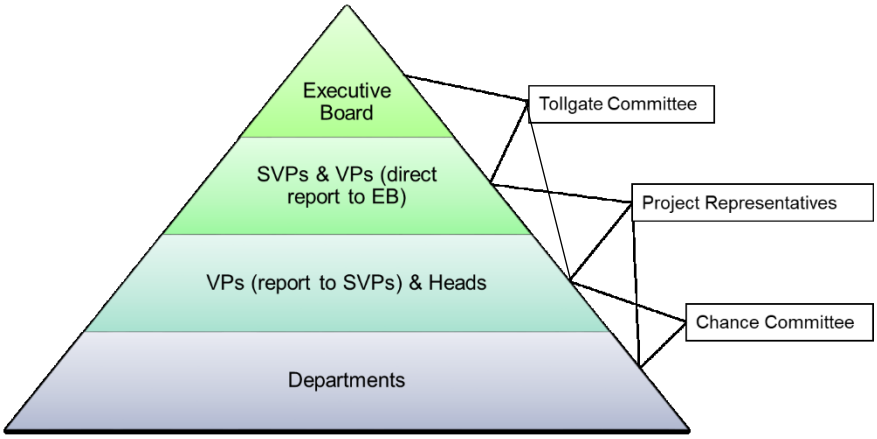

Figure 14: OMV company structure

To set up a risk factor determination process based on systems theory considerations it was crucial to define the major goals of the new process that were simultaneously the major pitfalls of the current process:

- **Acceptance in management**
- **Bias mitigation**

Input to the process, as indicated in Figure 15 comes from various sources outside and inside the company. Factors that influence the risk factor determination are vast amounts of information regarding political interests, risks, shareholders, clients, suppliers etc. The geological chance of success (Pg) and the risk matrix are regarded as inputs to the process, as the determination process of Pg and risks is out of scope of this thesis. The “Throughput” of the process is the actual determination of the risk factor, which takes place by the project representatives and a group of experts (e.g. Chance Committee and other experts). Currently, the risk factor is then communicated directly to the tollgate committee (this will be different for the improved process, where a review by the independent gate review will take place by default). Although the current process should make sure that the proposed risk factor is widely unbiased, tollgate members do not accept the value, which results in extensive discussions in tollgate meetings. The updated, improved process should address this issue.

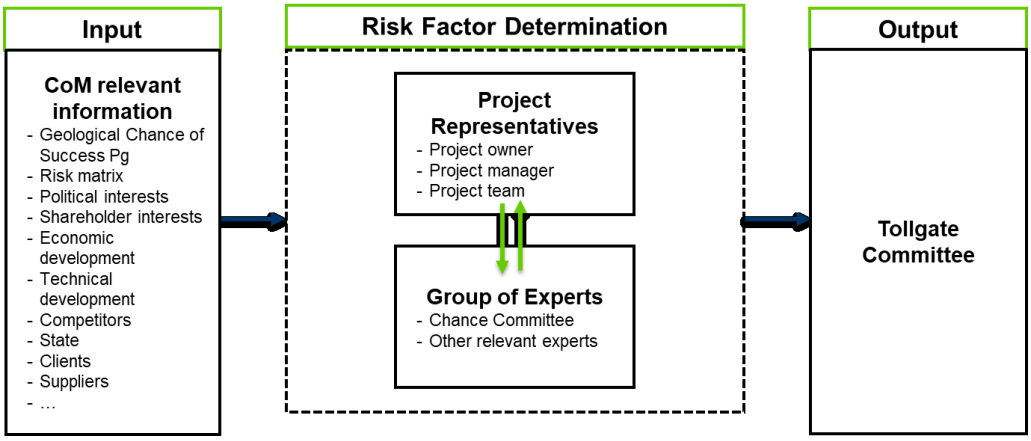

Figure 15: Systems theory considerations, current process

3.1.4 Analysis of Current Process

In the current CoM determination process, there are three main roles defined: CoM Owner (CO), Chance Committee (CoMm) and CoMm Coordinator (CCC).

The CO (part of the project team) is responsible for providing the CoM proposal. Usually the CO is the Exploration Manager, Development Manager, Project- or Asset Manager.

The Chance Committee acts as an independent review board and ensures a consistent risk approach. The Chance Committee consists of senior OMV Headoffice staff members that represent certain disciplines and cover different risk aspects. The Chance Committee is furthermore responsible to provide training sessions and information material.

The Chance Committee Coordinator organizes chairs and is responsible for the documentation of the Chance Committee meetings. He/she is responsible for tracking the CoM and maintaining the CoM records. The Comculator tool is an Excel spreadsheet that provides guidance in evaluating the four CoM quadrants.

Figure 16 shows the summarized CoM determination procedure and visualizes the different steps in the process.

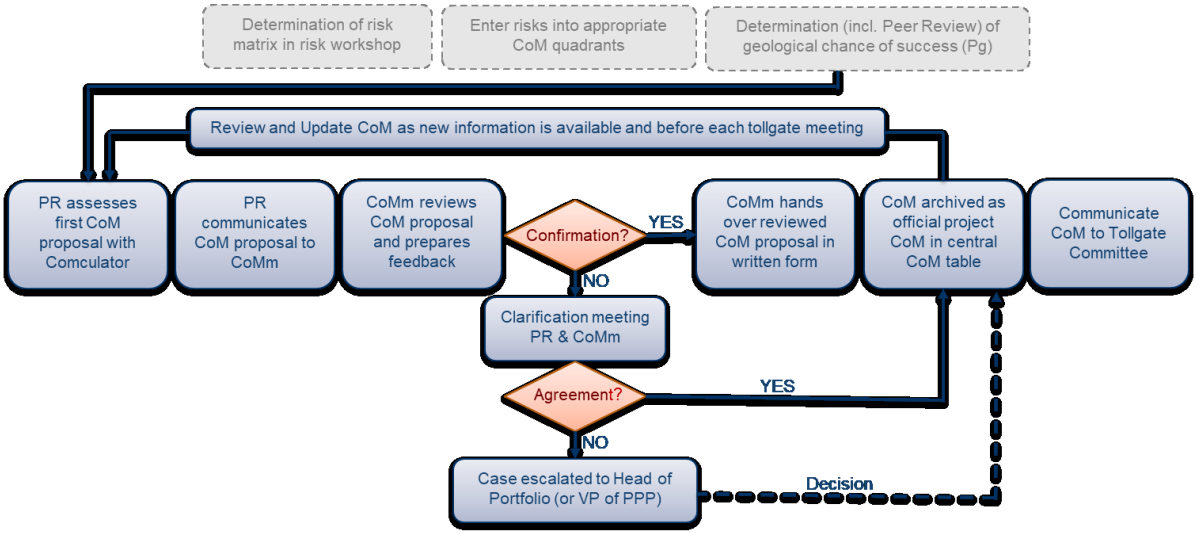

Figure 16: Current CoM determination procedure

The CoM determination process is repeated after and before each tollgate meeting or as new information comes up. It is crucial that the project CoM always represents the status of knowledge.

Tasks of the current risk factor determination process were identified and linked to the responsible party in an analysis of tasks and structure (“Aufgaben-Struktur-Analyse”). The outcome of this analysis is shown in Table 4. The abbreviation “A” stands for “act”, “I” stands for “inform” and “C” stands for “coordinate”. The parties involved are Project Representatives (PR), Chance Committee (CC), Head of Portfolio (HoP) (in case that no consensus can be reached), Independent Gate Review (IGR) and Tollgate Committee (TC).

Table 4: Analysis of task and structure of current process

Tasks	**PR**	**CC**	**HoP**	**IGR**	**TC**
Assess first CoM proposal with Comculator	A				
Communicate CoM proposal to CoMm	A	I			
Evaluate and review CoM proposal and prepare feedback	I	A			
Confirmation: Hand over reviewed CoM proposal in written form	C	A			
No Confirmation: Clarification meeting	A	A			
Agreement: Include review results and update CoM	A	I			
No Agreement: Case escalated to Head of Portfolio (or VP of PPP)	I	C	A		
Archive CoM as official project CoM in central CoM table	A	I			
Communicate CoM to Tollgate Committee	A				C
Review and update CoM as new information is available and before each tollgate meeting	A	I			I

This analysis revealed some possible weaknesses and improvement potentials of the current process. First, it was determined that there are some tasks where responsibilities are not fully clear. Furthermore, it is clearly visible that the whole process is dominated by contributions of the project representatives. Shifting some contributions to other parties could enhance the objectiveness of the process.

There is currently no guideline for the initial assessment of the CoM proposal by project representatives. Introducing some recommendations that enhance objectiveness of the initial proposal could highly improve the process at an early stage. More pre-defined steps aiming to enhance discussion between various stakeholders of the process could improve the determination process. Finally, an additional review of the proposed CoM values by an independent gate review (IGR) could highly improve the decision quality.

3.2 Results of Expert Interviews

To develop an improved risk factor determination process various experts and stakeholders of the current process were interviewed. The goal was to capture all relevant opinions on the current procedure and to reveal weaknesses and improvement potentials of the process. Interviews were conducted as open discussions with some pre-defined questions. The main elements that were in focus of discussion during the interviews were:

- Opinion on CoM
- Standardized vs. non-standardized procedure
- Danger of biased decisions
- Reasons for lack of acceptance in management
- Opinion on CoM tollgate connection

3.2.1 Interview Partners

Several internal stakeholders of the process as well as experienced experts that were involved in the definition of the CoM procedure and the development of the Excel Comculator were considered.

The first interview partner was Erwin Rieser, the Central Upstream Risk Coordinator. He has been involved in this process for a long time and was able to give useful ideas for optimizing the process. Additionally, he provided several possible interview partners for further discussions.

Furthermore, all members of the chance committee and other internal experts that have contributed to this process in some way were polled. In the following table, all interview partners and their role within the CoM process is shown:

Table 5: Interview Partners CoM Procedure

Name	Role in CoM Procedure
Erwin Rieser	Central Upstream Risk Coordinator
Daniel Eichhober	Participated in revising CoM procedure Already worked on increasing acceptance in management and increasing the involvement of experts in the reviewing process
Harald Scheruga Rosmarion	Member of the Chance Committee (Commercial) Involved in elaborations of Comculator (3rd and 4th quadrant)
Martin Hubbig	Member of the Chance Committee (Technical Assurance) Involved in reserve classification process (PRMS, SEC)
Johann Roithinger	Involved in defining CoM procedure for portfolio considerations
Dieter Freytag	Member of the Chance Committee (Project Services)
Ross Northover	Member of the Chance Committee (Engineering)
Christina Gaber	Senior Expert E&A Analysis
Martin Zanetti	Member of the Chance Committee (Commercial)
Christina Gaber	Senior Expert E&A Analysis
Markus Nüsslein	Member of Chance Committee (Exploration)
Marion Graggober	Senior Expert Portfolio
Birgit Stoiser	Head of Economics & Project Finance
Jasmin Gril	Technical Assurance, Organisation of Tollgate-Meetings
Jose Gonzales-Rojas	Member of Chance Committee, PE & Development
Lisa Posch	Head of Department Portfolio & Planning
Jost Püttmann	Advisor Decision Making in Developments

3.2.2 Opinion on Chance of Maturation

First, it was intended to capture the interviewee's opinion on the concept of chance of maturation. The goal was to evaluate whether experts think that the CoM is a good concept to capture project related risks or if they think that more or less risk aspects should be incorporated in the project and portfolio evaluation.

All interview partners think that the concept of chance of maturation is a good one to capture project related risks. No one of the respondents would include additional factors into the risk evaluation. Everyone thinks that the four sub-categories are a good representation. On the other hand, also decreasing the number of factors that are taken into account and moving back to a less sophisticated approach, like e.g. only considering subsurface risks (Pg) is not desired. The point was raised that although the idea behind

the CoM concept is well considered, the application is not always properly done, which leads to acceptance issues in the management afterwards.[101]

3.2.3 Standardized vs. Non-Standardized Procedure

The second question targets gaining an impression if experts prefer a standardized risk factor determination, using the Excel Comculator, or a non-standardized way, which maybe allows for more flexibility. The answers of this question were very clear. All respondents prefer the standardized procedure as they think it is crucial to increase objectivity[102], to calibrate results[103], to have a thinking aid, to make results better comparable and transparent[104][105] and to have consistency throughout different projects[106].

3.2.4 Danger of Biased Decisions

The majority of interview partners stated that they are convinced that there is a considerable threat of biases in the first assessment of risk factors by the project team. Obviously, project team members are influenced by motivational biases, as they already invested energy into the project and want it to continue to exist.[107] This issue is especially dominant in branch offices, where a certain number of projects needs to be conducted to justify their existence.[108] Especially the project owner (usually takes part and decides in tollgate committee meetings) is highly biased and is generally too optimistic about the project outcome. Often the project owner is convinced that his/her projects succeed and will achieve a producing status and therefor a too optimistic CoM is suggested.[109]

In addition, strategic decisions highly promote biases, especially in the top management. Members of the chance committee instance that it is quite common that CoM values are overruled by management decisions to let projects appear in a more advantageous way.[110] Furthermore, enhancing the reserve classification might lead to biases as the management is interested in having a more favourable reserve estimation. In OMV, the reserve classification is dependent on economic viability, maturity of the project (tollgate) and on the CoM of the individual project. Increasing chance of maturation to make it fit to a certain reserve class might be the intention of the management and is therefore prone to biases.[111]

The majority of interviewees is convinced that the chance committee is extensively unbiased, as they have no interest in the success or failure of the project. Nevertheless,

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[101] Expert Interview Ross Northover (2019)
[102] Expert interview Daniel Eichhober (2019), Christina Gaber (2019), Birgit Stoiser (2019)
[103] Expert interview Harald Scheruga Rosmarion (2019)
[104] Expert interview Martin Hubbig (2019)
[105] Expert interview Dieter Freytag (2019), Markus Nüsslein (2019)
[106] Expert interview Ross Northover (2019)
[107] Expert interview Daniel Eichhober (2019), Harald Scheruga Rosmarion (2019), Johann Roithinger (2019)
[108] Expert interview Martin Zanetti (2019)
[109] Expert interview Lisa Posch (2019)
[110] Expert interview Martin Zanetti (2019)
[111] Expert interview Martin Hubbig (2019)

every human being suffers from cognitive biases due to their personal experiences, risk awareness and knowledge.[112]

3.2.5 Lack of Acceptance in Management

Two main points came up that could be a reason for the lack of acceptance in tollgate meetings. The first one was that the lack of acceptance results from a lack of knowledge and communication about the exact definition of the CoM, the risks that are captured and what the CoM exactly stands for.[113] If no common understanding of the CoM is established, it will always lead to discussions about different decisions. Additionally, there could be an issue in communicating that the CoM will always remain a subjective but well-founded expert estimation, but still it is no mathematical model.[114] Some interview partners remark that issues that should be solved out in front of the Tollgate meeting (according to CoM procedure) are often communicated much too late and therefore discussions come up in the TG meeting. Discussions at an earlier stage (between project team members or between project team and chance committee) should therefore be enhanced and the TG meeting should only take place if a consensus was reached beforehand. [115]

The second big issue is related to the before mentioned cognitive biases that result from the unwillingness to accept low CoM values and the resulting low project ranking. Strategic and managerial decisions affect the preference of specific projects or countries and often these preferences are more important than the project accompanying risks.[116] The issue was raised that the CoM is abusively used to push preferred projects according to strategic interests.[117] When project owners realize the ranking position of their project, they often want to increase the CoM to achieve a higher ranking.[118]

It seems that the pre-defined determination process is sometimes not treated with enough care. Some respondents mentioned that reviewing the CoM in IGR meetings could improve the reliability of the value.[119]

3.2.6 Opinion on CoM Tollgate Connection

A tollgate connected CoM value is viewed quite critical. Most of the respondents fear a loss of crucial information and do not see a benefit in a CoM value connected to the tollgate. Some stated that linking the chance of maturation to a tollgate would distort the value[120] and such a high systematization is extensively unrealistic and does not lead to

[112] Expert interview Daniel Eichhober (2019), Harald Scheruga Rosmarion (2019), Johann Roithinger (2019), Martin Hubbig (2019), Ross Northover (2019)

[113] Expert Interview Daniel Eichhober (2019), Lisa Posch (2019)
[114] Expert Interview Erwin Rieser (2019), Dieter Freytag (2019)
[115] Expert Interview Johann Roithinger (2019)
[116] Expert Interview Martin Zanetti (2019)
[117] Expert Interview Harald Scheruga Rosmarion (2019)
[118] Expert Interview Marion Graggober (2019)
[119] Expert Interview Ross Northover (2019)
[120] Expert Interview Johann Roithinger (2019)

an improvement.[121] Nevertheless, using a tollgate connected CoM value could be useful for portfolio evaluations.[122] One respondent stated that at maximum, the tollgate connection should be used as an additional parameter in the portfolio evaluation[123], but it should not replace the individual project CoM.

Nevertheless, it was mentioned that a CoM tollgate connection also has some advantages, e.g. completely de-biasing the risk factor and less effort to determine CoM values for individual projects as well as making sure that all projects are treated in exactly the same way. Furthermore, it was assumed that when the portfolio value is calculated, it makes no big difference whether an individual CoM value or a pre-defined CoM value is used.[124] The idea was raised that buying additional data about past projects from other companies could be used to increase statistical relevance.[125]

3.2.7 Pitfalls in the Current Process

Four main sources of errors were identified based on the interviews with internal stakeholders and experts:

Biases have a great potential to decrease the objectiveness of the risk factor determination process. Obviously, project representatives are affected by biases as they have the biggest interest in continuing the project and therefor might adjust the risk factor in a too optimistic way. In addition, members of the tollgate committee usually have preferences due to strategic decisions and are therefore greatly endangered to suffer from cognitive biases. Nevertheless, also members of the chance committee suffer from cognitive biases (as every human being). Bias mitigation measures are urgently needed to improve the risk factor determination process.

Another big source of errors is the circumstance that there exists a lack of information. Members of the chance committee stated that there is too little information before the chance committee meeting takes place and therefore a proper preparation is not possible. The issue for project representatives and members of the tollgate committee is that not all of them are fully aware of the CoM meaning and what risks are captured in the CoM. Further trainings should ensure a sufficient state of information in future.

Furthermore, a lack of discussion definitely has a negative impact on the process. Steps that ensure a consensus between project representatives are necessary. Especially the project owner is sometimes not comprehensively informed before the tollgate meeting takes place. In addition, in chance committee meetings discussion should be improved as it was stated that CoM values are sometimes nodded through and no discussion at all takes place. Another big improvement potential is the introduction of independent gate reviews (IGRs) into the improved process. This second independent review greatly enhances objectivity of the determined risk factor.

[121] Expert Interview Dieter Freytag (2019)
[122] Expert interview Marion Graggober, Lisa Posch (2019)
[123] Expert Interview Harald Scheruga Rosmarion (2019)
[124] Expert Interview Marion Graggober (2019)
[125] Expert Interview Birgit Stoiser (2019)

The fourth issue that is in focus of optimization for the improved process is to ensure that the process is treated with enough care. During the interviews it turned out that this is not always the case for the current process.

A summary of the main error sources is shown in Figure 17.

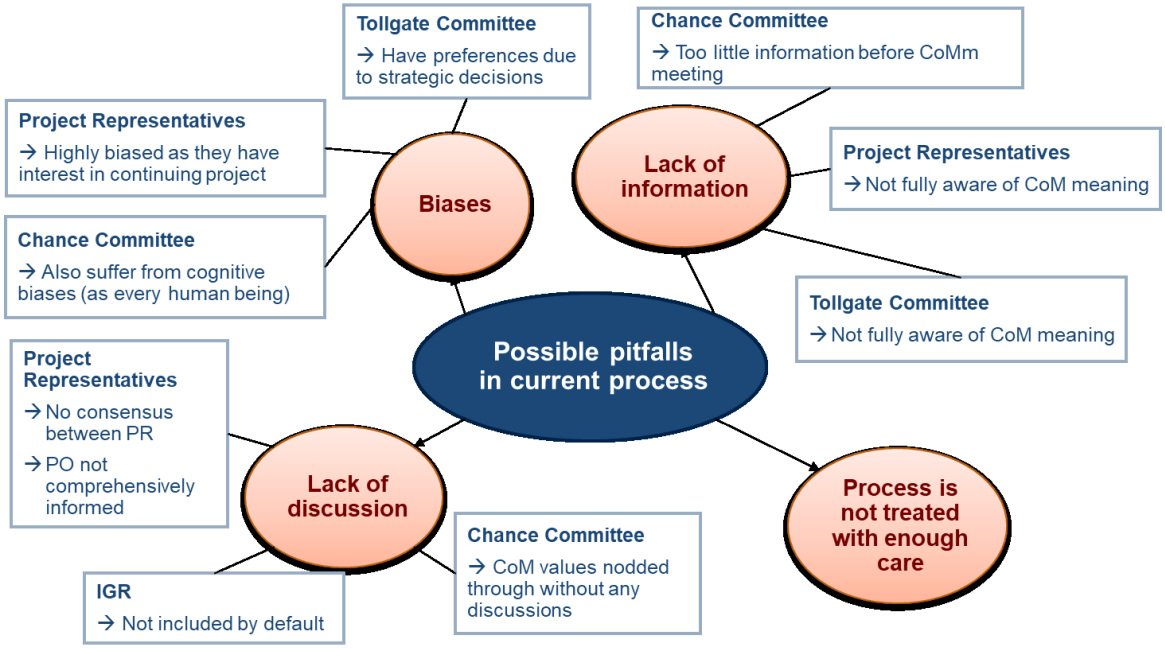

Figure 17: Possible pitfalls in current process

3.3 Improved Risk Factor Determination Process

Results from expert interviews as well as findings from the literature review were taken into account to define a new, improved process that addresses the revealed issues. The overall goal is to mitigate biases as much as possible and furthermore increase acceptance in management. Biases that might have an influence on the project team, the chance committee and the tollgate committee were identified to ensure effective bias mitigation measures.

A big adjustment of the new process is to include Independent Gate Reviews (IGRs) by default in the process, at least for complex projects with high project budget. This adds another sub-system into the risk factor determination process as shown in Figure 18.

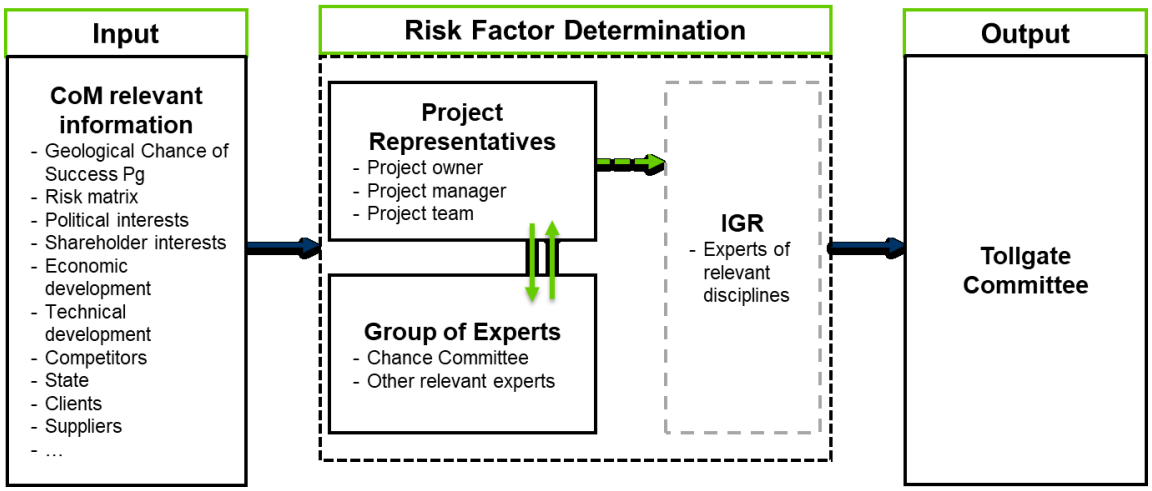

Figure 18: Systems theory considerations, updated process

A summarized explanation of IGRs is provided later on. Furthermore, arguments in favour of or against a standardization of the process are listed in this chapter. Finally, three possible processes, depending on the complexity and project budget, are proposed. The first, most comprehensive process includes the independent gate review. The second and third are less comprehensive and could be realised in a shorter period of time, but with less de-biasing measures.

3.3.1 Identified and Addressed Biases

As mentioned earlier, members of the project team are most at risk to be influenced by biases. Information, motivational and social biases could adversely affect decisions by project team members. In case of information biases, availability, anchoring and confirmation biases come into play. Furthermore, as the project team is the sub-system that is most interested in a success and a continuation of their project, motivational biases (excessive optimisms, overconfidence or sunk cost fallacy) are critical to be removed from decisions. Last, social biases might also have a detrimental impact, as project team members usually come from different hierarchical levels, which promotes halo effects and groupthink biases.

Members of the tollgate team are also highly endangered to suffer from various biases. Motivational biases definitely come into play, as members of the tollgate committee are interested in a positive or negative outcome (project owners are members of the tollgate committee meetings). There is also a significant risk that groupthink biases and halo effects as well as information biases influence decisions. All those biases should be taken into account during the process development.

The most important difference for the chance committee is that they “do not have a skin in the game”. This means that detrimental impacts of motivational biases are reduced significantly. Only the overconfidence bias might have an influence, as members of the chance committee are senior experts in their field and highly experienced people are usually prone to exaggerate their expertise, even if it is not legit in specific situations. For information biases nearly the same ones come up as for the project representatives. Only the confirmation bias is less probable, as members of the chance committee usually do not have pre-defined expectations about the project. In terms of social biases the halo effect is extensively diminished as trusted experts from the same hierarchical levels are less endangered to suffer from halo effects. Still, groupthink biases might influence the decision and should therefore be considered.

All those identified biases (as shown in Figure 19) have to be addressed with appropriate de-biasing measures. “PR” stands for project representatives, “TC” for tollgate committee and “CC” for chance committee.

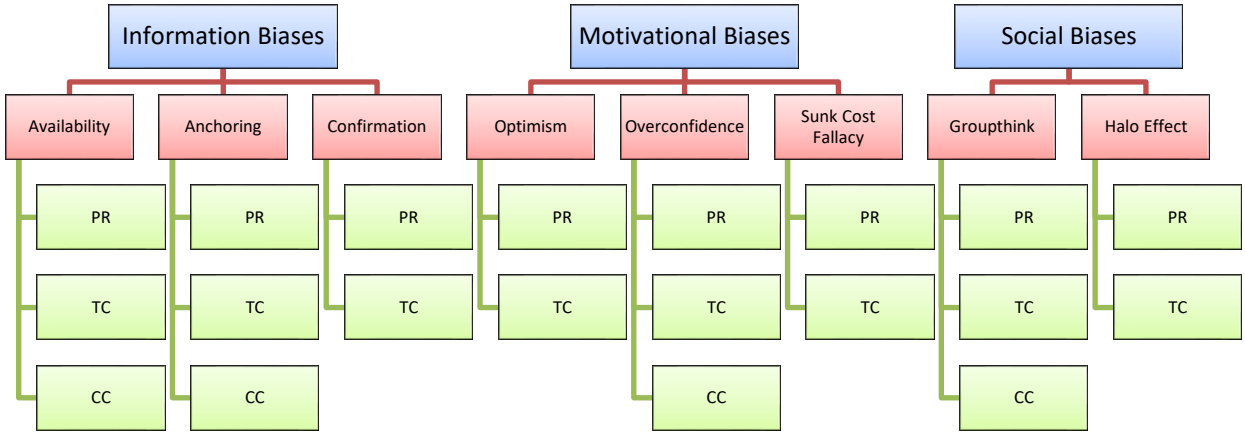

Figure 19: Identified and addressed biases

3.3.2 Standardized vs. Non-Standardized Process

One important question was to decide whether a standardized procedure or a non-standardized procedure is more favourable.

Standardized in this context means that a tool (like the Comculator) is used with pre-defined questions, which have to be answered to come up with a risk factor. Pre-defined questions should provide a thinking aid to consider all circumstances that might influence the project success. Furthermore, ranges are given to make judgements of how severe certain risks should influence the risk factor. Finally, one risk factor is calculated based

on the individual components. As soon as new information comes up, the value has to be updated.

Another idea that is currently under investigation is to use a fully standardized CoM, connected to the maturity state of the project. This means that individual project aspects would not be considered at all, the chance of maturation would only be determined according to the tollgates the project already passed. The obvious advantage of this technique is that an influence of biases is evaded and furthermore the effort to determine a risk factor is considerably reduced. On the downside, this procedure would lead to an information loss and a project ranking based on CoM values would not be meaningful anymore. A tollgate-connected CoM would then only be useful for portfolio considerations and not for individual projects. If this fully standardized CoM is applied, there should be a review for exceptional cases. This check makes it possible to adjust the CoM accordingly. Therefore, the chance committee should also review the decision criteria and the CoM in case of a fully standardized determination procedure.

Non-standardized processes do not have a pre-defined procedure, checklists or questions at all. Experts of different areas evaluate themselves possible threats that might come up and define a risk value based on their expertise. Obviously, there is much more freedom (and furthermore flexibility) in decision making in a non-standardized process, but on the downside this way of deciding about risk factors offers much more potential for subjective and biased decisions.

Daniel Kahneman (2011)[126] spent several years researching on the advantages and disadvantages of using algorithms instead of expert judgements. He concluded that in low-validity environments it always leads to better decisions when objective (sometime very simple) algorithms are applied in comparison to highly subjective expert opinions. He argued that even if the same expert is asked to do a risk judgement of exactly the same case with the same raw data two times, it is very likely that two different results come up. People are influenced inevitably by numerous impacts from the environment and most of the time they are not aware of them. The climate, their mood, background noise, people surrounding them etc. are just a few examples of influences on their subjective decisions. In environments that do not really allow for high-quality decisions, no matter how much expertise someone provides, decisions should not be influenced too much by human's judgements. Algorithms provide much better solutions in those environments. Nevertheless, he recommends a final human judgement on the calculations to provide room for issues that might not be captured in the algorithm.

Determining risk factors in petroleum exploration projects are prime examples of decision-making in low validity environments. Based on the arguments of Kahneman a pro and contra list for standardized vs. non-standardized decision-making processes was created, as shown in Table 6.

[126] Compare D. Kahneman (2011), p. 275-288

Table 6: Standardized vs. non-standardized procedure; Pros and Cons

	PROS	CONS
Standardized	Faster	Less „flexible“
	Less costs and effort	
	Lower risk for bias	Could be seen as less trustworthy
	Less subjective	
Non-standardized	Higher transparency	More prone to bias
		Higher subjectivity
	Higher flexibility for special cases	More effort
		Higher costs
	Maybe higher acceptance in management	Determination takes longer
		Less transparent

This evaluation reveals that a standardized procedure is preferable for the risk determination of E&P projects. For this reason, the project representatives should use the already existing Comculator with pre-defined questions and checklists to evaluate recovery chance, skills & technology chance as well as authorization & market chance, for assessing a risk factor.

3.3.3 Independent Gate Review

A big modification of the new, improved process is to introduce independent gate reviews (IGRs) by default into the risk factor determination process. These IGRs are already performed to review projects in front of tollgate meetings, but a review of the CoM is not yet implemented. Adding a CoM review to this already established process would not cause huge effort, but would lead to a considerable improvement by introducing a second independent review in terms of bias mitigation and objectivity increase.

Independent gate reviews are mandatory in OMV for all projects with a total budget greater than 20 mn EUR. The review team gives an independent view on the maturity of the project to the project owner. The main purpose is to help the Project Owner by providing confidence to the rest of the organization that requirements will be met.

The IGR event typically takes 3-5 days plus the time necessary for preparation. The usual process includes a presentation of the case by the project team, a review of the IGR team including enquiries of the team and a summary of the findings in form of a written closing report. The review team has to come up with a clear opinion of the project. Independent Gate Reviews should take place in front of every tollgate meeting as shown in **Error! Reference source not found.**. Including a CoM evaluation by default into this review could enhance reliability of the CoM and improve acceptance in management by proofing a well-founded value that underlies an extensive review.

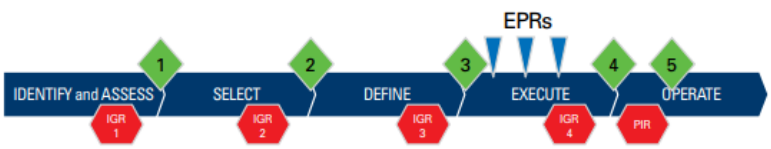

Figure 20: Opportunity Maturation Project Delivery process, OMV

3.3.4 Analysis of Tasks and Structure of Improved Process

A second analysis of task and structure (See Figure 21) links the extended list of tasks to responsible teams and committees. The abbreviation “A” stands for “act”, “I” stands for “inform” and “C” stands for “coordinate”. This analysis provides the basis for the definition of the improved process and is performed based on the first, most extensive process variation. New tasks are highlighted in blue, whereas tasks that will not find application in the updated process are coloured in grey. The green line indicates the responsible party for each task. When comparing the old process with the new process it is visible that more responsibilities lie outside the project representatives. This should enhance the objectivity of the updated process. Furthermore, the second independent review by the IGR team improves the decision quality. Various bias mitigation approaches are included as well as steps to enhance discussion within the teams as well as between different teams and committees. In addition, process fixes are included that make sure that the process is treated with care and relevant information is available.

Tasks	OLD					NEW				
	PR	CC	Head of Portfolio	IGR	TC	PR	CC	Head of Portfolio	IGR	TC
Assess first CoM proposal individually using standardized procedure						A				
Find first common CoM proposal (compare and discuss individual results)	A					A				
Perform "Premortem"-session to reveal further uncertainties and risks						A				
Prepare pre-read with main information and arguments						A	I			
Communicate CoM proposal to CoMm	A	I				A	I			
Evaluate and review CoM proposal and prepare feedback	I	A				I	A			
Confirmation: Hand over reviewed CoM proposal in written form	C	A								
No Confirmation: Clarification meeting	A	A								
Present feedback results (corrections) and discuss differences in personal meeting						C	A			
Perform second "Premortem"-session to reveal further uncertainties and risks						A	A			
Agreement: Include review results and update CoM	A	I				A	I			
No Agreement: Case escalated to Head of Portfolio (or VP of PPP)	I	C	A			I	C	A		
Extend pre-read with new findings						A	I		I	
Communicate CoM to IGR team						A			C	
Review risk factors and evaluate quality of decision making									A	
Present findings of IGR						C	I		A	
Incorporate IGR findings in CoM						A	I		I	
Archive CoM as official project CoM in central CoM table	A	I				A	I			
Communicate CoM to Tollgate Committee	A				C	A				C
Review and Update CoM as new information is available	A	I			I	A	I			I
Provide guidelines for continual improvement of process						I	A			I
Provide training sessions and information material about CoM							A		I	I

Figure 21: Analysis of tasks and structure improved process

3.3.5 Process Variations

Three processes that differ in the amount of time and effort that is necessary for the risk factor determination are suggested. The first process includes the most comprehensive bias mitigation approaches and is therefore the most time-consuming alternative. The independent review by the IGR-team is only conducted in this proposal. This results from the circumstance, that IGRs only take place for projects with a budget of more than 20 mn EUR or if the division instructs the project representatives to follow the practice of inviting an independent view on the project prior to the planned tollgate.

The second and third proposal are graduations of the first process. In the second process, several steps are diminished and the IGR phase is skipped. The third process is applied if it was decided that the project does not get a CoM based on individual project characteristics, but a pre-defined CoM connected to the maturity state of the project. These pre-defined values stem from a statistical database of historical projects that reached or did not reach a producing status. An examination of advantages and disadvantages of this approach to determine a risk factor for projects was out of scope of this thesis. Nevertheless, one question during the expert interviews targeted on this issue. Respondent's opinions greatly differed hereby and so it is not possible to give a clear conclusion without further investigations.

Figure 22 shows in which case which process needs to be applied to determine a CoM value.

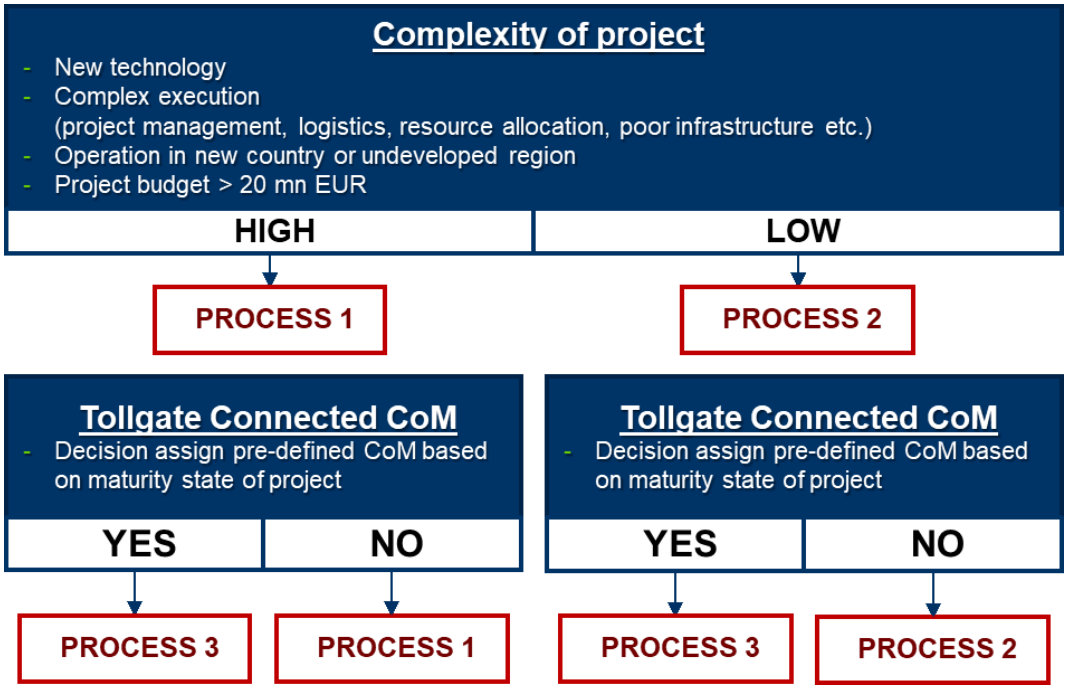

Figure 22: Decision tree process variations

3.3.6 Process 1: High Complex Projects

All proposed processes are separated into different phases and each phase is divided into several stages. The first process (see Figure 23 and Figure 24) includes the IGR as phase 3; this phase is excluded for lower complex projects with a smaller project budget.

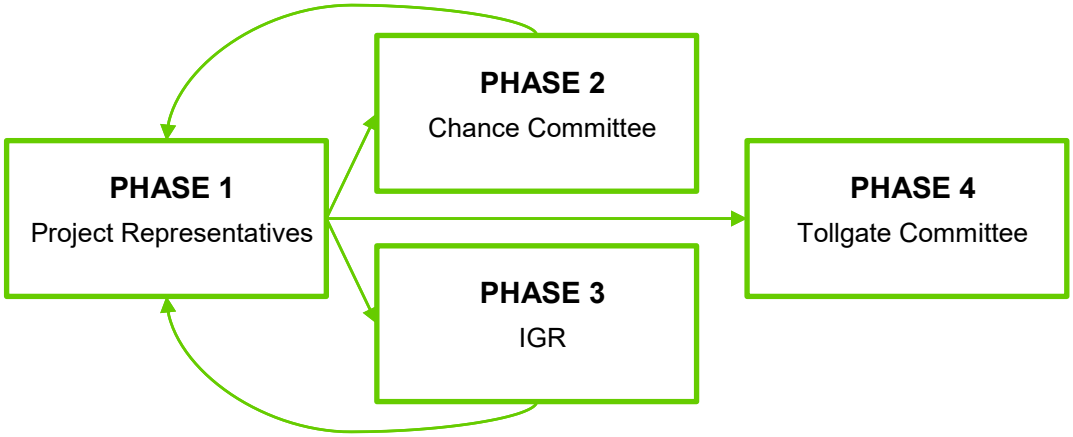

Figure 23: Process 1, schematic

Phase 1

During the first phase, the project representatives (project owner, project manager and project team members) gather and evaluate information and risks for the project of interest. As mentioned earlier, the risk matrix and the geological chance of success (Pg) are regarded as inputs to the process.

Afterwards each member assesses a risk factor with the standardized Comculator individually. This individual proposal of the initial CoM value is related to the concept of "Delphi"[127] and has several advantages. E.g., it helps to mitigate social biases like the groupthink bias and halo effect.

In a project team meeting, a common factor should be determined by comparing different results and sharing ideas and thoughts that led to the individual conclusions. This open discussion helps to mitigate individual information biases, e.g. availability or confirmation biases. Furthermore, the risk of overconfidence bias is reduced by increasing accountability of all team members (when people have to defend their decisions they spend more efforts on the soundness of their arguments).

As soon as a common factor is determined a "premortem"-session (as described in 2.6.4 Process Fixes) is conducted. This session increases awareness of all team members and helps to broaden their view on undiscovered risks and uncertainties.

After this session, the project team prepares a short pre-read of the project. This pre-read should include a rough description of the main project characteristics as well as the main points that led to decisions in the CoM determination process. It should not be too extensive to avoid misleading influences that could lead to biases later on. This step again helps to review the soundness of arguments and helps the members of the chance committee to make well-founded reviews.

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[127] Compare prioritysystem.com (Accessed 07/2019) http://www.prioritysystem.com/glossaryd.html#decisionanalysis

As soon as this pre-read is finished, the pre-read and the Excel file (Comculator) are handed over to the central risk coordinator of the chance committee.

Phase 2

Phase 2 as whole is a bias mitigation process fix. It focuses especially on mitigating motivational biases. Independent experts, that “do not have a skin in the game” review decisions of very likely biased project team members, which are obviously interested in a success of their project, as they have already invested energy into accomplishing it. The first stage of phase 2 includes the hand-over of the initial CoM proposal from project representatives. During the Chance Committee meeting all four sub-quadrants of the CoM are reviewed and evaluated. It is crucial to promote discussions within the Chance Committee and to avoid that values are just nodded through without any further debate. In case of corrections, experts should provide feedback and arguments for a different decision.

In a meeting with project representatives, members of the Chance Committee present feedback results. This should increase accountability and people tend to use system 2 thinking if they are asked to defend their decisions. Intuitive and not well-considered decisions should be minimized by this process fix. During the discussion a common factor should be determined. In case that no consensus can be reached, the expert committee has the last say. Otherwise, the case needs to be escalated to a higher hierarchical level (e.g. Head of Portfolio).

A second “premortem” session is recommended at the end of this meeting. Including “outside views” and additional opinions of experienced people further enhances the reliability of the resulting risk factor.

If any points come up that long for a more intense evaluation of the project representatives, a loop back to phase 1 is necessary. If a common factor can be determined, the project representatives probably just have to elongate the pre-read material to prepare the handover to the independent review gate.

Phase 3

Phase 3 is again a process fix that aims to mitigate motivational as well as social and information biases. The quality of the decision making process significantly increases with independent reviews. As the independent gate review, as a process fix, is already implemented for high complex projects with a budget of more than 20 mn EUR the CoM procedure should definitely benefit from it. During the handover of results at the closing meeting of the IGR-team and the project team, the project team gets one more possibility to broaden their view on the risks and uncertainties of their project. High urgency findings need to be incorporated by the project team.

When the IGR is finished, the CoM value needs to be archived by the project team as official project CoM in the central CoM table.

Phase 4

Phase 4 starts with the hand-over of the CoM material to the tollgate committee. The tollgate committee is afterwards responsible to compile a comprehensive investment portfolio and to decide which projects pass the tollgate or are dismissed. It is crucial that members of the tollgate committee should be convinced that the CoM value results from a well-founded, thoughtful preceding determination process.

Archiving past risk factors as future performance indicators is crucial to ensure continuous improvement of the process. Project representatives as well as members of the expert committee should feel responsible for storing risk factors in a central database. Furthermore providing guidelines for the continuous improvement of the process is necessary to improve decision quality. All stakeholders of this process should feel responsible for a continuous improvement of the process.

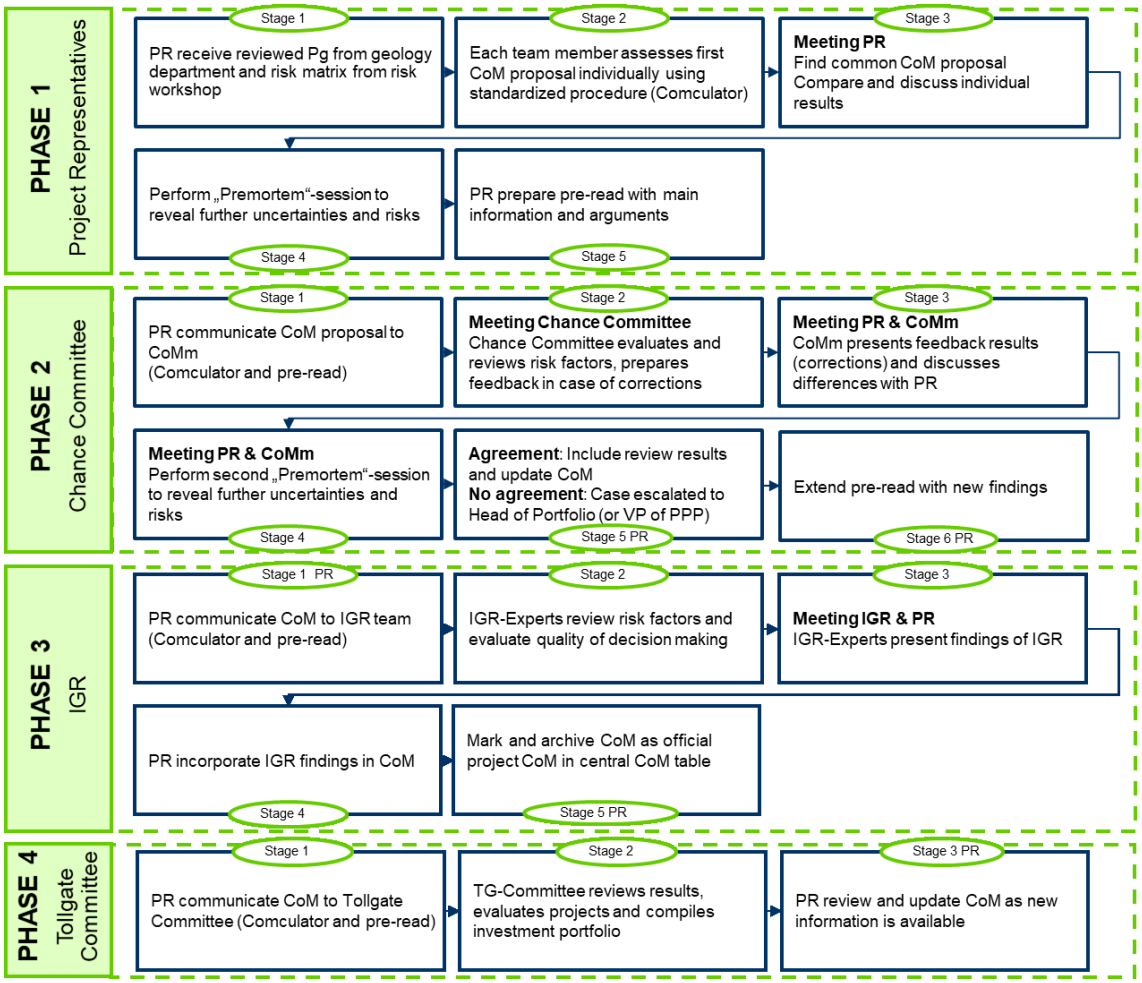

Figure 24: Risk factor determination process 1

3.3.7 De-biasing Measures in Improved Process

To proof that all biases are mitigated by de-biasing actions, a matrix was created that confronts possible biases with mitigation measures. Strong and intermediate influences are shown with different symbols. (See Figure 25) This matrix proves that all biases are addressed with at least three de-biasing actions to ensure a decreased detrimental impact of them on the risk factor determination.

The initial individual assessment of the CoM proposal by project representatives diminishes the impact of social biases. Every member of the project team should think of arguments for determining the risk factor in a specific way and should not be influenced by groupthink biases or halo effects.

During the comparison and discussion of the individual results, information and motivational biases are mitigated. Combining different subjective opinions and discussing the differences helps to increase objectivity.

The premortem sessions address all identified biases of the process. These sessions greatly enhance objectivity and help all stakeholders to increase awareness of risks and uncertainties of the project.

Furthermore, the pre-read for the chance committee mitigates information and motivational biases. Summarizing main arguments by the project representatives helps to re-think the reasoning and meaningfulness of their arguments. In addition, it prepares the conscious independent review by the chance committee. The presentation of feedback results by the chance committee members reduces the effect of information biases. If the accountability is increased by personal feedback sessions, the detrimental influence of information biases is less likely.

Finally, the independent gate review including the personal discussion with the project team of the IGR team mitigates once again information and motivational biases.

Phase/ Stage	Type of Bias / Bias Mitigation	Information Biases			Motivational Biases			Social Biases	
		Availability	Anchoring	Confirmation	Optimism	Over-confidence	Sunk cost fallacy	Groupthink	Halo effect
Ph. 1 / St. 2	Assess initial CoM value individually							●	●
Ph. 1 / St. 3	Compare and discuss individual results	●	●	⊙	●	●	⊙		
Ph. 1 / St. 4	Premortem Session	⊙	⊙	⊙	⊙	⊙	●	●	●
Ph.1 / St. 5	Preparation of pre-read for Chance Committee	⊙	⊙	⊙	●	●	●		
Phase 2	Process fix: Independent Review by Chance Committee	⊙	⊙	⊙	●	⊙	●		
Ph. 2 / St. 3	CoMm presents feedback	⊙	⊙	⊙					
Ph. 2 / St. 4	Premortem Session Chance Committee & Project team	⊙	⊙	⊙	⊙	⊙	●	●	●
Phase 3	Independent Gate Review incl. personal discussion with project team to enhance communication	⊙	⊙	⊙	●	⊙	●		

Figure 25: Bias mitigation measures

(● = strong impact; ⊙ = intermediate impact)

3.3.8 Process 2: Low Complex Projects

As an alternative to the first process for projects with lower complexity and a budget of less than 20 mn EUR the second process was developed. It has to be pointed out that this process includes considerably less de-biasing actions and the whole IGR is skipped. Nevertheless, determining a CoM value would take much less time and effort in case that the second process is applied. Figure 26 shows the schematic of the second process.

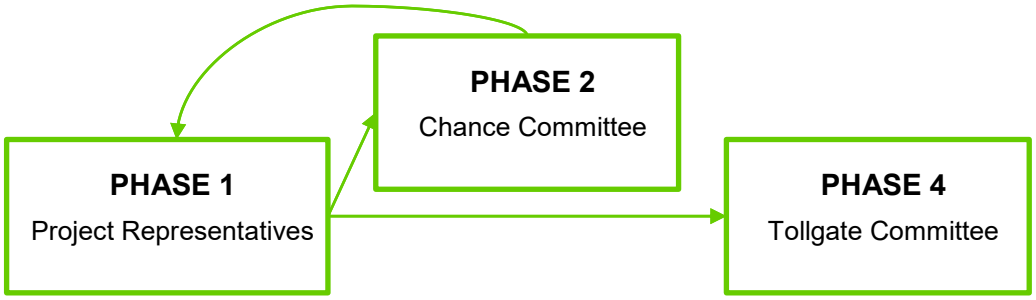

Figure 26: Process 2, schematic

Again, the process is separated into different phases. The main difference in phase 1 is that mostly no formal risk assessment took place, as this is not performed by default for all projects. After gathering information, each team member should assess the CoM value individually and afterwards differences are discussed in the PR team meeting. This process only includes one “premortem”-session that is performed within the project team. After this meeting, main arguments and project characteristics should be summarized in a pre-read that is afterwards handed over together with the Comculator-file to the chance committee.

In phase 2, the Chance Committee is responsible for the evaluation of proposed CoM values. They have to give feedback in written form to project representatives. To decrease effort, no personal meeting and therefore no personal discussion takes place. Nevertheless, project representatives have to include feedback results into the pre-read material and have to adjust CoM-values if necessary. After a successful review of the project, CoM values are archived in the central CoM table. In case that no consensus is reached between the chance committee and project representatives, the case is escalated to Head of Portfolio.

As mentioned, the independent gate review of CoM values is skipped, as this review is not performed for projects with a budget of less than 20 mn EUR. Hence, phase 2 is the only independent board review.

Results are directly handed over to the tollgate committee were projects are evaluated, ranked and an investment portfolio is compiled.

In Figure 27 the summarized process two is shown.

Figure 27: Risk factor determination process 2

3.3.9 Process 3: CoM Tollgate Connection

The third process (see Figure 28) is only applicable for a fully standardized CoM, connected to the maturity state. In other words, the CoM is only dependent on the number of Tollgates that were passed and no individual project characteristics are considered. Therefor no individual CoM determination by the project team members is necessary. Project representatives only have to review the geological chance of success (and possibly the risk matrix) and assign a pre-defined CoM to the project.

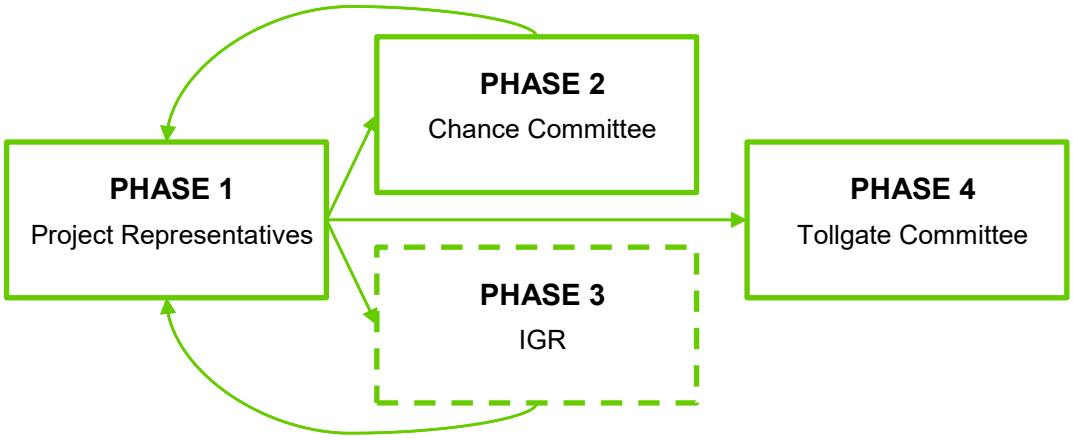

Figure 28: Process 3, schematic

Still, a review by the chance committee in phase 2 is crucial to make sure that corrections are possible and that the chance committee has the opportunity to gather important data to improve their statistical database. For projects with high complexity the independent gate review is informed and reviews the determined factor. For low complex project, this

phase is skipped anyhow. Afterwards, the CoM is archived in the central CoM table and project representatives prepare a proper pre-read.

In phase 4, the tollgate committee meeting takes place and decisions about continuation or abandonment of projects are made. The summarized process description is shown in Figure 29.

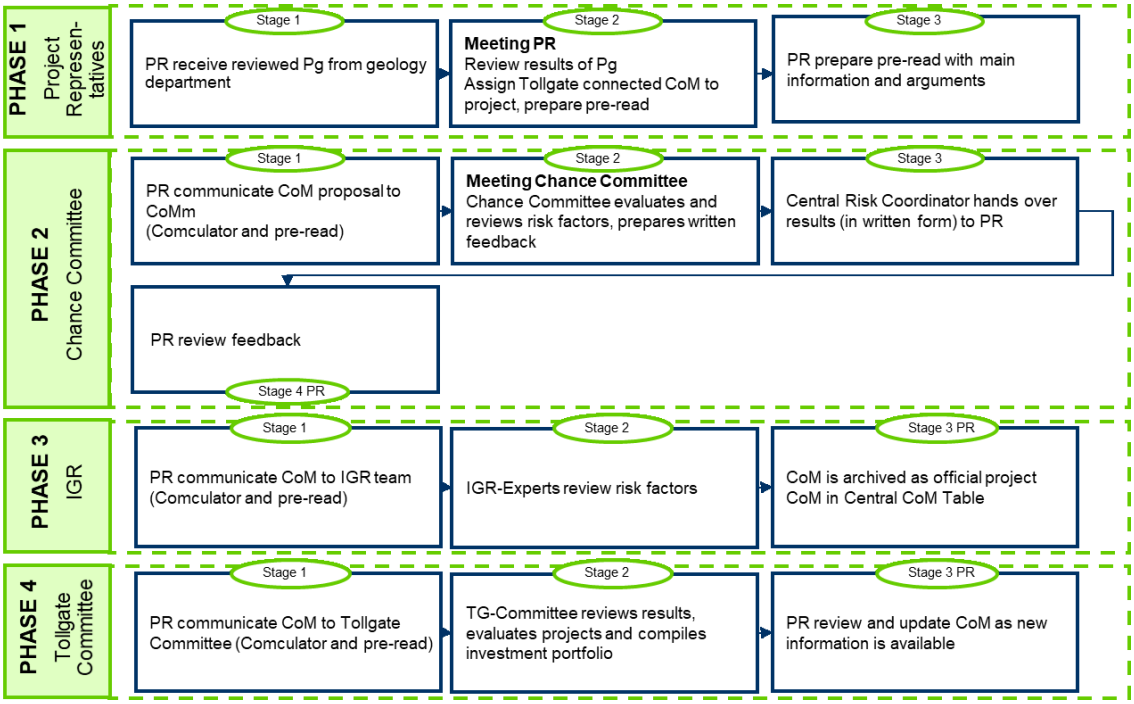

Figure 29: Risk factor determination process 3

3.4 Recommended Trainings

Outside the regular updated process further trainings are recommended to increase awareness of biases and to reach a common and comprehensive understanding of the OMV risk factor, the CoM.

3.4.1 CoM Training

Expert interviews revealed that a big issue, which causes the lack of acceptance of CoM values in top management, is that the different constituents and their interaction as well as the Excel Comculator are not fully understood. Therefore, a “CoM workshop” should take place, where crucial information regarding the CoM procedure is presented and evaluated. Illustrative examples should be presented to enhance the learning effect. As a personal training is quite cumbersome it is further recommended to create an E-Learning-Tool for the CoM and the Comculator. This tool should be accessible for everyone who needs information about the procedure. Especially for project team members, who cannot get a personal training, this E-Learning-Tool should help to give introduction and guidance to the usage of the Comculator.

3.4.2 Bias Workshop

As mentioned in the previous chapters a bias awareness and mitigation training is strongly recommended to decrease the negative influence of biases on the risk factor determination process. This training should be offered to every employee that needs to make decisions and wants to improve his/her decision-making ability. People should be taught how to identify and avoid biases in their thinking. Educating people about the possible influence of biases and the likely direction how biases affect decisions is a prerequisite to avoid them. As mentioned in chapter 2.6.3 several studies have shown the positive influence of bias awareness trainings on mitigating biases from decisions. These trainings should be offered on a regular basis to ensure a long-term advantageous effect.

4 Summary

The purpose of this thesis was to develop a new risk factor determination process that largely diminishes the influence of biases and ensures acceptance of the resulting risk value in management. It is assumed that the current process includes too less de-biasing actions and therefore highly subjective estimations can possibly come up. Nevertheless, it has to be kept in mind that in such low-validity environments as they are faced in E&P projects, results will always be based on subjective expert opinions and hence the risk factor will inevitably be subjective to a certain degree.

The goal was to develop a process that encourages employees to review the soundness of their decision-making arguments, to discuss results and perspectives with peers and to base their judgement on objective argumentation. Process fixes that safeguard independent reviews of committees that have no interest in manipulating the risk value in a certain direction should further help to decrease subjectivity.

An intense analysis of the current risk factor determination process was performed by reviewing internal documents (e.g. standards, procedures) and by conducting interviews with stakeholders of the process and internal experts. This analysis revealed improvement potential for bias mitigation. Especially lack of communication seems to be an issue and therefor the new process has to make sure that communication is enhanced. In addition, discussions during committee and project team meetings have to be intensified. Proposed “pre-mortem” sessions aim to improve discussions and engagement of people in capturing relevant uncertainties and risks. Furthermore, by increasing accountability through the implementation of feedback presentations by the reviewing boards help to improve the soundness of arguments for decision-making.

Finally, three possible, ready to be implemented, processes were determined. The first process is the most comprehensive one and includes the broadest de-biasing approaches. Process fixes and de-biasing tools are applied to increase objectivity, reliability and transparency of the process. Caution was taken that the implementation of de-biasing actions does not cause too much effort. Bias mitigation measures were chosen such that they address as many biases as possible with the lowest possible additional effort. It was checked that all adversely affecting biases are mitigated by at least three de-biasing actions.

The second process proposal is a downgrade of the first process and is only recommended for projects with significantly lower complexity. It allows for a faster CoM determination with less effort. Nevertheless, bias mitigation measures are reduced and therefor subjective influences on the resulting CoM-value are more likely than for the first process.

The third process is applied if a CoM-value connected to the maturity state of the project is used. In this case, no individual project characteristics are considered, which obviously minimizes the effort to determine a risk factor.

It should be emphasised that process overarching training sessions are recommended to raise awareness among employees about the potential influence of biases. Studies underpin the great benefit of bias mitigation workshops and the positive effect they have

on enhancing decision quality. Nevertheless, it is necessary to conduct those workshops periodically, to ensure success of those trainings in the long-term.

Furthermore, CoM workshops should take place to ensure a sufficient status of knowledge of CoM constituents and the Excel Comculator. In case that no personal training is feasible, an E-Learning-tool should be developed that conveys crucial information about the CoM procedure.

What is definitely crucial for the improved process including new de-biasing actions to succeed in the end is that the organization accepts a change in policy and really adopts the new policy. Employees need to be convinced of the benefits they gain from implementing a sound decision making process for the risk factor determination. Therefor OMV should not spare efforts in increasing awareness of the need for de-biasing actions to enhance reliability of expert's judgements and to be finally able to ensure the company's long-term success.

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