Design and Evaluation of a Process Model for the Early Stages of Product Innovation

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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List of Abbreviations and Glossary

Abbreviation	***Full Text***
AR	Action Research
ARIS	Architecture of Integrated Information Systems
AUTH	Authenticity
BPM	Business Process Management
BPMN	Business Process Model and Notation
BPMR	Business Process Modelling Requirement
BPR	Business Process Requirement
CBA	Cost Benefit Analysis
CF	Corporate Foresight
CIP	Continuous Improvement Process
COMP	Completeness
CORR	Correctness
DB	Data Base
DIP	Innovation Pipeline
DR	Process Model Design Requirement
DS	Design Science
DSR	Design Science Research
DSRM	Design Science Research Methodology
EPC	Event-Driven Process Chain
EVAL	Evaluation
EWL	Steering Committee
EWR	Development Committee
FEI	Front End of Innovation
FEI-PR	Front End of Innovation Process Requirement
FG	Focus Group

FGP	Focus Group Participant
ICB	Industry Classification Benchmark
ICT	Information and Communication Technologies
IM	Image
INA	Innovation Committee
IP	Intellectual Property
IPM	Innovation and Product Management
I-PR	Innovation Process Requirement
I-PR	Innovation Process Requirement
IS	Information Systems
ISM	Idea Screening Meeting
IT	Information Technology
JR	Job Relevance
LP	Literature Principle
NCD	New Concept Development
NPD	New Product Development
OQ	Output Quality
P	Front End of Innovation Principle
P1-DR	Principle 1 Design Requirement
P2-DR	Principle 2 Design Requirement
P3-DR	Principle 3 Design Requirement
P4-DR	Principle 4 Design Requirement
PDMA	Product Development and Management Association
PESTEL	Political Economic Socio-Cultural Technological Environmental Legal
PFI	Platform for Innovation Management
PIM	Product Innovation Management
PLC	Product Lifecycle
PLM	Product Lifecycle Management

PM	Product Management
PMQ	Pragmatic Quality
PP	Practice Principle
PR	Process Requirement
PSQ	Perceived Semantic Quality
PU	Perceived Usefulness
PVP	Process Improvement Process
QCA	Qualitative Content Analysis
R&D	Research and Development
RD	Results Demonstrability
REL	Relevance
RQ	Research Question
S&W	Strengths & Weaknesses
SIM	Strategic Issue Management
SLR	Systematic Literature Review
SMQ	Semantic Quality
SN	Social Norm
SNQ	Syntactic Quality
SWOT	Strengths Weaknesses Opportunities Threats
TAM	Technology Acceptance Model
TD	Technology Development

Abstract

Title: Design and Evaluation of a Process Model for the Early Stages of Product Innovation

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Today's business world is highly dynamic, competitive and hardly predictable. In the context of innovation management, this leads to shorter product lifecycles, higher degrees of uncertainty and ultimately to high failure rates in New Product Development (NPD) processes. Most often, this is due to deficiencies in effectively and efficiently managing the early stages of the innovation process, which are referred to as the (Fuzzy) Front End of Innovation (FEI). As substantial work has been done in relation to the later stages of the FEI (idea generation, selection and concept development), the preceding stages of opportunity identification and analysis have been neglected. Especially in terms of identifying and depicting process-related factors and activities in practitioner relevant, formal process models, little to no research has been done so far.

This research identifies and analyses FEI principles, differentiates between process and non-process principles and combines process-related ones in a comprehensive, theoretically grounded and practically applicable process model. Employing a design science research approach, the artefact – the FEI process model – is designed and built together with industry partners of a current research project. Following the research methodology, principles at the FEI are step-by-step identified, process model design requirements are derived based on these and the formal process model specifically supporting process key activities at the strategic FEI is developed. Evaluation of process model is done design inherent (ex-ante, focus group study) and final outcome related (ex-post, web-based survey).

The pivotal contribution of the research is identification and structuring of process-related strategic FEI key activities. Ex-post evaluation results confirm the practical relevance of the developed process model and its syntactic, semantic and pragmatic quality. In addition, the thesis provides contributions to knowledge base by identifying general FEI principles, process and non-process design requirements and by indicating future research needs.

Keywords: *Front End of Innovation, Process Model Development, Design Science Research, Innovation Management, Corporate Foresight, Strategic Issue Management*

1 Introduction

"*Innovation has been the most important shaping force in the history of mankind*".

(Cumming 1998, p. 28)

1.1 Background and Overview

A global and volatile environment accompanied by constantly changing customer requirements and fierce competition poses major challenges to organisations. Increased costs of raw materials, the recent economic crisis, high failure rates in New Product Development (NPD) processes and shorter innovation cycles further increase the difficulties and burdens organisations have to face. It is becoming increasingly difficult for companies to succeed in such a high velocity, uncertain and often highly unpredictable environment without being able to quickly and flexibly react to potential or impending changes.

These developments and the resulting consequences clearly stress the necessity for strategically oriented and efficiently conducted innovation management (Filieri 2013; Schweitzer, Gabriel 2012; Rejeb et al. 2011; Vantrijp, Vankleef 2008). The importance of innovation management has also been emphasised by Henry Chesbrough, who is often referred to as "the father of open innovation" (Lindgren et al. 2012; Munkongsujarit, Srivannaboon 2012). According to Chesbrough "*Everyone knows that innovation is a core business necessity. Companies that don't innovate die*" (Chesbrough 2006, xiii).

This thesis focusses on one particular part of the innovation process: the so called Front End of Innovation (FEI). The aim is to develop and evaluate a conceptual process model that specifically addresses and supports this phase of the innovation process, which is subject to the innovation management domain. Conceptual models - such as process models or data models - are a prerequisite for planning and designing complex systems (Frank 1999). Conceptual modelling belongs to the information systems (IS) domain (e.g. Recker, Rosemann 2010a; Pastor 2008; Loucopoulos, Kavakli 1999; Frank 1998). Independent of implementation technology or other constraints, a conceptual model in the context of IS research represents the domain in which information systems will operate (Topi, Ramesh 2002; Angelou, Cornford 1993). The current research is hence partially settled within the domain of innovation management and the IS domain. The underlying design hypothesis of this thesis is that structuring the strategic FEI by specifically identifying and addressing key process activities at this early stage of the innovation process benefits to an organisation's innovation activities. The main objective of the current research is to investigate and identify the process and non-process elements, to structure the strategic FEI in the form of a process model and to evaluate it in practice.

To frame the view of this thesis, the position of innovation and innovation management is dealt with in section 1.1.1. The FEI and the process at this stage of the innovation process is elaborated in section 1.1.3, followed by a discussion on the relevance of the FEI as a research topic worth being investigated in section 1.2. In the subsequent section, the research problem is formulated (cf. section 1.3). The research objectives and the particular research questions are defined in sections 1.4 and 1.5. Subsequently, the literature review and the literature gaps observed are summarised (cf. section 1.6). Section 1 is concluded by section 1.7 which provides an overview of the structure of the thesis.

1.1.1 Innovation and Innovation Management

There is a multitude of publications on innovation with various definitions and categorisations. In the field of economic sciences, the term innovation was introduced by Schumpeter, who stated that innovation is "*the doing of new things or the doing of things that are already done, in a new way*" (Schumpeter 1947, p. 151). Building on Schumpeter's definition, other authors defined the term innovation in different ways. A well acknowledged definition originates from West and Farr, who define innovation as "*the intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual the group, organization or wider society*" (West, Farr 1990, p. 9). Another more comprehensive definition is provided by Myers and Marquis (1969), who state that "*Innovation is not a single action but a total process of interrelated sub processes. It is not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all these things acting in an integrated fashion*" (Trott 2005, p. 15). Another definition of the term innovation is provided by Damanpour, who defines innovation as "*adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organization*" (Damanpour 1991). There is a plethora of additional term definitions, which differ from each other by varying amounts. What they all have in common is that an innovation is something new, that innovation is critical for long-term economic success and that innovation includes development as well as introduction to a market or to an organisation.

In this thesis, innovation is understood as the intentional development and introduction of new products beneficial to the respective application domain (e.g. market or organisation). Accordingly, the thesis specifically focusses on product innovation and does not put an emphasis on service or process innovation. Innovation is regarded to as the result of a set of interrelated process steps, which need to be managed carefully and effectively. The management of these steps, activities and interrelated sub-stages is subject of innovation management. Most of the articles analysed in the literature review show a type of view, that innovation management aims at understanding this process as a whole and comprises all the managerial tasks necessary in order to successfully introduce the right ideas at the right time to the right markets respectively application domains (Vahs, Brem 2015; Brem, Voigt 2009).

This can be a challenging task and failure rates in New Product Development are still high (Vahs, Brem 2015; Wießmeier et al. 2012; Vantrijp, Vankleef 2008). Oftentimes, this is due to deficiencies in effectively and efficiently managing the FEI (Postma et al. 2012; Saetre, Brun 2012; Rejeb et al. 2011; Rice et al. 2001; Poskela, Martinsuo 2009; Poskela 2007). This further increases the importance of developing new theories and proposals that support effective implementation of the FEI (Koen et al. 2014a; Riel et al. 2013; Saetre, Brun 2012; Trotter 2011; Oliveira, Rozenfeld 2010; Verworn 2009; Reid, Brentani 2004;). The following section provides an overview of existing innovation process models.

1.1.2 Innovation Process Models

A plethora of process models describing the development and commercialisation of new products, services or processes can be found in literature. In order to cope with this plethora, innovation process models can be categorised into various dimensions, e.g. by distinguishing between generations of such models (Rothwell 1994; Cooper 1994). According to Rothwell, there are five main generations of innovation process models (Rothwell 1994). The first generation dates back to the 1950s, when new industries were emerging mainly based on new technological opportunities (e.g. semiconductors or electronic computing) and on the technology-led regeneration of existing sectors (e.g. in the areas of agricultural and steel industry). These models were strictly sequential, had a very strong technological orientation and did not consider marketing-related activities and stages (Gaubinger et al. 2015). The underlying assumption of generation one innovation process models was that the higher the R&D effort which was put into the product development process, the higher the economic success of the product (technology push). Little attention was paid to the actual transformation process or to the role of the marketplace (Rothwell 1994) (cf. Figure 1).

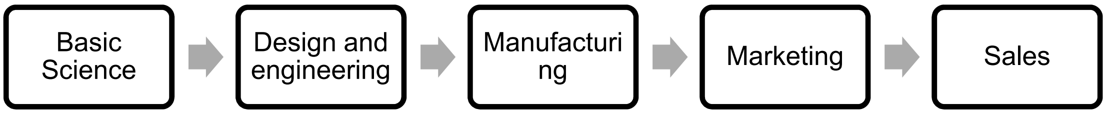


Figure 1: Generation one innovation process models according to Rothwell (1994)

Due to changing market conditions in the mid-1960s which was caused by more intensive competition, ongoing diversification and other economic developments, the emphasis of innovation process models was drawn away from a more technology based process towards a more demand-side oriented, market-pull-orientation. This led to the emergence of generation two models, which shifted the starting point of innovation from R&D to market, resulting in a strict customer and market orientation of innovation management related tasks and a merely reactive role of R&D in the innovation process (Gaubinger et al. 2015; Rothwell 1994;) (cf. Figure 2). As a result, most organisations confined themselves to incremental innovation alone (Ahmed, Shepherd 2010).

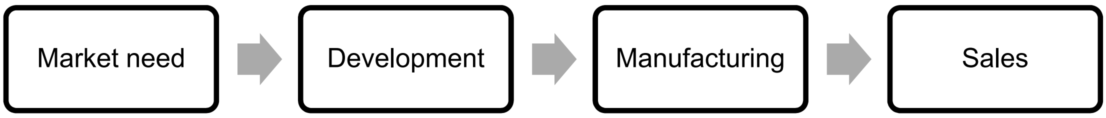


Figure 2: Generation two innovation process models according to Rothwell (1994)

Due to the oil crisis in the early 1970s and the high rate of inflation accompanied by demand saturation, another shift of innovation management emphasis was inevitable. This shift found its expression in the formation of a third generation of innovation process models, which sought to combine technological capabilities on the one hand and market needs on the other (Mowery, Rosenberg 1979). This third generation was also called interactive or "coupling innovation process model" (Rothwell 1994), in which the innovation impulse can be given by technology as well as by the demand side. A seminal example for a generation three process model was developed by Thom, who divided the innovation process into three main and several sub-phases (Thom 1980) (cf. Figure 3). This process model became a dominant standard literature and was taken as a reference framework for numerous consequent models of the innovation process.

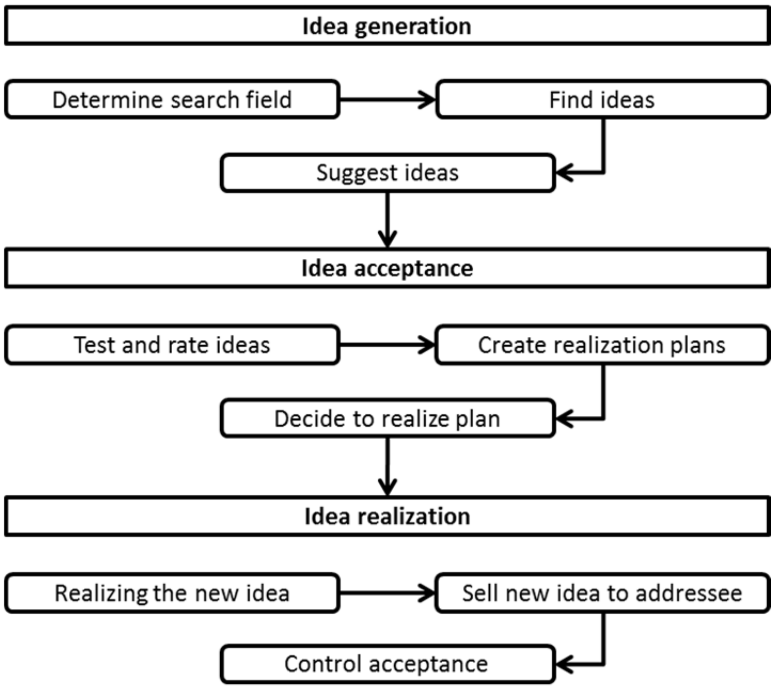


Figure 3: Standardised stages of the innovation process based on Thom (1980)

Third generation innovation process models still followed a sequential and linear structure, but began to allow feedback-loops between the single stages (Rothwell 1994). The next big step in the evolution of innovation process models was made between the early 1980s and the early 1990s. A general economic recovery accompanied by a growing awareness of the importance of evolving generic technologies (especially in the context of IT-based manufacturing systems) led to a new focus on innovation strategy (Bessant 1991). Strategic alliances between organisations started to build, often encouraged and supported by public respectively governmental funding (Dodgson 1993; Contractor, Lorange 1988). Consequently, shorter product lifecycles further increased the relevance of shorter and more flexible NPD-processes. Based on these developments, generation four innovation process models evolved. Such models sought to allow for integrating external and internal knowledge sources and for parallel development activities. A seminal fourth generation innovation process model was developed by Nissan in the early 1980s (cf. Figure 4).

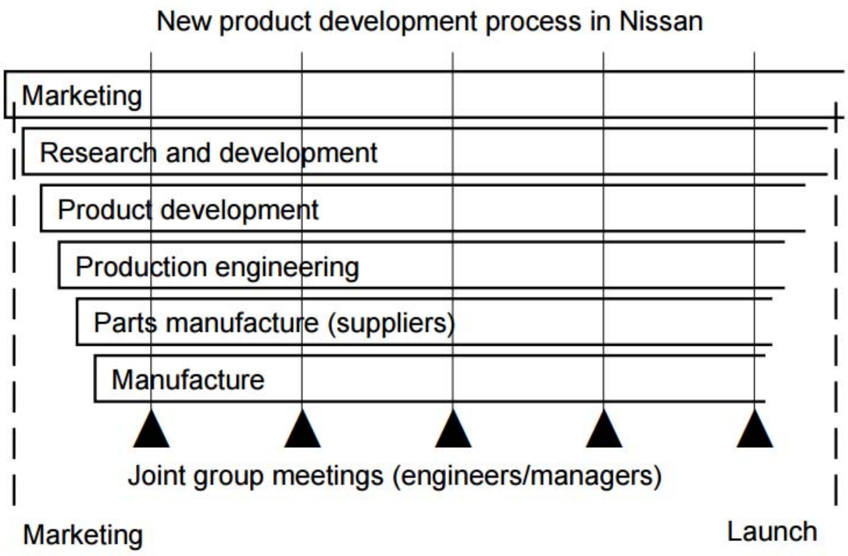


Figure 4: Fourth generation innovation process at Nissan based on Graves (1987), taken from Rothwell (1994, p. 12)

By integrating different sources, departments or partners at the same time and by introducing overlapping process stages, generation four process models allowed for shorter time to market than more sequential innovation management approaches. In this context, Takeuchi and Nonaka stated that "*the traditional sequential or 'relay race' approach to product development […] may conflict with the goal of maximum speed and flexibility. Instead, a holistic or ´rugby´ approach – where a team tries to go the distance as a unit, passing the ball back and forth – may better serve today´s competitive requirements*" (Takeuchi, Nonaka 1986, p. 137) (cf. Figure 5).

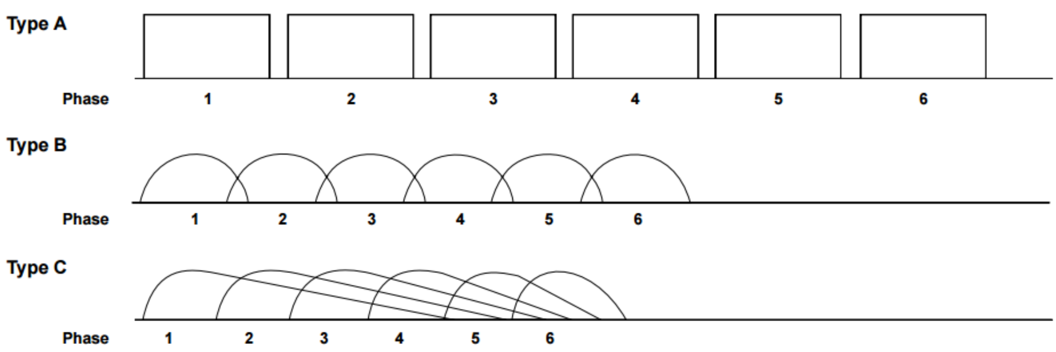


Figure 5: Sequential (A) vs. overlapping (B and C) phases of development (Takeuchi, Nonaka 1986, p. 138)

As depicted in the figure above, overlapping phases of development allow for shorter time to market. This approach of reducing development time is also known as "simultaneous engineering" and generation four innovation process models are still showing their importance as normative process models today (Wannenwetsch 2005). The crucial relevance of short development time and of integrating innovation networks has led to the development of generation five innovation process models in the early 1990s (Rothwell 1994).

Compared to generation four, generation five process models place an even stronger focus on parallel integration of different intra and cross organisational partners and on the sustainable formation of IT-supported innovation networks (Ritter 2005). According to Rothwell, many of generation five innovation process model features are already in place in organisations that have mastered generation four processes (e.g. early and effective supplier linkages, parallel and integrated operations, flatter structures, horizontal alliances and involvement with leading customers). The main difference or "*the most radical feature of 5G is the use of a powerful electronic toolkit to enhance the efficiency of these operations*" (Rothwell 1994, p. 25). In the style of lean management in production, generation five innovation process models are often related to as "lean innovation" process models: "*Lean innovation is a possible answer to the question: How can our innovation process be more efficient?*" (Sehested, Sonnenberg 2011, p. 17). The importance of integrating internal as well as external sources as postulated in generation five innovation process models was taken up by Henry Chesbrough, who shaped the popular and widely acknowledged term of "Open Innovation" in 2003 (Chesbrough 2003).

The open innovation paradigm, as defined by Chesbrough (cf. Figure 6), assumes that organisations need to consider external and internal sources of information and ideas equally. Same applies to outflows of information and ideas, where the open innovation approach postulates to expand existing markets or to outsource ideas if beneficial to the organisation (Chesbrough et al. 2006).

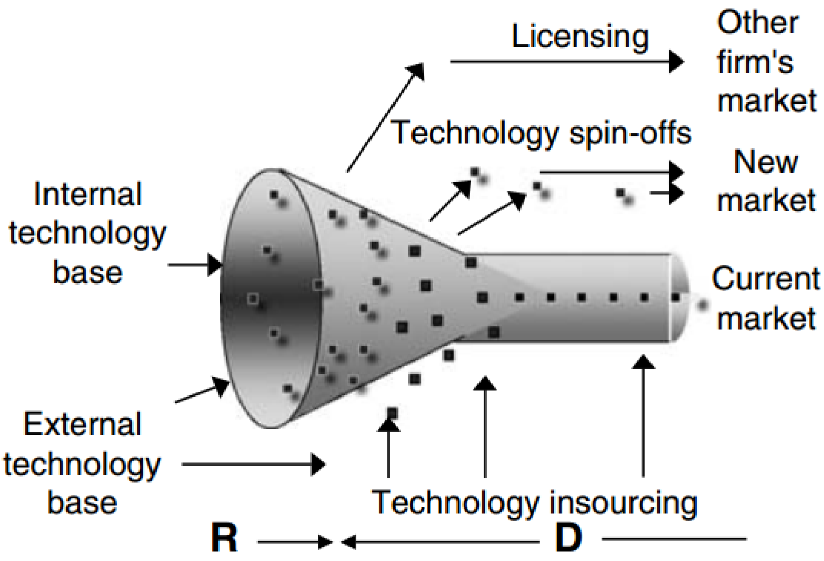


Figure 6: An open innovation paradigm Chesbrough et al. (2006, p. 3)

The popular stage-gate-model by Robert Cooper (Cooper 1983) can be considered another milestone in the development of innovation process models (Gaubinger et al. 2015). The stage-gate-model has been adapted by various organisations and is one of the most acknowledged approaches to innovation management (Vahs, Brem 2015). By dividing the innovation process into stages (activities) and gates (decision gates), Cooper proposed a conceptual and operational map for moving innovation projects from an initial idea to the final launch and beyond. Each stage consists of a set of recommended activities and tasks, which have to be executed to pass from stage to stage through defined decision gates (Cooper 1988a, 1988b, 1983) (cf. Figure 7).

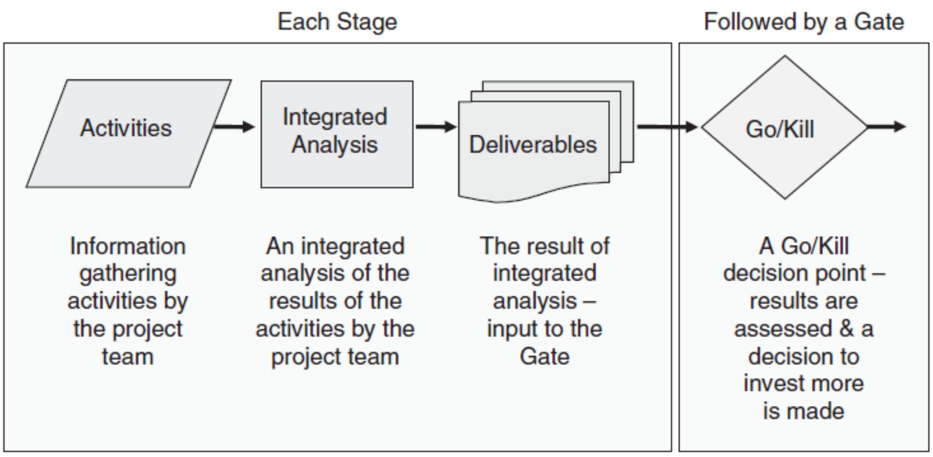


Figure 7: Stage-gate consists of stages followed by decision gates (Cooper 2008, p. 214)

Gates can either be hard or soft: soft gates can be passed through without all decisions being firm and allow for flexibility of control. Hard gates on the other hand are points in the process that can only be passed through if a firm decision is made and ensure that all work is progressing according to plan (Cooper, 1994).

Over the years, Cooper has adapted the stage-gate-model from version one to version 4 (Cooper 2008) (cf. Figure 8).

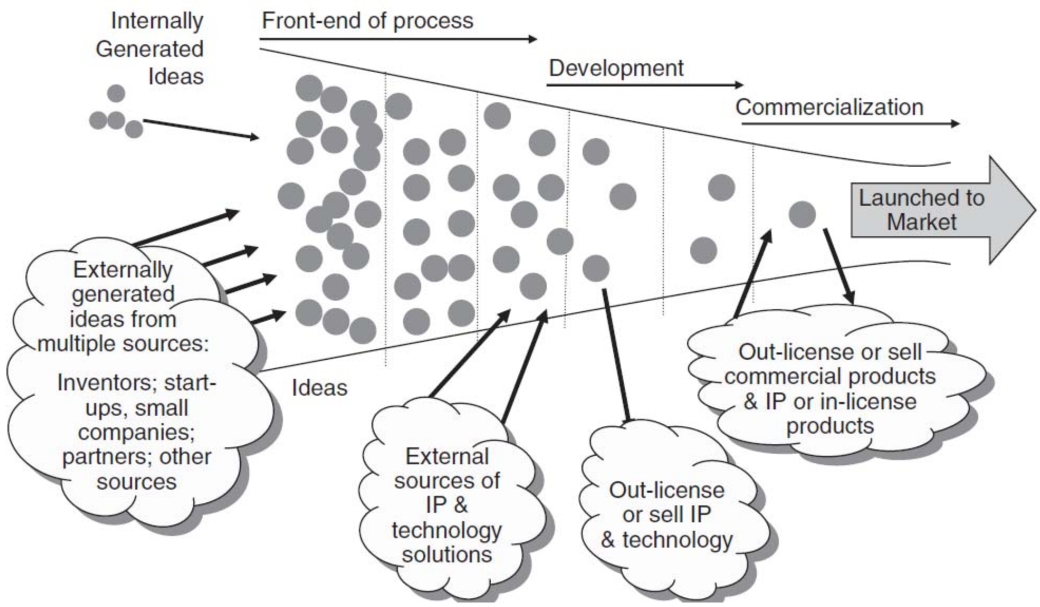


Figure 8: Version 4 stage-gate-model of the innovation process (Cooper 2008, p. 231)

Many of today's numerous innovation process models are based on the seminal work of Thom (cf. Figure 3) and the stage-gate-model by Cooper (Gaubinger et al. 2015). Figure 9 provides an overview of Rothwell's and Cooper's innovation process model categorisation and of the shift in focus of innovation management over the past decades as described in section 1.1.2.

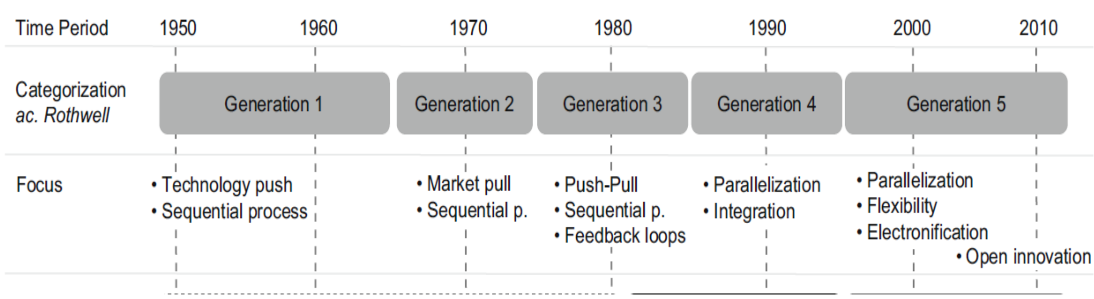


Figure 9: Development of innovation management systems (Gaubinger et al. 2015, p. 35)

It can be stated, that there is a consensus in literature regarding a phased structure of innovation projects. The amount of phases, their order and the activities they consist of varies from model to model. Applied to the current thesis, an innovation process model should:

- allow for parallelisation of activities and tasks along the innovation process (I-PR1),
- enable the integration of external and internal knowledge sources (I-PR2),
- allow and provide feedback loops between the single stages (I-PR3),
- consider the potential of appropriate methods and approaches for supporting the innovation process (I-PR4), and
- equally address market needs as well as technological developments as a source for innovation input (I-PR5).

These innovation process requirements (I-PR1 to I-PR5) are addressed accordingly in the course of process model design and development (cf. Figure 16).

To systematically improve the effectiveness and efficiency of an organisation's innovation activities, the early stages of the innovation process – which are known as the "Front End of Innovation" (referred to as FEI, cf. chapter 1.1.3) or "Fuzzy Front End of Innovation" - offer the greatest potential (Stevens 2014; Aagaard, Gertsen 2011; Hannola, Ovaska 2011; Backman et al. 2007). The FEI is the initial stage of the innovation process, takes place before the actual NPD process and usually ends when a go or no-go decision regarding the launch of a new product (pre-) development process is taken (Stevens 2014, p. 431).

Existing findings indicate that improving the FEI process offers the largest potential for improving an organisation's innovation capability as a whole with the least effort (Aagaard, Gertsen 2011; Verworn et al. 2008; Backman et al. 2007; Nobelius, Trygg 2002). Several authors refer to the FEI as "the root of success" for organisations involved with discontinuous product innovation (Reid, Brentani 2004) and clearly state that high failure rates in the NPD process are often related to too little effort put in the FEI activities (Cooper 2011; Ho, Tsai 2011; Verworn 2009; Khurana, Rosenthal 1998). This indicates that the FEI is critical for innovatory success and long-term competitiveness (Oliveira, Rozenfeld 2010). The central part of this thesis is to identify FEI principles, to derive process activities and to develop a process model providing structure to systematically address strategic orientation at this success-critical part of the innovation process.

1.1.3 The Front End of Innovation

Subsequently, different definitions of the “Front End of Innovation” are discussed (cf. section 1.1.3.1) and existing process models for this part of the innovation process are presented (cf. section 1.1.3.2).

1.1.3.1 Definition of the term “Front End of Innovation”

The term “Front End of Innovation” was introduced in 2001 by Koen et al. (Koen et al. 2001) opposed to the term “Fuzzy Front End”, coined by Reinertsen (Reinertsen 1985) with its implications that the front end is mysterious, lacks accountability, and cannot be managed. In the course of the current thesis, the term “Front End of Innovation” is used deliberately, rather than “Fuzzy Front End”, as the intent and research objective is to develop and define appropriate process support for just that phase of the innovation process. Different authors introduced varying definitions with distinct boundaries and there is no generally accepted FEI definition or process in literature (Aagaard, Gertsen 2011; Martinsuo 2009). Some of the more acknowledged definition attempts found in relevant, scientific literature are summarised in Table 49 (cf. Appendix B).

Comparing these definitions of the term Front End of Innovation, most authors share several similarities:

- The FEI is the first stage of the NPD process.
- The FEI covers all the activities that come before the well-structured development process.
- The focus at the FEI is of a more strategic nature and mainly lays on opportunity identification and analysis but also includes ideation and concept definition.

In the course of the current thesis, the FEI is defined based on the definitions proposed by Koen et al. (Koen et al. 2014a; Koen et al. 2001;) and Poskela (Poskela 2007) as follows: The FEI includes the activities that come before the formal and well-structured NPD process and consists of strategically oriented activities (opportunity identification, opportunity analysis) and the more operative ideation and concept development process (idea genesis, idea selection and concept and technology development).

The following section presents selected approaches to and process models of the FEI.

1.1.3.2 The process at the Front End of Innovation in literature

Most authors describe the process at the FEI as a sequential process that consists of single sub-phases including iterations among and within them (e.g. Russell 2008; Griffiths-Hemans 2006; Khurana, Rosenthal 1998). Other scholars do not particularly focus on the sequential order of the different activities and phases at the FEI, but rather concentrate on recurring key activities (e.g. Bröring et al. 2006; Koen et al. 2001). Within the conducted literature review, several process models describing the phases and activities at the FEI were collected. Various models started with an idea generation phase (e.g. Cooper 2008; Griffiths-Hemans 2006; Alam 2006; Montoya-Weiss, O'Driscoll 2000), but most began with an initial more or less strategically oriented scanning process (Riel et al. 2013; Trotter 2011; Brunswicker, Hutschek 2010; Oliveira, Rozenfeld 2010; Boeddrich 2004; Smith, Herbein 1999; Khurana, Rosenthal 1998) respectively with opportunity identification and analysis (e.g. Postma et al. 2012; Brem, Voigt 2009; Russell 2008; Sandmeier et al. 2004; Koen et al. 2001). Figure 10 provides an overview of elements, stages and building blocks of various process approaches to the FEI:

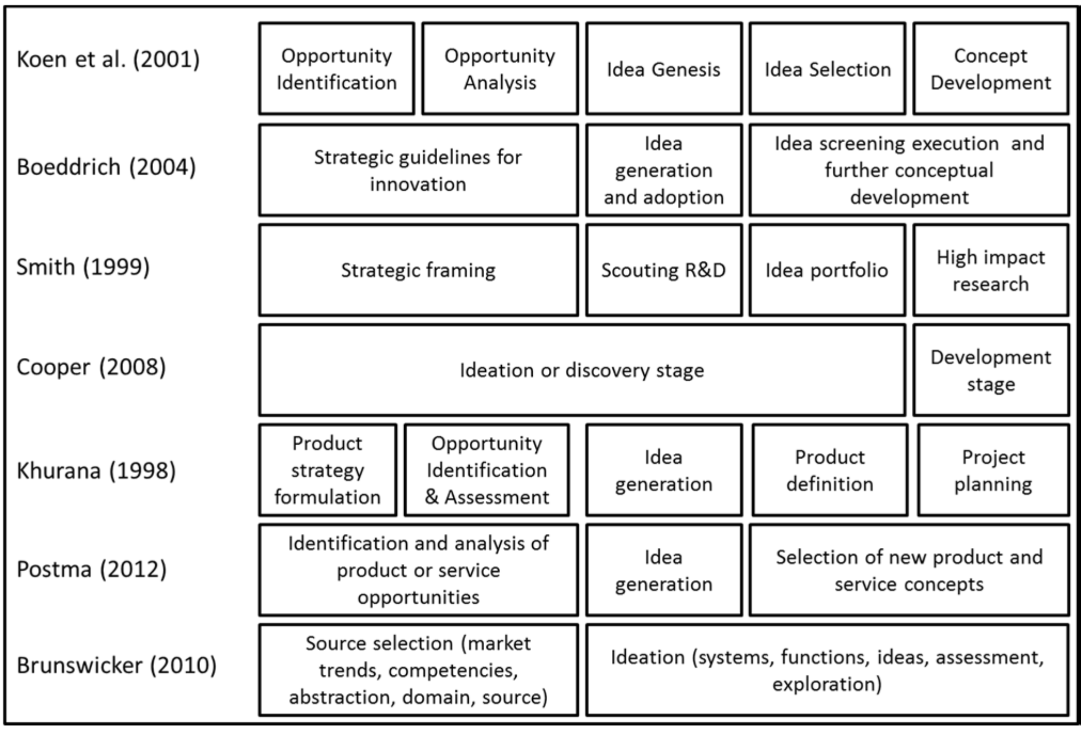


Figure 10: Overview of existing FEI process models elements

Most of the FEI process models provided in literature are activity based and sequential in nature. They divide the FEI process into separate stages with defined starting and ending points (Vahs, Brem 2015; Dörr, Müller-Prothmann 2014; Herstatt, Verworn 2004; Cooper 1994). Such models follow a linear course, suggest conducting task by task, allow for easy access of recommended activities and seem to provide transparency and predictability (Sandmeier et al. 2004; Khurana, Rosenthal 1998). Nevertheless, they run the risk of not corresponding to reality, of not considering creative exchange, of not allowing for or of not fostering feedback loops and of lacking flexibility (Gaubinger et al. 2015). Such models do not distinguish between project related and process oriented tasks and activities and the according framework creating tasks and activities. In this thesis, sequential, activity based FEI process models are considered useful for describing the FEI process and its single activities and tasks. However, they do not allow for distinguishing between project specific and cross project activities and are not capable of deriving appropriate and concrete organisational measurements (cf. Koen et al. 2001; Khurana, Rosenthal 1998). Taking into consideration the general requirements for holistic innovation process models as derived in section 1.1.2, strictly sequential FEI process models are not suited in the context of the current thesis. The shortcomings of such models have also been emphasised by various other authors, who propose iterative and integrative process approaches to the FEI (Brem 2008; Boeddrich 2004; Sandmeier et al. 2004; Koen et al. 2001; Khurana, Rosenthal 1998).

“Integrative” FEI process models seek to allow for clearly distinguishing between supporting, continuous and cross-project activities (so called “foundational elements”, “framework conditions” or non-process factors) and project-specific activities (process factors) (Khurana, Rosenthal 1998). Such models strongly emphasise an iterative approach to the FEI and explicitly allow feedback loops between the stages. In line with the research objective of the current thesis (cf. section 1.4) and the requirements of innovation process models (cf. section 1.1.2) integrative approaches to the FEI are more suitable than merely activity based ones.

1.2 Relevance of and Research Gaps at the FEI

Although the FEI has received quite some attention in research (cf. section 1.1.3), a generally accepted definition is still missing (Aagaard, Gertsen 2011), different authors disagree on its boundaries (Martinsuo 2009) and the terminology varies (Nobelius, Trygg 2002). A clear discrepancy can be observed in literature as to whether the FEI should and can be formalised and systematically managed (Markham 2013; Reid, Cooper 2011; Trotter 2011; Verworn et al. 2008; Boeddrich 2004; Brentani 2004; Montoya-Weiss, O'Driscoll 2000; Khurana, Rosenthal 1998), or whether a more informal, iterative, chaotic and non-prescriptive approach should be preferred (Nobelius, Trygg 2002; Stringer 2000; Smith, Herbein 1999).

Considering the above, it becomes clear that the FEI is on the one hand an important research area that already received quite some attention. On the other hand, there is no clear consensus on how exactly the FEI and its boundaries can be defined. Discrepancies concerning an advisable approach to the Front End can be found in literature. Existing literature mainly focussed on the idea generation stage, other stages at the Front End have received little attention (Wowak et al. 2016; Košmrlj et al. 2015a; Riel et al. 2013; Alam 2006). The amount of holistic and practical approaches on how to manage the FEI is low (Markham 2013) and there are still few empirical studies clarifying Front End practices (Gregor, Hevner 2015; Aagaard, Gertsen 2011). According to Koen et al. there have only been eight empirical studies so far that specifically focussed on the FEI and even these are limited to a certain degree. Most focussed on one specific FEI project or were conducted in relatively small organisations (Koen et al. 2014a).

In conclusion, there is a need for further research on the FEI. The significance of developing new theories and proposals that support effective implementation of the FEI is immense, from a scientific perspective as well as from a practical one (Wowak et al. 2016; Riel et al. 2013; Saetre, Brun 2012; Trotter 2011; Oliveira, Rozenfeld 2010; Verworn 2009; Reid, Brentani 2004;). In this context, structuring the FEI by specifically addressing key tasks and activities at this early stage is emphasised as an approach offering high potential (Markham 2013; Martinsuo 2009; Tatikonda, Rosenthal 2000). It is apparent that the FEI can be regarded to as the most error-prone and the most difficult to manage phase in the whole innovation process. There are major weaknesses in economic practice and there has been relatively little research published on how exactly to improve the FEI from a practical point of view. This is particularly the case for the strategically oriented stages and activities at the FEI, as most published guidelines and recommendations mainly focus on the operative FEI stages respectively on the ideation process only. The current thesis aims to develop a process model specifically addressing the strategically oriented key activities at the Front End preceding the more operative ideation process.

1.3 Problem Statement, Motivation and Design Hypothesis

The FEI is not only of great relevance for successful innovation, but it also is one of the most challenging areas in an organisational context. This thesis lays an emphasis on the early, strategic phases of the FEI, namely opportunity identification and opportunity selection (cf. section 3.1.4). The transition from early strategic to later operative FEI is focused, aiming to achieve a consistent and comprehensive FEI process model. The problem addressed in this thesis is how to systematically structure the strategic parts of the FEI in the form of a process model, coupled with the motivation to evaluate research results in practice and to validate their applicability in an organisational environment. The underlying design hypothesis of this thesis is as follows:

Structuring the early, strategically oriented parts of the FEI, by specifically addressing and supporting process key activities at this early stage of the innovation process, increases FEI performance from an expert's point of view.

The identified research problem and the design hypothesis appear even more important, considering the ongoing debate in literature whether or not the FEI can and should be formalised at all. Two different and directly opposing approaches are proposed in relevant scientific literature: One point of view is that only an informal, iterative, chaotic and non-prescriptive approach to the FEI allows creativity to happen and encourages people to take the initiative. Formalisation and structure on the other hand may have harmful effects on creativity and especially on radical ideas (e.g. Reid, Brentani 2004; Bonner et al. 2002; Nobelius, Trygg 2002; Tatikonda, Rosenthal 2000). The directly opposing view goes back to Smith and Herbein, who stated that "the front end of the innovation process can be treated like any other business process" (Smith, Herbein 1999, p. 24). Hence, it could be completely organised by using a formalised and structured approach. This clear statement by Smith and Herbein may have its roots in the predominance of business process management which was observable in the 1990s. The importance of a clear structure and a systematic approach to the FEI is also emphasised by Zirger and Maidique, who stated that a coherent process ranging from research to market introduction is a critical success factor for new product development (Zirger, Maidique 1990). Stockstrom and Herstatt, too, emphasise the relevance of strict and early process structures at the FEI, regardless of novelty and nature of technology and product innovation (Stockstrom, Herstatt 2008). In addition to these views of the FEI, a third group of scholars follows a hybrid approach and suggests that structuring the FEI is beneficial and required, but only up to a certain degree: "*a certain amount of control appears necessary to secure the effective use of resources and the achievement of the company's long-term objectives*" (Poskela, Martinsuo 2009, p. 671). According to this group, the attention should be drawn to key activities and tasks at the FEI rather than to their linear order or decision gates (Koen et al. 2001). Several empirical studies support their hypotheses that Front End effectiveness and efficiency benefits from extending the new product development process and suggest incorporate selected FEI key activities into a formal process through adding earlier stages of work such as pre-stage-zero (e.g. D'Aujourd'hui 2015; Markham 2013; Koen et al. 2014a; Cooper 2011; Trotter 2011; Verworn et al. 2008).

The amount of research underpinning this view is high. Following this position, a formalised approach to the FEI

- reduces market and technical uncertainty (Verworn et al. 2008),
- results in product concept superiority (Poskela, Martinsuo 2009),
- significantly improves the overall front-end success (Markham 2013),
- consists of both process and non-process factors (Trotter 2011),
- offers the possibility for managers to intervene and give guidance on decisions (Tatikonda, Rosenthal 2000), and
- is a stronger predictor to the overall product performance than the actual NPD process (Markham 2013).

Front End formalisation not only positively impacts FEI efficiency, but also overall product performance and innovation success. The current thesis follows the third group of scholars and postulates a positive impact of formalisation at the FEI. Nevertheless, the need for both integrating process but also addressing non-process factors is recognised and is addressed accordingly in the course of the current thesis. Hence, the thesis focusses on deriving and defining exactly such key activities at the FEI that can be structured and formalised (process factors). It also identifies the non-process factors relevant in order to achieve and maintain strategic orientation at the FEI. The crucial importance of deriving process and non-process factors for the FEI is also emphasised by Gaubinger and Rabl (2014), who state that "*it is essential for organizing the front end of innovation (FEI) in order to find the right balance between flexibility and creativity (weak-defined processes and targets) on the one hand and structure and bureaucracy (well-defined processes and targets)* *on the other hand"* (Gaubinger, Rabl 2014, pp. 15–16). This implies that too little as well as too much formality has negative impacts on the FEI.

Considering the arguments presented above, the main challenge to be addressed in this thesis is the identification of process and non-process factors at the FEI and the appropriate incorporation of process factors in the form of a comprehensive, theoretically grounded and practically oriented process model. The research dilemma underlying this challenge is as follows: How much structure and formalisation is possible and beneficial without inhibiting creativity and flexibility at the early stages of the innovation process? From a practitioner's point of view, this dilemma appears even more challenging: Theoretical process models for the FEI and the innovation process in general may depict reality in a structured and proper manner. However, they are not suitable for implementation in an organisational context and as general FEI guidelines (Koen et al. 2014a; Markham 2013; Riel et al. 2013; Saetre, Brun 2012; Ho, Tsai 2011; Oliveira, Rozenfeld 2010).

To analyse the practical relevance of a structured approach to the early, strategic parts of the FEI, a series of meetings with practitioners and experts with both organisational and academic background were held over the initial months of the thesis. In order to allow for an open and unimpaired setting, informal meetings were arranged, in the course of which the problem statement and the main research area of the thesis were discussed. In order to facilitate these informal meetings, the FEI process model proposed by Koen et al. (Koen et al. 2001) served as a basis for discussion (cf. section 3.1.2). It was also taken as a reference framework for a self-evaluation of theoretical knowledge of the respective stage and its actual performance. The findings of this first series of informal meetings are in line with literature on the FEI. The clear difference between theoretical and practical FEI performance in the stage of opportunity identification and opportunity analysis indicates that although practitioners are aware of their relevance, they do not address them accordingly. Results also indicate wide disparities between the strategically oriented (opportunity identification and analysis) and the more operatively oriented FEI stages (idea generation and selection). These differences were not only reflected regarding theoretical but also practical performance at the respective stage of the FEI. Similar results supporting the relevance for developing new theories and guidelines for the early, strategic parts of the FEI could also be observed during focus group conduction (cf. section 3.2.2).

Besides the author's personal interest in the field of innovation management, the main motivation for this doctoral thesis is to investigate and specifically address this gap in scientific research and economic practice. The thesis is set in the current research project InnoStrategy 2.0. The aim of this project is the conceptual development and software technical realisation of an Open Innovation Platform (based on MS Sharepoint). The platform effectively and efficiently supports the early stages of the innovation process (early, strategic and later, operative level FEI activities). The project specifically focuses on acquiring and integrating strategically relevant information from the company environment (e.g. by use of trend monitoring, opinion mining). It also focuses on effectively and efficiently improving the (virtual) collaboration within the meaning of the open innovation approach at the FEI. The project consortium consists of partners from both academia and industry. The academic partners consist of the University of Applied Sciences Upper Austria (research areas: "Innovation and Product Management" and "Digital Business") and Dublin City University (research area: "Business Informatics Group"). The key industry partners, which contributed throughout the whole project, consisted of three large-scale organisations from the areas of 1) concrete formwork, 2) charging devices and solar electronics and welding systems and 3) agricultural machinery (cf. section 3.2.2). This setting does not only allow for a close collaboration between industry and academia but also contributes to ensuring the relevance and rigor of the artefact developed and evaluated in this thesis. Additional organisations (e.g. from the ICT-sector, the field of biotechnology, the area of glass-solutions, the injection moulding machine sector or the field of rolling bearings) were integrated in the initial stages of the project. In the course of the previously mentioned series of meetings these organisations also contributed to defining the project scope and ensuring research relevance.

The findings of previous section 1.2 and the current section 1.3 also serve as evaluation results for ex-ante evaluation 1 (cf. section 2.2.3.1) and confirm the theoretical and practical relevance of the identified research problem and research gaps as well as the scientific novelty of the research objectives.

1.4 Research Objectives

Based on the identified problem statement, the main objectives of the current research are to (1) identify principles at the FEI, to (2) derive process model design requirements based on these and to (3) develop and (4) evaluate a formal process model specifically supporting process FEI key activities.

As discussed before, an emphasis is laid on the early, strategically oriented parts of the FEI as well as on the transition between early strategic and later operative Front End activities. In the course of process model development, findings and recommendations found in scientific literature (cf. section 3.1) serve as a basis to identify, collect and analyse requirements and weaknesses observable in economic practice (cf. section 3.2.2). The development and the ex-ante evaluation of the process model is conducted in cooperation with partner organisations of the research project InnoStrategy 2.0 (cf. section 1.3). In order to ensure an evaluation independent from design and development, ex-post process model evaluation is done with professionals from different organisations, which have not been involved in process model development. Thus, it secured that no tailored process model, which would only fit to the partner organisations of the project, is created (cf. section 6).

1.5 Research Questions

To systematically address the outlined research problem and to achieve the research objectives described above, the following research questions are defined. In order to develop the aimed at process model, principles at the FEI have to be identified, process model design requirements and key activities based on these have to be derived and the process model has to be developed and evaluated in accordance with the research approach. Research question one aims at identifying the principles (i.e. success factors, challenges, key elements, recommendations from literature and practice) at the FEI:

- (RQ1) What are the principles at the FEI?
    - 1.1. What are the success factors, key elements and recommendations for the FEI according to scientific literature?
    - 1.2. What are the challenges and success factors at the FEI in economic practice?
    - 1.3. What are the principles at the FEI?

Based on the findings and the FEI principles resulting from research question one, the second research question aims to address those principles in the course of process model design and development. FEI principles, which lie in the focus area of this thesis and which are depictable in formal process models are then discussed in detail. This provides the foundation to derive process model design requirements in subsequent steps. On the basis of this, process model elements are then defined and assembled into a process model:

- (RQ2) Process model design and development: how can a FEI process be designed?
  - 2.1. Which FEI principles affect the strategic parts of the FEI and which of these can be considered as process factors?
  - 2.2. Which process model design requirements can be derived from relevant and process related FEI principles?
  - 2.3. How can the process (key) activities be assembled into one process model taking into account the theoretical and practical principles at the strategic FEI?

Based on the defined principles at the FEI (RQ1), the process model resulting from research question two is to be evaluated in research question three. The evaluation approach of the thesis covers ex-ante and ex-post evaluation and is explained in detail in sections 2.2.3 (ex-ante) and 6 (ex-post):

- (RQ3) Application and evaluation of the process model: Can the proposed process model be regarded as a valid approach for organisational practice?
  - 3.1. Based on which quality requirements and criteria can the developed process model be evaluated?
  - 3.2. Is the process model considered of high quality and usefulness from a practitioner's' point of view and would it be applied and utilised in an organisational context?

The final process model consists of a set of key activity groups and respective sub-activities, which provide a practical framework to foster structure, flexibility and strategic orientation at the FEI.

Figure 11 visualises the main research questions and the content structure from deriving FEI principles and defining process model design requirements to developing and evaluating the process model:

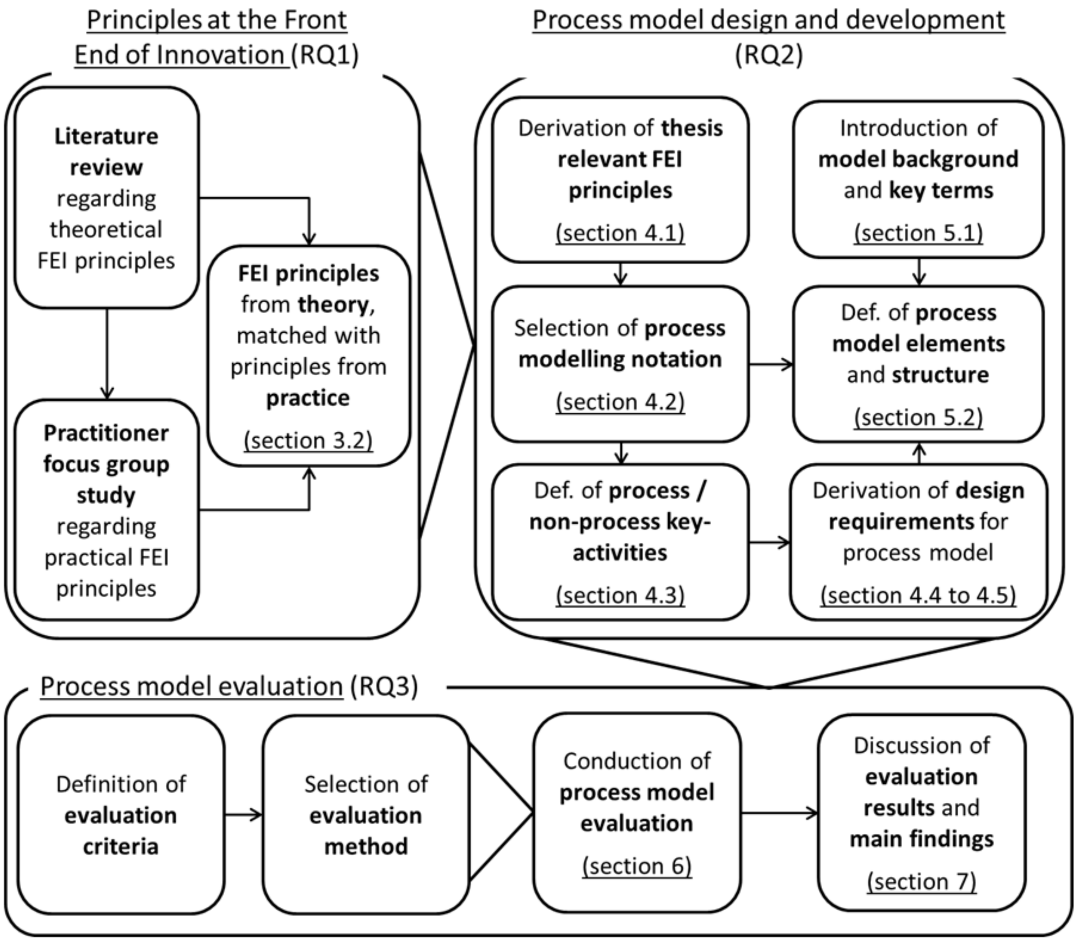


Figure 11: Research questions and content structure of the thesis

1.6 Research gaps contrasted to research objectives of the thesis

The facts described in section 1.2 lead to the conclusion that the FEI is a highly relevant research topic, offering not only high potential for improving economic practice but also great contributions to the current research and knowledge base. The literature review shows that the identification of process and non-process (or soft) FEI elements, the structuring of these activities and processes at the FEI and the implementation of a continuous strategic orientation hold great potential for improving an organisation's innovation capability. Existing FEI process models either do not distinguish between process and non-process elements or fail to deliver comprehensive and practicable recommendations for the strategic FEI. Table 1 summarises the research gaps identified in the course of the literature review and contrasts these to the goals of the current research as defined in section 1.4:

Table 1: Summary of identified literature gaps and goals of the thesis

Literature Gaps	***Goals of the thesis***
The significance of developing new theories and proposals that support effective implementation of the FEI is immense (Wowak et al. 2016; Brandtner et al. 2015b; Koen et al. 2014a; Riel et al. 2013).	This research thesis contributes to the FEI within the field of Innovation Management by developing a theoretically grounded and practically oriented process model. This model is based on scientific literature, on the results of an exhaustive focus group study and on continuous practitioner involvement. Process model evaluation is done from an ex-ante as wells as from an ex-post perspective.
There are still few empirical studies clarifying FEI practices and even those are often limited (Gregor, Hevner 2015; Brandtner et al. 2014; Koen et al. 2014a; Markham 2013; Aagaard, Gertsen 2011).	
Previous work on the FEI mainly focussed on idea generation only and neglected the preceding phases of opportunity identification and analysis (Alam, 2006; Košmrlj et al. 2015a; Wowak et al. 2016; Brandtner et al. 2015a; Riel et al. 2013).	The current thesis specifically focusses on the stages of opportunity identification and analysis. Idea generation, evaluation and concept development have already received quite some attention in scientific literature. Most organisations have established structured and organised ideation and concept development processes. Hence, the thesis does not need to put an emphasis on these.
The few existing FEI process models which cover the stages preceding idea generation fail to deliver practicable and concrete sets of guidelines and measures for practitioners (Gaubinger, Rabl 2014; Košmrlj et al. 2015b; Glassman 2010).	This research aims at developing a practicable process model for the strategically oriented parts of the FEI by providing a structured approach to process FEI factors and by identifying non-process factors. Practicability and value for practitioners is analysed in the course of process model evaluation.

1.7 Roadmap of the thesis

The thesis consists of eight chapters and applies a mixed-method approach of qualitative and quantitative research methods (Venkatesh, 2013). The remaining chapters of the thesis are structured as follows:

Chapter two deals with research methodology and introduces and justifies the methodological setup of the thesis.

Chapter 3 addresses research question one and aims at deriving principles at the FEI as defined in scientific literature (structured literature review and qualitative content analysis) and as observable in organisational practice (focus group study).

The chapter summarises with a list of principles for the FEI based on literature and practice, which serve as a basis for deriving design requirements for process model development in chapter 4.

Subsequently, chapter 5 consists of defining and developing the single process model elements and deals with the structural setup of these elements in the form of one process model.

In the course of chapter 6, the evaluation approach of the thesis is presented and the process model developed is evaluated in terms of process model quality.

In chapter seven, evaluation results are discussed and main findings derived.

Chapter eight concludes the thesis, deals with limitations of the thesis and provides an outlook on future research.

The following figure visualizes the roadmap of the thesis. For each chapter, the main focus, the methods applied and the results gained are presented.

Chapter	Focus	*Methods Applied*	Results
1. Introduction	Identification of research problem, objectives and research questions	*Literature review*, initial *practitioner interviews*	Rigorous and relevant research problem, objectives and questions; interview results
2. Research Methodology	Identification of an appropriate research methodology and development of specific research approach.	*Literature review*	Application of DSRM by Peffers et al. to the thesis; Definition of Process Model Development and Evaluation approach
3. FEI Principles ***RQ 1***	Identification of FEI principles as basis for process model design requirements	*SLR* (Webster & Watson 2002), *Focus Groups* (Tremblay et al. 2010), *QCA* (Mayring, 2000), *Peer-Debriefing* (Thomas & Magilvy 2011), *Framework Analysis* (Kruger & Casey, 2009), *EPCs* (Scheer et al. 2005)	Consolidated FEI principles derived from literature and practice; 3 Focus group reports and 3 EPC-FEI process models (one per organisation).
4. Process Model Design Requirements ***RQ 2***	Identification of process and non-process FEI principles and derivation of process model design requirements/foundations.	*SLR* (Webster & Watson 2002) for Uncertainty Reduction and Innovation Strategy Development, *QCA* (Mayring, 2000)	Process and non-process FEI principles; process model design requirements; SLR results
5. Process Model Development ***RQ 2***	Development of process model based on process model design requirements and foundations.	*SLR (Webster & Watson 2002)* for Corporate Foresight (CF) and Strategic Issue Management (SIM), *Event-Driven Process Chain Notation* (Scheer et al. 2005),	SLR results for CF and SIM; Process Model key terms; Process Model elements and structure
6. Ex-Post Process Model Evaluation ***RQ 3***	Ex-post evaluation of final Process Model quality independent from design-inherent (ex-ante) evaluation.	*SLR* (Webster & Watson 2002) for Process Model quality dimensions, *Technology Acceptance Model* (Venkatesh 2000), *Web-based Survey* (Rittgen 2010), *bflow-toolbox* (Böhme et al. 2010)	Ex-post evaluation approach for FEI Process Model quality; Results of Web-based survey (PSQ & PU), results of bflow-toolbox (SNQ)
7. Evaluation Results & Discussion	Discussion of ex-post evaluation results for process model quality dimensions PSQ, SNQ and PU and their items.	*Quantitative analysis, Qualitative discussion*	Findings of survey result analysis for PSQ and PU; results for items and textual statements; overall process model quality
8. Summary and Conclusion	Aggregation of main findings and discussion of future work	*Textual discussion*	Results for each RQ; main contributions of thesis; impact on theory and practice; limitations; outlook on future work.

Figure 12: Roadmap of the thesis

2 Research Methodology

In general, research tries to find solutions and answers to questions concerning the unknown. In literature, research is defined as a logical process of steps applied to collect and analyse data to improve knowledge and understanding of a topic or issue respectively to solve a problem perceived (Johnston 2014; Creswell 2012; Walshaw 2012; Bryman, Bell 2011;). Various approaches on how to conduct research can be found in literature (Flick 2011; Kumar 2008). Information systems research to date has produced knowledge by two complementary but distinct paradigms: behavioural sciences and design sciences (Hevner, Chatterjee 2010; Winter 2008; Hevner et al. 2004; March, Smith 1995). Behavioural science originates from natural science paradigm and aims at finding the truth, usually starting with a hypothesis. Behavioural science research collects data to either prove or disprove a defined hypothesis (Hevner, Chatterjee 2010).

Design science follows a different approach and positions itself as a problem solving paradigm (Peffers et al. 2007) with the objective of producing an artefact which must be designed and then evaluated thoroughly (Ostrowski, Helfert 2012). While behavioural science tries to understand the truth and reality, design science hence focuses on creating “things” or artefacts that serve a particular human purpose and address urgent or “wicked” (Rittel, Webber 1973) problems. Design science is technology and process oriented and its outcomes (the artefacts) have to be assessed against criteria of value and utility (March, Smith 1995) (cf. Table 2).

Table 2: Juxtaposition of traditional and design science based on Dresch et al. (2015) and Romme (2003)

Categories	***Traditional science***	***Design science***
Purpose	Understand organisational phenomena by uncovering general patterns and forces that explain them.	Produce artefacts that do not yet exist and change existing organisational systems and situation to achieve better results.
View of knowledge	Representational – knowledge represents world as it is; descriptive and analytic search for general and valid knowledge.	Pragmatic – knowledge in the service of action; normative, prescriptive and synthetic. Design assumes each situation to be unique, draws on purposes and ideal solutions,

		systems thinking and limited information.
Nature of objects	Organisational phenomena as empirical objects, with descriptive and well-defined properties, that can be effectively studied from an outsider position.	Organisational issues and systems as artificial objects with descriptive as well as imperative (ill-defined) properties, requiring non-routine action by agents in insider positions.
Focus of theory development	Discovery of general causal relationships among variables (expressed in hypothetical statements). Aim is to find out if hypothesis is valid; conclusions stay within the boundaries of the analysis.	Aim is to find out if an integrated set of design propositions works in a certain ill-defined (problem) situation. Design and development of new artefacts tends to move outside boundaries of initial definition of the situation.

A method which could be seen similar to design science at a first glance is action research. Like design science, action research also contributes to both practical concerns of organisations and people in immediate problem situations and to goals of science and research (Rapoport 1970) and has gained increased acceptance as qualitative approach in IS research (Goldkuhl 2012). However, these two approaches are actually not similar, especially in terms of a paradigmatic comparison, where DS offers greater variability (Iivari, Venable 2009). The main difficulty with action research is that scientific rigor is often sacrificed to practical benefits, which makes it difficult to assess action research work for publication in e.g. academic journals. The fact that paradigmatic foundations of action research are not always clear also undermines credibility of the method in terms of research funding (Baskerville, Wood-Harper 1996). Furthermore, there are several obscurities and ambiguities with action research that need to be resolved (Goldkuhl 2012). Another issue with action research in the current context is its underlying assumption that complex social settings - for example an organisation and its processes or its information technology - can only be understood as whole entities and factoring it would not produce reliable knowledge. A social complex setting according to action research is best studied by introducing adaptions and changes into its process and by subsequently observing theses changes' effects and results (Baskerville 1999). Design science in turn is primarily concerned with utility of a particular artefact and its applicability to solve a specific and clearly defined problem (Hevner et al. 2004). Table 3 contrasts design science and action research based on orientation, goal, specificity, design role, outcome and axiology:

Table 3: Characteristics of DSR and AR based on Baskerville et al. (2009) and Papas et al. (2012)

Characteristic	***Design Science Research***	***Action Research***
Orientation (method for)	Research	Practice and research
Goal	Problem solving	Problem solving and / or behavioural understanding
Specificity	Generalised	Situation specific and generalised
Design role	Generative / invention	Application or invention and application
Outcome	Design theory or artefact shown to have utility	Situated organisational improvement
Axiology	Practice is improved and learning has taken place. Participant practitioners may benefit from the research.	Practice is improved by the development and use of an artefact. . Participant practitioners may benefit from the research, but utility of artefact is paramount.

Applied to the thesis, design science is selected rather than action research. The reasons are as follows: Firstly, fulfilling scientific and paradigmatic requirements is an essential element of the thesis. Following the discussion presented above, design science better corresponds to these. Secondly, the objective of this research is to examine, how the FEI can be structured in the form of a process in economic practice to support critical strategic level FEI activities. Hence, the main component of the current study is the design of a practical process model (the design science artefact) which is of utility at the early stages of the innovation process. As discussed above, such a research outcome is typical for the design science methodology. The highly unstructured and often ill-defined FEI is characterised by unstable requirements, complex relationships and interactions among subcomponents of the problem (Stevens 2014; Akbar, Tzokas 2013; Ho, Tsai 2011; Jörgensen et al. 2011). This is a good example for what is called a wicked application domain. Such domains are characterised by the existence of vicious circles, risks that new solutions may introduce new problems or by a lack of self-evident solution options (Goldkuhl, Röstlinger 2009). This is typically addressed by design science research (Hevner et al. 2004). In line with the discussion presented above, with the identified problem statement, the defined research objective and the developed research questions, design science research (DSR) (Hevner, Chatterjee 2010; March, Storey 2008) can be considered as an appropriate and applicable research methodology in this specific research setting.

2.1 Design Science Research (DSR)

To contextualise DSR, the taxonomy of IS theory by Gregor (Gregor 2006) is applied. According to Gregor, the classification of theory for IS starts with the primary goal of the theory. In the context of DSR, "*a theory is an artefact in that it is something that would not exist in the real world without human intervention. […] The goal of a theory is 'what the theory is for': analysing, explaining, predicting or prescribing*" (Gregor 2006, p. 619). Combinations of these four goals lead to a taxonomy of five theory types in IS research: (I) analysis, (II) explanation, (III) prediction, (IV) Explanation and prediction (EP), and (V) Design and action. As the core mission of DSR is to develop knowledge that can be used by practitioners to design solutions to their field problems (van Aken 2005), the DSRM and thus the current research can be placed within theory type V - design and action - in IS research as defined by Gregor (Gregor 2006) (cf. Table 4).

Table 4: Taxonomy of Theory Types in IS Research according to Gregor (2006)

Theory type	***Distinguishing Attributes***
I. Analysis	Says what is: The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made.
II. Explanation	Says what is, how, why, when, and where: The theory provides explanations but does not aim to predict with any precision. There are no testable propositions.
III. Prediction	Says what is and what will be: The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations.
IV. Explanation and prediction (EP)	Says what is, how, why, when, where, and what will be: Provides predictions, has both testable propositions & causal explanations.

V. Design and action	Says how to do something: The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artefact.

The term artefact describes something that is constructed by humans, hence, that is artificial and does not occur naturally (Simon 1996). According to March and Smith (March, Smith 1995) there are four types of DSR outputs or artefacts: constructs, models, methods and instantiations. Constructs form the vocabulary of a domain and constitute a conceptualisation used to describe problems within the research domain on the one hand and specify their solutions on the other hand. Models are a set of propositions or statements expressing relationships among constructs and represent situations as problem or solution statements in design activities. Methods can be regarded to as a set of steps, e.g. an algorithm or guidelines, which can be applied to perform a certain task. Methods are based on underlying constructs, providing the method's language, and a representation (model) of the solution space. Finally, an instantiation is the realisation of an artefact in its environment and operationalises constructs, models and methods. Furthermore, instantiations provide the possibility to demonstrate the feasibility and effectiveness of the models and methods they include (March, Smith 1995). Applied to the current research thesis, the main output is the FEI process model, which can be classified as method against this theoretical background.

2.2 Research Approach of the Thesis

Several DSR process and procedures can be found in literature, e.g. the three cycle view of design science by Hevner (Hevner 2007), the build-evaluate framework by March and Smith (March, Smith 1995), the DSR process by Offermann et al. (Offermann et al. 2009) or the DSR process by Helfert and Donnellan (Helfert, Donnellan 2012). In the course of the current thesis, the six-step design science research methodology (DSRM) by Peffers et al. (Peffers et al. 2007; Peffers et al. 2006) is taken as a reference framework. The components of the DSRM were synthesised by Peffers et al. based on seven research papers and provide a set of phases for implementing design science research methodology following a sequential process. The six steps of the DSRM include (1) problem identification and motivation, (2) definition of the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation and (6) communication. A particularity of the DSRM method is that both the starting and the end point of the research can be modified and adapted to the type of problem and the respective research objectives (Peffers et al. 2006).

Figure 13 provides an overview of the DSRM applied to the current research, demonstrates the outputs of each research question along the design science research process and includes the research techniques used to address the particular research questions:

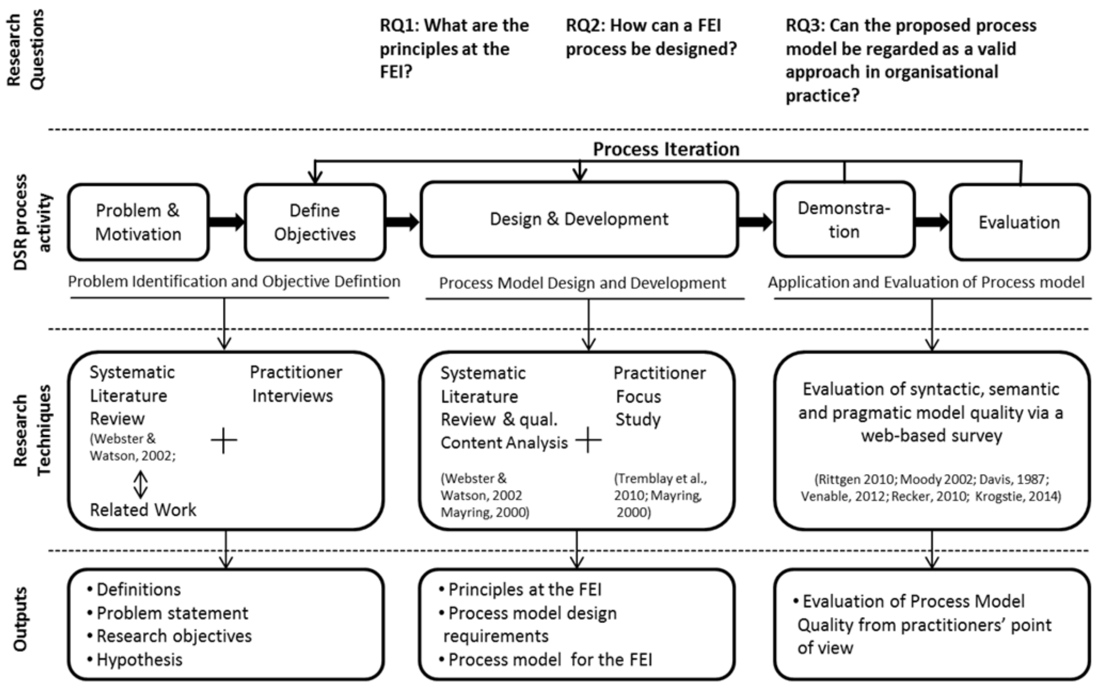


Figure 13: Summary of the research approach

2.2.1 Problem Identification and Define Objectives

Problem identification is the first step of the research approach. At this stage, the research problem is identified and the importance and motivation of the research is justified (Peffers et al. 2007). Problem identification and motivation is presented in section 1.3 of the thesis. The second step of the DSRM is concerned with the definition of expected outcomes and research objectives; these are defined and presented in section 1.4 of the thesis.

2.2.2 Design and Development

The third step of the research methodology covers process model design and its development. In this stage, the design requirements related to process model activities and structure are derived and the process model is developed (Peffers et al.

2007). These steps are conducted based on the structural roadmap presented in section 1.5 and depicted in Figure 11.

2.2.3 Demonstration and Evaluation

Step four of the research methodology comprises the demonstration and evaluation of the design science artefact. In DSR, artefact evaluation within the specific environment is of crucial importance (Peffers et al. 2012a; Peffers et al. 2012b; Sein et al. 2011; Hevner, Chatterjee 2010). Artefacts should be evaluated based on the requirements of the context of their respective application and implementation environment (Peffers et al. 2012b).

Applied to the current thesis, the purpose of artefact evaluation is to confirm that the artefact respectively the process model meets the context-specific requirements at the strategic FEI. Furthermore, the aim is to validate that it is a correct and useful model as based on practitioners' knowledge as domain experts (Iivari 2007; Piirainen et al. 2010). According to Niederman et al. (2012) the initial evaluation of a novel artefact may simply be to show that it works and produces adequate solutions. The challenge is to define "adequacy". Evaluation criteria are socially constructed and what one researches may consider adequate, may be considered inadequate by another (Niederman, March 2012). A plethora of evaluation approaches and methods in a DSR context can be found in literature (e.g. in Helfert et al. 2012; Peffers et al. 2012b; Venable 2011; Cleven et al. 2009; Hevner et al. 2004; March, Smith 1995).

Nevertheless, little work has been done so far specifically addressing the choice and combination of evaluation strategies and methods in DSR evaluations (Prat et al. 2014; Sonnenberg, vom Brocke 2012a). One of the few papers addressing this issue was written by Pries-Heje et al. (2008), who proposed a framework supporting researches in building evaluation strategies. They distinguish between three core dimensions of an evaluation strategy: 1) when to evaluate, 2) what to evaluate and 3) how to evaluate (Pries-Heje et al. 2008). Regarding the evaluation timing, design science evaluation approaches often divide between ex-ante and ex-post evaluations, depending on when the evaluation occurs. In the ex-ante perspective, evaluation is conducted before the construction of any artefacts and is based on design specifications only. In the ex-post perspective, evaluation is conducted after the construction of an artefact (Sonnenberg, vom Brocke 2012a; Pries-Heje et al. 2008; Arnott 2006). Choosing between these two options or deciding for both depends on the scope of the respective research project. Pries-Heje et al. (2008) clearly state that “*evaluation is not limited to a single activity conducted at the conclusion of a design-construct-evaluate cycle. In fact, there are at least two evaluation episodes available: design-evaluate construct-evaluate*” (Pries-Heje et al. 2008, p. 6).

Figure 14 depicts ex-ante and ex-post evaluation as categorised by Pries-Heje et al. (2008):

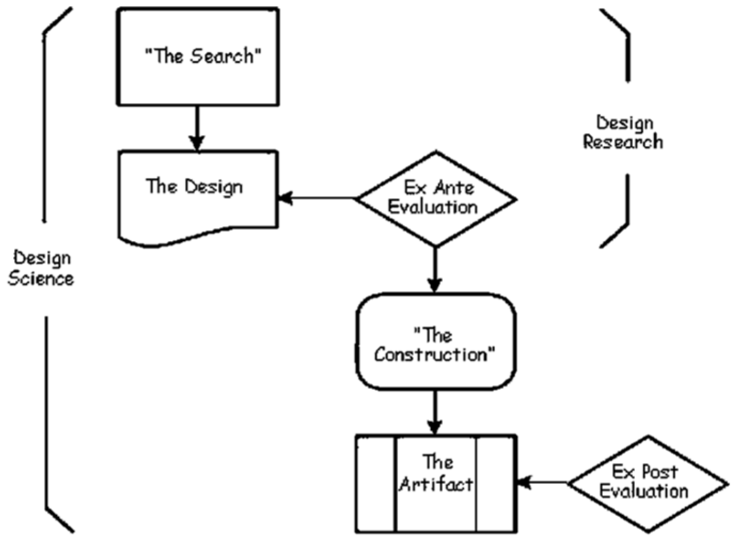


Figure 14: Ex-ante and ex-post evaluation in DSR (Pries-Heje et al. 2008, p. 7)

Besides the evaluation timing it is also important to define for what purpose and how to evaluate the artefact (Venable et al. 2016). Regarding the “what to evaluate” perspective, the objective is to define whether to evaluate artefact design process or the artefact design product (Sonnenberg, vom Brocke 2012a). “How to evaluate” relates to the form of evaluation and may be naturalistic or artificial. Naturalistic evaluation focusses on exploring respectively evaluating the artefact in its real environment, in this instance in the organisations of survey participants (Venable et al. 2012) (cf. section 6). This allows for embracing all the complexities of real users, real problems and real systems (Sun, Kantor 2006). Naturalistic evaluations are always empirical and may be positivist, critical and/or interpretive. Typical naturalistic evaluation approaches include field studies, focus groups, surveys or case studies. Artificial evaluation on the other hand includes laboratory settings, field experiments, mathematical proof or simulations. Each of these evaluation forms has its strengths and weaknesses (Venable et al. 2012; Sun, Kantor 2006), for example:

- The dominance of the naturalistic evaluation brings to naturalistic DSR evaluation the benefits of internal validity. However, naturalistic evaluation outcomes could also be affected by confounding variables or misinterpretation.
- The dominance of scientific/rational paradigm brings to artificial evaluation the benefits of stronger reliability in the form of better falsifiability and repeatability. However, artificial evaluation may not allow for embracing all the complexities of real user, real systems and real problems.

In summary, even though the crucial role of artefact evaluation is acknowledged in IS design science literature, only fragmented or incomplete lists of criteria are provided. Same applies to evaluation methods, which are only presented in a fragmented manner, without more detailed indication on how to apply which methods to which criteria (Prat et al. 2014; Ostrowski, Helfert 2012). What also could not be found in literature is an aggregated approach for evaluating artefacts in the form of process models. The actual implementation of such a wide ranging and long-term oriented process model in organisational practice would not be possible in the short or medium term. Furthermore, the results of its implementation in the form of its concrete effects and its factual results in the form of e.g. new products or increased turnover would take additional time to be visible, quantifiable and relatable. It would hardly be possible to identify the direct causal relation between actions and measures taken due to process model implementation and specific quantifiable outcomes in organisational practice. Hence, an appropriate evaluation framework had to be developed, allowing for evaluation of process model quality and usefulness prior to its actual implementation.

2.2.3.1 Build-Evaluate Cycles in the thesis

Build-evaluate cycles are a typical element of DSR and are usually iterated a couple of times before a final artefact is created (Winter 2008; Hevner et al. 2004; Markus et al. 2002). In the course of build cycles, innovative products in the form of artefacts for a specific purpose are generated. Evaluate cycles focus on determining how well the produced artefact performs in the context of the environment in which it operates (March, Smith 1995). Following this understanding, DSR emphasises on "*creating prescriptive knowledge that is assumed to have no truth-like value and with gathering evidence through descriptive research that an artifact proves to be useful*" (Sonnenberg, vom Brocke 2012b, p. 383). The DSR methodology by Peffers et al. (2006) – a quite acknowledged example of such a build-evaluate oriented DSR-process -

has already been presented in section 2.2 of the thesis. Applied to the current thesis and matched to the research methodology presented in section 2.2, the following build-evaluate-cycles can be identified as shown below (cf. Figure 15).

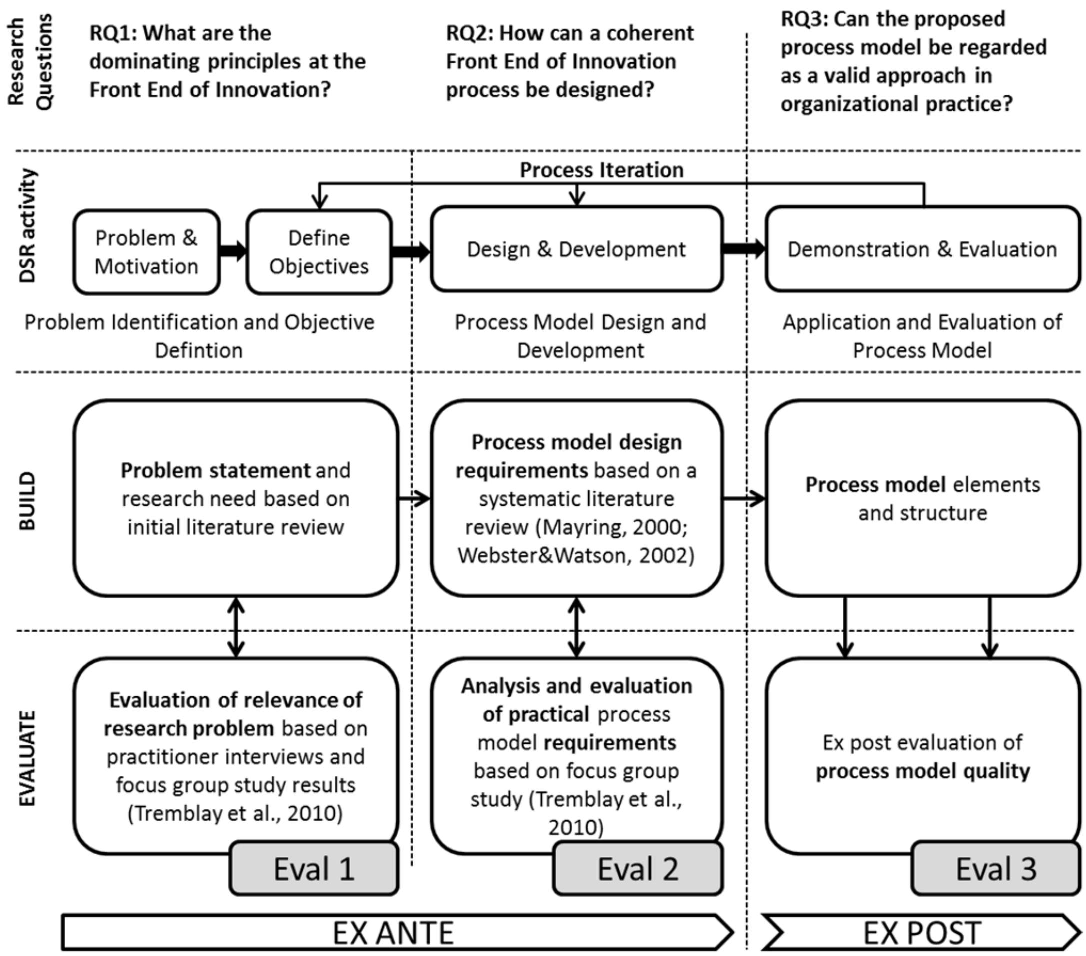


Figure 15: DSR Build-Evaluate Cycles of the Thesis

As discussed above, the evaluation approach divides between ex-ante and ex-post evaluation. Ex-ante focusses on the design inherent evaluation in the course of process model development, and ex-post evaluation aims at analysing the quality and usefulness of the constructed artefact in the form of the final process model in its application environment. The specific evaluation approach of the thesis focusses on these ex-ante and ex-post evaluate cycles.

2.2.3.2 Defining the Evaluation Strategy

According to DSR literature evaluation timing (when), evaluand (what) and evaluation method (how) have to be considered when defining an evaluation approach. Regarding evaluation timing, the thesis distinguishes between ex-ante and ex-post, as already discussed in the previous section. Applied to the conceptual model development research domain "*to build the model, one has to go through the audience's understanding of the domain, and to check the model one has to compare this with the audience's interpretation of the model*" (Krogstie et al. 1995, p. 222). Going through audience's understanding of the domain is done in the course of the iterative build-evaluate cycles of ex-ante evaluation. The evaluand for ex-ante evaluations are design products generated in the course of artefact development. In the present case, these are the problem statement and research need of the current thesis and the proposed literature derived principles for deriving process model design requirements. This form of design inherent evaluation in the course of process model development allows for early and structured evaluation before actually constructing the final artefact in the form of the process model (Sonnenberg, vom Brocke 2012b). Table 5 provides an overview of ex-ante evaluation in the thesis:

Table 5: Ex-ante evaluation activities of the thesis

Eval. activity	***Input / Evaluand***	***DSR Criteria***	***Eval. Methods***	***Output***
Eval. 1 **(ex-ante)**	• Problem statement, • Research gaps	• Importance • Novelty	• Literature review • Informal practitioner meetings	• Justified problem statement • Justified research gap
Eval. 2 **(ex-ante)**	• Identified FEI principles (literature)	• Fidelity with real world	• Focus Group Study	• Validated, rigorous and relevant FEI principles

The results of ex-ante evaluation "Eval 1" are presented in section 1.2 and 1.3 and contribute to deriving and defining a rigorously grounded and practically relevant problem statement and research gap as starting point for process model design requirements derivation. Likewise, the results of ex-ante evaluation "Eval 2" are presented in sections 3.2.2.2 to 3.2.2.4 and summarised in section 3.2.2.5. The specific FEI principles observable in organisational practice are then contrasted to the FEI principles derived from literature (cf. section 3.2.1). This allows for evaluating the theoretical principles in terms of their fidelity with real world, leads to further enrichment of the theoretical design specifications and provides the basis for the final definition of design requirements. The knowledge achieved during these ex-ante evaluation activities "*enables a traceable documentation of inputs and outcomes of the artifact construction process*" (Cleven et al. 2009, p. 4).

The ex-post evaluation on the other hand focusses on the final outcome, i.e. the process model. The ex-post evaluation strategy for the process model is presented in section 6 of the thesis.

2.3 Reliability and Validity

Throughout the research process, it has to be ensured that the research work is both valid and reliable (van Aken, Joan E. 2004; Golafshani 2003; Morse et al. 2002). Validity can be defined as the degree to which findings are interpreted in the correct way; reliability is the degree to which findings are independent of fortuitous research circumstances (Ostrowski 2014). Validity can further be divided into internal and external validity: while internal validity seeks to assure that the research investigates what is meant to, external validity is the degree to which research results can be applied to the respective application domain (Malterud 2001).

The evaluation approach of the current thesis is presented in section 2.2.3 and 6. The ex-ante evaluation steps conducted during process model design and development allows for a stepwise evaluation of preliminary results like FEI principles. The final process model can be categorises into theory type 5 of IS research according to Gregor (cf. Table 4) and is considered to have no general truth in itself. In order to demonstrate the internal validity of the artefact already in its design phase, a truth, inherent in the conceptual knowledge from which the artefact has been deduced, has to be resorted to (Sonnenberg, vom Brocke 2012b). To this end, the knowledge has to be documented in a way that allows for making inferences on the artefact's suitability and its correctness of design. In the present case, this is achieved in two ways: firstly, it is assured that the research problem is both rigorous and relevant ("Eval1", cf. Figure 15). Secondly, FEI principles derived from literature (cf. section 3.2) are aligned with principles derived from practice (cf. section 3.2.2) ("Eval 2", cf. Figure 15). Thus, the evaluation approach is capable of validating incremental design decisions right from the beginning of the research process (Sonnenberg, vom Brocke 2012b).The collection of theoretical FEI principles followed the systematic literature review (SLR) process by Webster and Watson (2002). Practical FEI principles were collected following the focus group procedure by Tremblay et al. (2010).

The aggregation and alignment of theoretical and practical FEI principles was done based on the qualitative content analysis (QCA) approach proposed by Mayring (2000) (cf. section 3.2 and 3.2.3). The development of a structured coding scheme and the analytic procedure of QCA further increased the validity of research results (Hsieh, Shannon 2005). Additionally, the technique of peer debriefing was applied in the course of QCA, which also contributes to research validity (Thomas, Magilvy 2011; Onwuegbuzie, Leech 2007; Morse et al. 2002; Cooper et al. 1998).

The final evaluation of external artefact validity is conducted based on naturalistic evaluation of its quality and usefulness in its intended application environment (cf. section 6). This corresponds to literature on DSR, where e.g. Venable et al. state that "*the validity and strength of an evaluation study for DSR is situated in […] the artefact's achievement of its intended purpose(s)*" (Venable et al. 2016, p. 87) or Pries-Heje and Baskerville, who postulate that "*validity is proven by an evaluation of […] artifacts and their achievement of the design goals*" (Pries-Heje, Baskerville 2008, p. 736).

Reliability of the research is addressed by following structured, acknowledged, repeatable and transparent approaches regarding the focus group study (cf. section 3.2.2.1) and the ex-post evaluation of the thesis (cf. section 6) (Dresch et al. 2015; Yin 2009). In terms of the focus group study, a questionnaire protocol is pretested and made transparent to participants right from the beginning. The collection of raw data and the analysis of results followed the framework analysis developed by Krueger and Casey (2009). Furthermore, data collection is done collaboratively by the focus group moderator, the second observer and by participants as well (cf. section 3.2.2.1.7). Regarding the ex-post evaluation, the evaluation approach follows the acknowledged TAM model proposed by Davis (1989) and Venkatesh (2000), which is of high reliability (Venkatesh, Davis 2000; Hendrickson et al. 1993;). Table 6 summarises the discussion presented above:

Table 6: Validity and reliability in the thesis

Characteristic	***Definition***	***Adressed in thesis***
Internal Validity	The degree to which the research investigates what is meant to.	SLR by Webster and Watson (2002) QCA by Mayring (2000); Focus group procedure by Tremblay et al. (2010);

External Validity	The degree to which research results can be applied to the artefact's application domain.	TAM by Davis (1989) and Venkatesh (2000)
Reliability	The degree to which findings are independent of fortuitous research circumstances.	Focus group procedure by Tremblay et al. (2010) Framework analysis by Kruger and Casey (2009); TAM by Davis (1989) and Venkatesh (2000);

2.4 Philosophical Stance and Epistemological Underpinning

From a philosophical point of view, research can be perceived along two main dimensions: ontology and epistemology. Ontology relates to the nature of knowledge (the position on the nature of reality) and epistemology to the development of that knowledge (what constitutes acceptable knowledge) (Vaishnavi, Kuechler 2015; Weber 2004; Wahyuni 2012; Hjørland 2005; Recker 2005).

In the thesis and in accordance with the research methodology (cf. section 2.2), an interpretivist approach is pursued: the ontological position is that reality is constructed subjective based on stakeholder perceptions and that person (researcher) and reality are inseparable. From an epistemological point of view, knowledge is perceived as being intentionally constituted through lived experiences. Hence, the research does not postulate the one and only truth but rather focusses on utility as perceived by stakeholders. This view is also reflected in the ex-post evaluation approach presented in section 6.

Table 7 summarises the characteristics and the philosophical stance of the thesis:

Table 7: Philosophical stance of the thesis based on Vaishnavi, Kuechler (2015) and Weber (2004)

Characteristic	***Philosophical stance in the thesis***
Ontology	• There are multiple, contextually situated realities and world states • Reality is constructed subjective based on stakeholder perceptions • Person (researcher) and reality are inseparable • Phenomena and relationships are social constructs by which individuals make sense of reality

Epistemology	• Knowledge is intentionally constituted through lived experiences • Those active in the research project construct knowledge • Rules governing behaviour are context-dependent

Data collection in the course of the research is mainly conducted qualitatively by conducting focus group studies (cf. section 3.2.2.1). However, for ex-post evaluation a semi quantitative survey is conducted for data collection in order to evaluate process model quality based on selected items (cf. section 2.2.3 and 6.2). These methods are integrated within the research process. The combination of qualitative and quantitative methods allows for triangulation of data from different sources, which can lead to new insights and modes of analysis (Kaplan, Duchon 1988; Jick 1979) and can produce "*rich insights into various phenomena of interest that cannot be fully understood using only a quantitative or a qualitative method*" (Venkatesh et al. 2013, p. 21).

3 Principles at the Front End of Innovation

The first research question "What are the principles at the FEI?" (cf. section 1.5), is addressed using a systematic literature review in accordance with the systematic literature review process by Webster and Watson (Webster, Watson 2002) and following Mayring's qualitative content analysis approach (Mayring 2000) (RQ 1.1) (cf. section 3.2.1.1). The results gained this way (literature principles – "LP") provide the basis for an extensive focus group study (cf. section 3.2.2) for gathering and analysing practitioners' requirements and problematic areas and activities at the FEI (RQ 1.2, practitioner principles – "PP"). This enables deriving key principles for the FEI ("P") not only based on scientific literature (rigor) but also on key influencing factors in economic practice (relevance) (cf. section 3.2.2.6). Based on these principles, the requirements for process model design can be derived (process model design requirements, "DR"). In order to provide a basis for systematic literature review as well as for focus group study, an existing process model was selected as a starting point for the following elaborations (cf. section 3.1).

Besides literature and practitioner principles, general innovation process requirements ("I-PR", cf. section 1.1.2) and general FEI specific process requirements (FEI-PR, cf. section 3.1.3) are also part of process model foundations. Figure 16 summarises the above mentioned points and provides an overview of the key abbreviations introduced and used throughout the thesis.

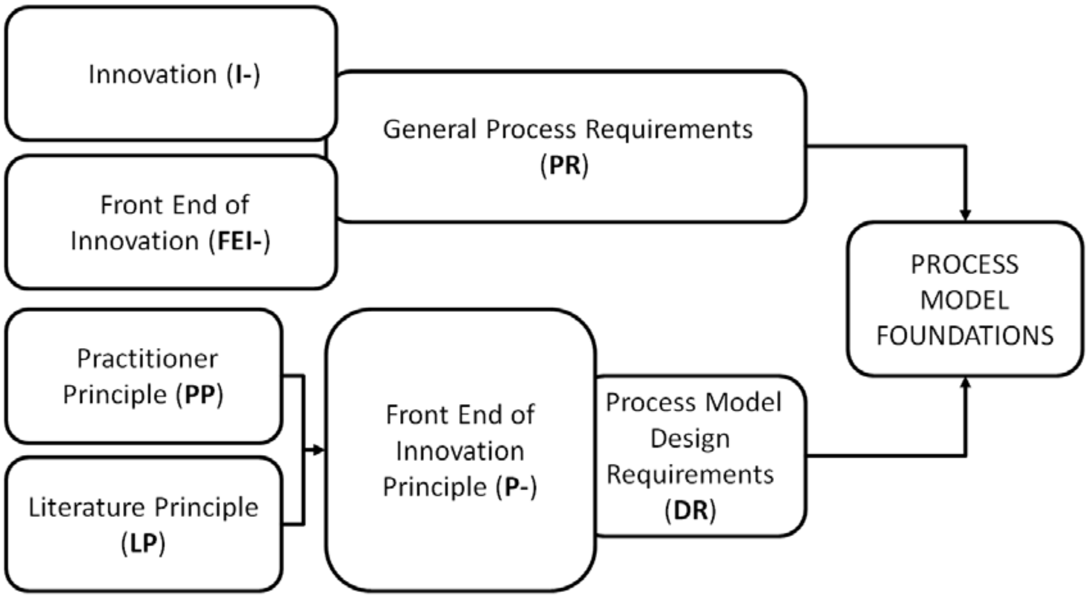


Figure 16: Key abbreviations used in the thesis

3.1 Basic FEI Process Model for Thesis

Selected from the multitude of available activity based and integrative innovation and FEI process models discussed in section 1.1.3.2, two of the more frequently cited, integrative approaches to the FEI are presented in more detail in the following sections.

3.1.1 The Three-Phase Front End Model by Khurana and Rosenthal

The three-phase-model by Khurana and Rosenthal (Khurana, Rosenthal 1998) has received big response in scientific literature (e.g. Reid, Brentani 2004; Kim, Wilemon 2002; Nobelius, Trygg 2002; Koen et al. 2001; Zhang, Doll 2001). This integrative FEI process models distinguishes between three stages and supporting foundational elements: pre-phase zero (ongoing) includes the identification of new opportunities and business ideas and aims at reaching a go or no go decision for concept development projects. In order to achieve this, the activities of pre-stage-zero have to be constantly matched up to organisational and product-strategy (Khurana, Rosenthal 1998). Based on the outcome of pre-phase zero, phase zero covers the composition of an innovation team responsible for collecting information about customer requirements as well as market and technological constraints in order to evaluate the concept's technological feasibility and economic viability. The actual evaluation of a concept's feasibility is part of phase one. Phase one represents the last stage of the FEI as defined by Khurana and Rosenthal, and ends with definite go or no go decision regarding the realisation of the concept. Figure 17 depicts this integrative FEI model.

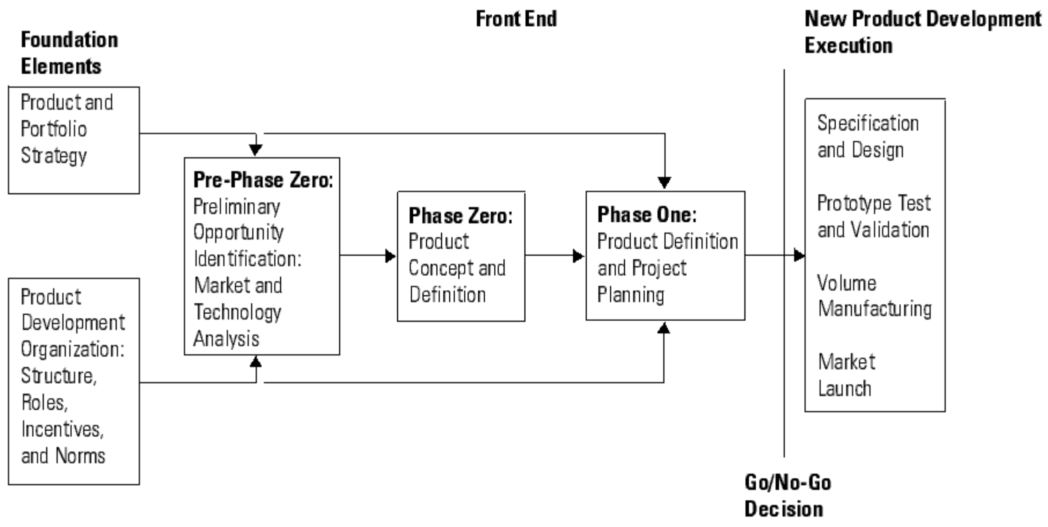


Figure 17: A stylised model of the Front End of NPD by Khurana and Rosenthal (1997, p. 105)

Despite the clear integrative elements of this model, it appears to follow a rather sequential order of activities and tasks and feedback loops are not explicitly stated.

3.1.2 The New Concept Development (NCD) Model by Koen et al.

The NCD-model by Koen et al. (Koen et al. 2001) was developed in the course of a large research project with participating organisations from various industries and has received big response in literature (e.g. in Gaubinger, Rabl 2014; Dewulf 2013; Brem 2008). The aim of this project was to develop a non-linear, integrative process model that is capable of providing a common language and clarity to the FEI. Building on the three-phase-FEI model developed by Khurana and Rosenthal (cf. section 3.1.1), the NCD model consists of several key activities, a central engine and so called influencing factors (cf. Figure 18).

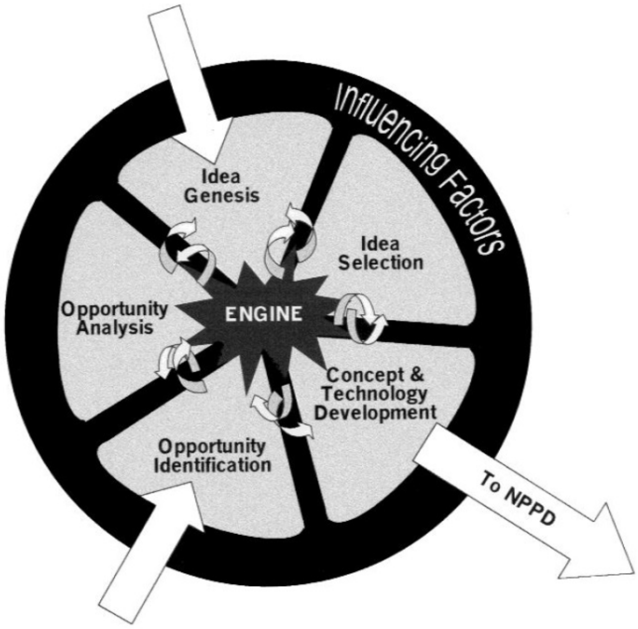


Figure 18: The new concept development model by Koen et al. (2001, p. 47)

The key activities are similar to those of Khurana and Rosenthal, and comprise opportunity identification, opportunity analysis, idea genesis, idea selection and concept development. Just like the three-phase FEI-model, the NCD model ends with developing and selecting a concept which can be forwarded to the actual NPD process. In contrast to the foundational FEI elements as provided by Khurana and Rosenthal, Koen et al. introduced a central FEI-engine and influencing FEI factors (Koen et al. 2001): the engine consists of organisational culture, leadership and strategic orientation of the company and summarises the foundational elements that are manageable by the organisation. In contrast, the influencing factors are influencers that are (mostly) beyond an organisation's control and include internal (e.g. skills of employees, technologies, capabilities) as well as external factors (e.g. customer needs, maturity of technologies) (Koen et al. 2001). Although or just because such influencing factors may not be as influenceable as the FEI-engine, they should constantly be monitored and incorporated in the innovation process. However, the NCD model does not propose further recommendations or measurements applicable by practitioners.

3.1.3 Comparison and contrast of FEI process models

Comparing the two FEI process models discussed above, the following strengths and shortcomings can be identified (cf. Table 8).

Table 8: Strengths and shortcomings of the NCD and the Three-Phase FEI model following Gaubinger, Rabl (2014) and Glassman (2010)

Model	***Strengths***	***Shortcomings***
NCD model by Koen et al. (2001)	First FEI model to distinguish between a controllable "FEI-engine" and more or less uncontrollable "influencing factors".	The model itself (as it is) is hardly transferable to an actual business situation.
	Flexible process model which explicitly allows feedback loops and various starting points.	Although influencing factors are introduced, there is no guidance provided for practitioners on how to deal with these.
		Unclear flow of activities
	The NCD model's circular structure provides a certain degree of formality and yet does not "kill" creativity by leaving enough room for flexible sequences of tasks.	Due to missing decision gates there is a confusion about when to eliminate or transfer ideas
		Practitioners criticise the applicability of the methodologies provided in the NCD model.
Three-phase FEI-model by Khurana and Rosenthal (1998)	Provides a good visualisation and structure of FEI elements.	Feedback loops are not explicitly stated
	Does not only address project related, but also cross-project factors (in the form of foundational FEI elements).	Opportunity identification and analysis is not described in further detail

	Also emphasises the importance of organisational culture and motivation of employees.	Mainly focusses on showing the influence of strategy on the FEI rather than providing guidance to it.
		Concrete measurements and recommendations for practitioners are missing

Based on the discussion above and on the findings of section 1.1, several key aspects of such models can be derived. In order to address the research question defined in this thesis, a process model for the FEI should include and take into account the following aspects:

- The FEI process is iterative in nature, rather than following a strictly sequential order of stages or tasks. The process model to be developed should be designed accordingly (FEI-PR1).
- Besides defined sets of key activities and tasks, a FEI process model framework should also point out several framework conditions respectively non-process or soft process factors by indicating e.g. organisation-, culture- and management related aspects or motivational and creativity supporting issues (FEI-PR2).
    - FEI process models should divide between process and non-process factors and should be designed in a way that a balance between overall flexibility and focus and direction is achieved.
- The definition of recurring key activities in form of a FEI process model should rather focus on solving highly unstructured problems or on addressing FEI process factors by a structured process than on prescribing an only true approach to these stages of the innovation process. A process based approach to the FEI should therefore focus on problem solving by structured means (FEI-PR3).
- Existing process models often fail to deliver specific, comprehensible sets of recommendations and measurements for practitioners. Such models are well suited for developing an understanding of the FEI elements rather than for serving as an actual guiding process model. The process model to be developed should be applicable in practice and should be perceived as useful by practitioners (FEI-PR4).

- Method based support for FEI activities is not part of existing FEI process models and target-oriented, systematic application of appropriate methods and approaches is not proposed in these models. A comprehensive FEI process model should also address this issue (FEI-PR5).
- Includes internal (e.g. skills of employees, technologies, capabilities) as well as external factors of influence (e.g. customer needs, maturity of technologies) (FEI-PR6).

These requirements are addressed accordingly in the course of the process model development.

3.1.4 The Process at the Front End of Innovation relevant for this thesis

Considering the research objective of this thesis, its focus on the strategically oriented parts of the FEI, the derived requirements for innovation process models (cf. section 1.1.2) and following from the above, an adaption of the New Concept Development model proposed by Koen et al. (2001) is used as a preliminary process framework for further elaborations. A key criterion for choosing this process model was its circular structure and the FEI engine which represents opportunities for action and the importance of high level management support as the main driving source at this stage of the innovation process. This clearly shows that the FEI can be structured and organised up to a certain degree. The circular structure of the model also implies that there is no strict sequential order of tasks as such strictness of form may have negative effects on creativity and performance. The introduction of “influencing factors” is in line with the research objectives of this thesis (cf. section 1.4) and allows for integrating manageable process as well as controllable and uncontrollable non-process factors.

Hence, this model is in accordance with the underlying design hypothesis of the current thesis, which states that the FEI can be formalised and controlled by an organisation, but only up to a certain degree. A comprehensive approach to structuring the FEI should therefore not only include process but also non process factors (Trotter 2011) and should effectively link business strategy, product strategy and product specific decisions. The current thesis emphasises the early, strategically oriented FEI elements of the NCD model (opportunity identification and opportunity analysis) as well as the transition to the later, operative and better established ideation process by defining recurring key activities and by providing corresponding methods and tools. Based on the findings of the literature review, the strategic parts of the FEI (opportunity identification and analysis, further referred to as “strategic FEI") are particularly relevant for all subsequent innovation activities and form the basis for the following stages of the FEI (idea generation, idea evaluation and selection and concept & technology development, further referred to as “operative FEI”) and the subsequent actual new product development process. The adapted NCD model is depicted below; the focus areas of the thesis are highlighted using a darker colour (cf. Figure 19).

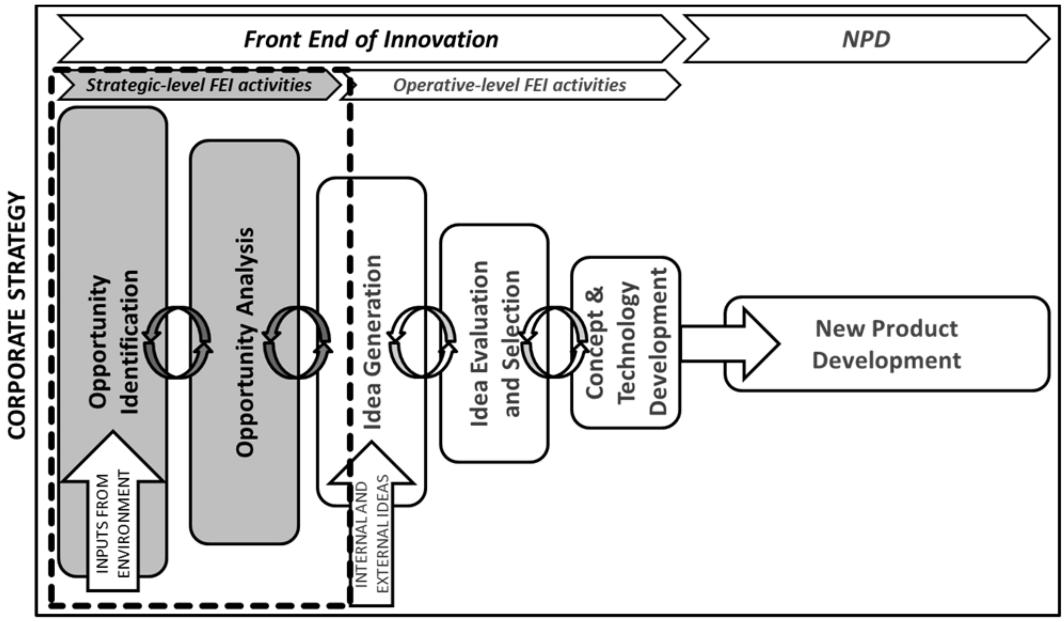


Figure 19: Focus of the thesis depicted based on the NCD model by Koen et al. (2001)

Initial opportunity identification hereby triggers the chain of activities at the FEI, which ends with transferring selected ideas in the form of first product concepts to the actual New Product Development process. Companies that are first to identify and contextualise emerging trends and issues are expected to be in a position to gain competitive advantages. The sooner a relevant development in the respective company environment is perceived and the better it is understood by an organisation, the faster and the more appropriate the response will be (Rohrbeck 2011; Liebl, Schwarz 2010; MacKay, McKiernan 2010; von der Gracht et al. 2010; Ruff 2006).

Applied to the popular and widely acknowledged stage gate model presented in section 1.1.2 (cf. Figure 8), the focus of the thesis is only partially on what Cooper calls “Front-end of process” in his NexGen model (Cooper 2008). As depicted in the following figure, the actual focus of the thesis is on the activities that precede Cooper’s Front-end of process (cf. Figure 20).

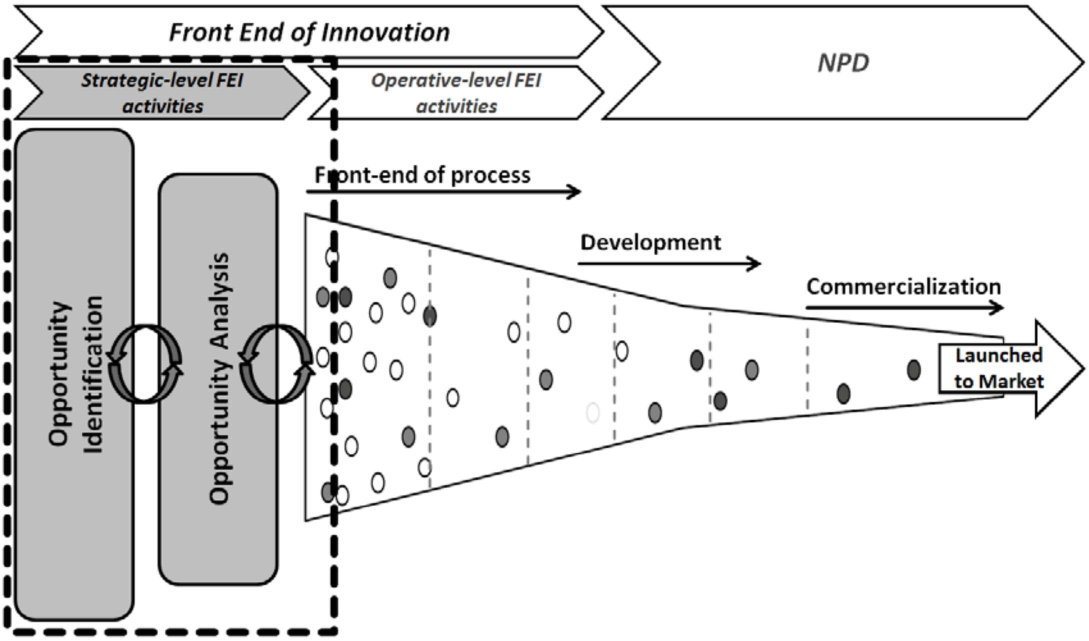


Figure 20: Focus of the Thesis Depicted Based on the Stage-Gate Model (Cooper, 2008) and the NCD model (Koen et al. 2001)

In contrast to the NCD and / or Cooper' stage-gate model, the process model to be developed in this thesis puts a special emphasis on practical applicability and aptitude of the single FEI key activities. It aims at providing clearly structured, comprehensible and transferable sets of process steps and activities for an organisational context (cf. section 1.4 and 1.5).

3.2 Principles at the Front End of Innovation

Chapter 3.2 addresses research question one and aims at deriving principles at the FEI as defined in scientific literature (structured literature review and qualitative content analysis, cf. section 3.2.1) and as observable in organisational practice (focus group study, cf. section 3.2.2). The chapter summarises with a list of principles at the FEI based on literature and practice, which serves as a basis for deriving design requirements for process model development.

3.2.1 Principles at the Front End of Innovation according to literature

In the following sections the methodological steps applied in the course of the literature review are explained (cf. section 3.2.1.1) and the results of the literature review are presented (cf. section 3.2.1.2).

3.2.1.1 Literature Review and Analysis Process

In order to obtain a sound scientific basis for deriving FEI principles an extensive, literature review is conducted in accordance with the systematic literature review process by Webster and Watson (Webster, Watson 2002). Literature reviews allow for developing a solid foundation and framework for subsequent research activities (vom Brocke et al. 2015). In the present context, the literature review provides the basis for capturing and analysing practitioner principles at the FEI in the course of focus group study. The literature review is conducted by searching for articles with the keyword combination “Front End” and “Innovation” in title or abstract. The following databases are used: Ebsco Host, Emerald Insight, Science Direct and ISI Web of Science. The search revealed a total of 800 results. Subsequently, a second selection criterion is defined and only journal articles are further selected. This revealed over 400 articles, of which 68 are considered relevant based on their abstract and are analysed in detail. Additional 31 articles are further considered relevant based on backward citations in the selected 68 articles. Hereby, also more relevant conference and other research papers are included. The following table provides an overview of the SLR-approach applied:

Table 9: SLR-approach applied in the thesis

Step	***Selection Criterion***	***Results***
1	Key-word based search in defined databases (Ebsco Host, Emerald Insight, Science Direct and ISI Web of Science).	> 800 results
2	Journal articles only.	> 400 results
3	Analysis of abstracts	68 results
4	Backward-citation	additional 31 results
Result:	99 articles in total were selected for in depth analysis of FEI principles.	

In order to identify the principles at the FEI, the selected literature is analysed regarding the critical success factors, constraints, suggestions and organisational requirements at the FEI (research object), following the step model of inductive category development proposed by Mayring (Mayring 2000). A list of the selected 99 articles and papers is provided in Appendix A.

In a first step, the literature identified and selected in the course of the literature review is analysed in detail regarding general FEI principles (selection criterion). Hereby, a comprehensive list of over 140 principles is derived (Table 51, Appendix C).

In a second step, categories of FEI principles are deduced tentatively using a step-by-step approach. After having worked through 50% of the collected material, the categories are revised and where necessary reduced respectively combined. The categories are checked in respect to their reliability as well. After the category revision, the remaining material is worked through, concluding with a final check of category reliability. This structured, step-by-step approach allows for a category definition as near to the selected material as possible (Mayring 2000) (cf. Figure 21).

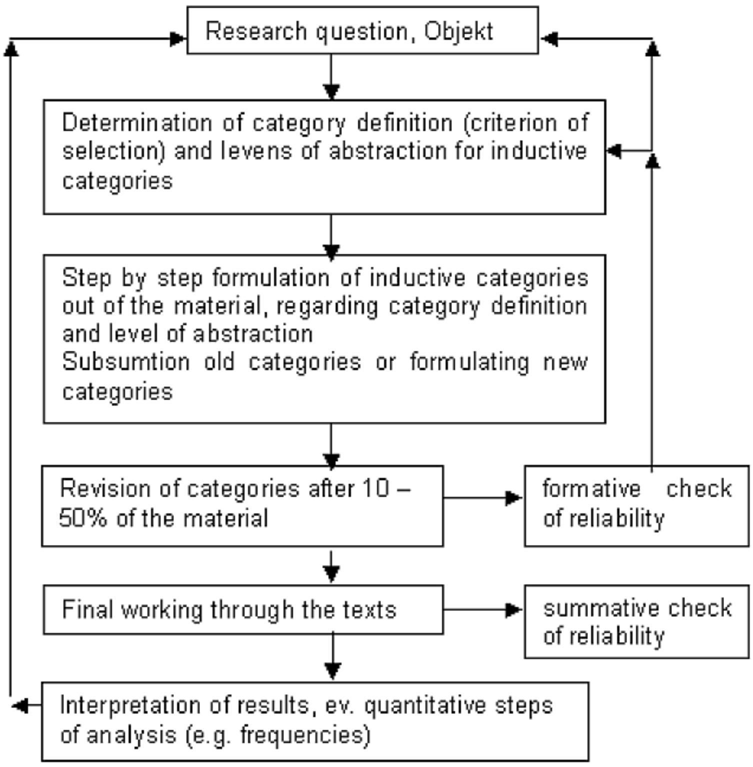


Figure 21: Step model of inductive category development by Mayring (2000)

To increase validity of the final results of the inductive category development process, the technique of peer-debriefing is applied (Morse et al. 2002; Onwuegbuzie, Leech 2007; Thomas, Magilvy 2011; Cooper et al. 1998). In conclusion, a list of 7 principles for the FEI according to selected high level scientific literature is generated and presented in the following section 3.2.1.2.

3.2.1.2 Results of the literature review

Following the step model of inductive category development by Mayring (2000) the following list of FEI principles according to literature is derived (cf. Table 10).

Table 10: Overview of derived FEI principles from literature

No.	***Description***	***Matched derived principles (cf. Appendix C)***
1	Systematic uncertainty reduction	LP1, LP11, LP12, LP13, LP14, LP17, LP18, LP19, LP20, LP22, LP23 LP32, LP37, LP41, LP44, LP48, LP49, LP56, LP60, LP61, LP68, LP70, LP81, LP85, LP86, LP90, LP91, LP95, LP97, LP99, LP101, LP105, LP108, LP110, LP112, LP113, LP114, LP124, LP128, LP129, LP136, LP137, LP142
2	Composition and management of roles and teams	LP3, LP24, LP38, LP39, LP45, LP46, LP47, LP58, LP63, LP65, LP69, LP71, LP72, LP74, LP76, LP77, LP78, LP79, LP91, LP92, LP96, LP100, LP103, LP106, LP107, LP109, LP115, LP116, LP118, LP125, LP126, LP132, LP134, LP141, LP143, LP144, LP146, LP147
3	Definition of an innovation strategy and strategic alignment of innovation processes and projects	LP8, LP9, LP21, LP25, LP27, LP28, LP29, LP30, LP35, LP36, LP42, LP48, LP54, LP55, LP57, LP64, LP69, LP87, LP88, LP90, LP93, LP101, LP104, LP111, LP119, LP120, LP123, LP128, LP135, LP138
4	Creation and fostering of an innovation-friendly, motivating culture	LP5, LP6, LP26, LP40, LP59, LP63, LP65, LP66, LP67, LP68, LP73, LP74, LP91, LP98, LP106, LP117, LP121, LP122, LP127, LP132, LP133, LP139, LP140, LP143, LP144, LP145
5	Systematic idea generation and enrichment	LP2, LP4, LP7, LP50, LP51, LP56,

		LP75, LP84, LP105, LP135
6	Systematic idea evaluation and selection	LP53, LP56, LP62, LP68, LP81, LP105
7	Systematic concept development and selection	LP10, LP15, LP16, LP31, LP33, LP34, LP43, LP52, LP56, LP68, LP80, LP81, LP82, LP83, LP89 LP102, LP105

In the next step this list of literature principles is matched with respectively evaluated based on the requirements and principles collected in the course of a comprehensive focus group study (cf. section 3.2.2). This represents the second ex-ante evaluation step (“EVAL 2”, cf. section 2.2.3.2) Thus, the final list of principles for the FEI is both literature based (rigor) and industry relevant (relevance) (cf. section 3.2.2.6). This allows for meeting the DSR requirement of design inherent evaluation (cf. section 2.2.3.1).

3.2.2 Analysis of practitioners’ requirements – focus group study

As important part of the current thesis, an extensive focus group study is conducted to identify and analyse practitioner’s requirements and constraints at the early stages of the innovation process. Firstly, the background of focus group studies and the methodology applied is presented (cf. section 3.2.2.1). Secondly, the results of each focus group study are discussed (cf. sections 3.2.2.2 to 3.2.2.4), and finally a summary of results is provided (cf. section 3.2.2.5) and FEI principles in organisational practice are derived (cf. section 3.2.2.6).

3.2.2.1 Focus groups as a research method

Focus groups have long been applied in market and medical research and offer great potential for qualitative research in general (Brandtner et al. 2015a). The term focus group indicates that this method aims to study a clearly defined area or set of issues (focus) in the context of a group discussion (Stewart et al. 2007). The direct interaction between the group members is the main source to collect information in focus groups which would have been less accessible in simple one-to-one interviews (Morgan 1998). Encouraged by a moderator, a small group of people shares ideas and thoughts on open ended predefined questions. The questions are hereby meant to feel spontaneous, but must be clearly defined in the so called “questioning route” (Krueger, Casey 2009; Puchta, Potter 1999).

A typical focus group, as defined in literature consists of three to twelve participants, depending on the source of literature (Tracy 2013; Krueger, Casey 2009; Sim 1998). When complex issues or problems are the focus of the study, smaller groups are advised and the size of the focus group should not exceed seven participants (Krueger, Casey 2009). Morgan (1998) considers focus groups particularly useful for

- orienting within a new field of study,
- generating hypotheses based on informants' insights,
- evaluating different research sites or study populations,
- developing interview schedules and questionnaires, and for
- getting participants' interpretations of results from earlier studies.

Additionally, focus groups offer a more economical way of collecting multiple views at one time (Krueger, Casey 2009), provide information on the dynamics of opinions and attitudes by observing group interaction (Morgan 1998), encourage spontaneity, offer a safe forum for expressing opinions, as participants do not feel obliged to answer every question (Vaughn et al. 1996), and support a feeling of belonging to a group (Peters 1993). In a design science context, focus groups offer great opportunities. For the refinement of an artefact, design focus groups can be applied to study the artefact to propose improvements. Once the artefact is released for field tests in the application domain, focus groups can be applied to establish its utility (Tremblay et al. 2010).

According to Tremblay et al. (2010) there are several key reasons why focus groups are an appropriate technique for design science studies: Allowing for an open format, focus groups are flexible enough to be applied in a wide range of design topics and domains. By putting the researcher into direct contact with potential users of the artefact and with domain experts, focus groups support clarifying artefact design questions and probing respondents on key design issues. The high level of interaction during a focus group study allows for deeper understanding on respondents' reactions, on the use of the artefact and on other issues in the respective environment influencing design. Furthermore, the high degree of interaction also fosters the emergence of ideas or opinions that would not have emerged in traditional, individual interviews (Brandtner et al. 2015a; Tremblay et al. 2010).

An acknowledged procedure for applying focus groups in a design science context was proposed by Tremblay et al. (2010). Building on traditional elements of focus groups, Tremblay et al. (2010) derived eight procedural steps on how to plan and conduct focus groups in a design science context. Figure 22 visualises the sequence of those steps. Subsequently, the content of each step is explained and further enriched with additional literature in more detail in sections 3.2.2.1.1 to 3.2.2.1.8.

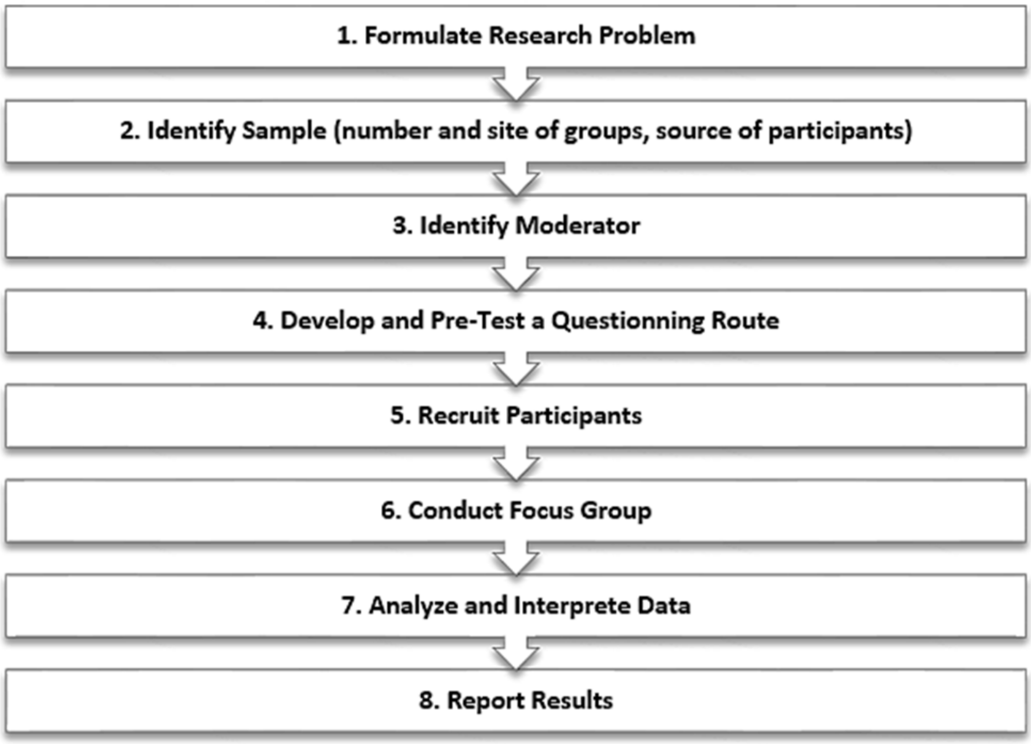


Figure 22: Focus Group Steps by Tremblay et al. (2010)

3.2.2.1.1 Research Problem: Process Model for the FEI

In accordance with the focus group procedure by Tremblay et al. (2010), the research problem and the objective of the focus group study are defined. As design science artefact for analysis the development of a process model for the early stages of innovation was selected (cf. section 1.4). An initial rough draft of a process model was developed based on literature and particularly on the New Concept Development Model proposed by Koen et al. (2001) (cf. section 3.1.2 and 3.1.4). Figure 23 provides an overview of the FEI process stages and exemplary descriptions of possible key activities covered by the process model. The process stages are taken as the structural frame for the questioning route (cf. section 3.2.2.1.4). In order to reduce possible bias, the exemplary descriptions are not presented to participants.

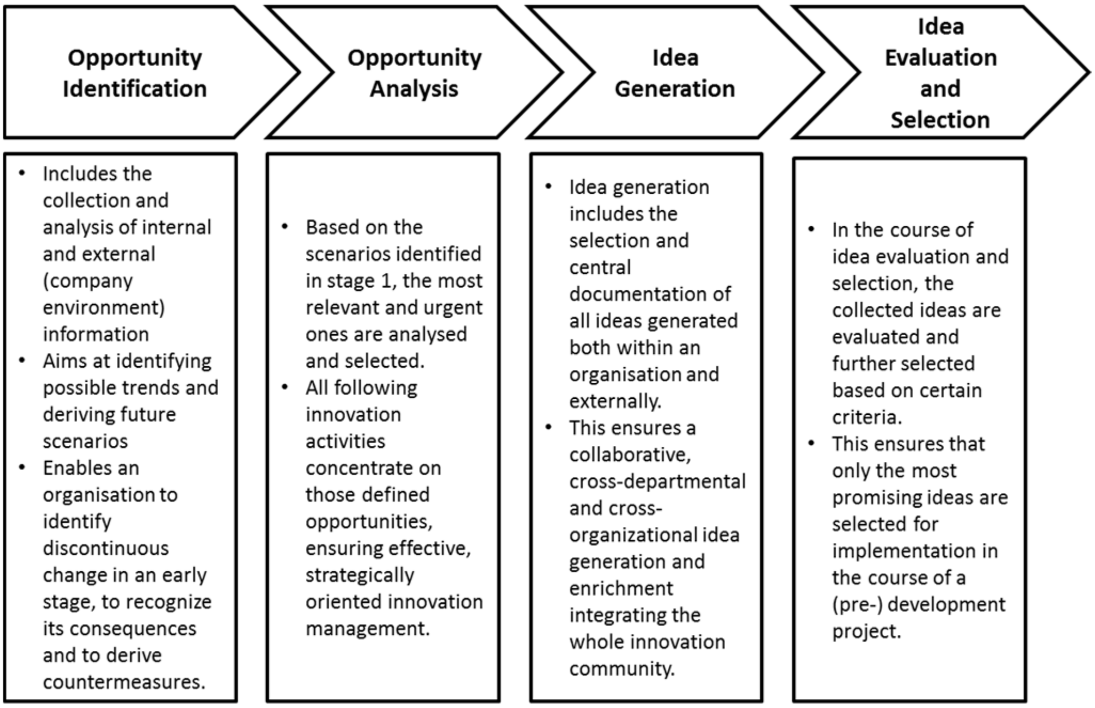


Figure 23: Initial rough draft of process model for focus group study

The objective of conducting the focus group study was to improve the knowledge required to design the artefact by collecting data on current processes, activities, challenges and critical success factors at the FEI in selected organisations participating in the project InnoStrategy 2.0 (cf. section 1.3). Hence, the main goal of the focus group study was to enrich and improve the theoretical knowledge with insights and knowledge from business practice. Additionally, the results obtained in such manner also contribute to the underlying knowledge base. For the current thesis, this means that the main objective of and the reason for conducting the focus group study was to create the basis for deriving a theory based but also practically relevant process model addressing the early stages of the innovation process, as well as to collect critical success factors, challenges and experiences in this context from practitioners. In this respect, a pre-test is conducted (one pilot focus group with selected participants from each of the partner organisations) followed by three explanatory focus groups (one per organisation) and one confirmatory focus group. The final confirmatory focus group allows for validating the artefact adaptions, which were made based on the results of the explanatory focus groups (Brandtner et al. 2015a). Conducting a pre-test focus group is recommended in relevant literature (e.g. Israni et al. 2009; Gibson, Arnott 2007; Birkett et al. 2004) and provides a setting for testing and evaluating the questioning route as well as the setting of the focus group. Explanatory and the final confirmatory focus group(s) support artefact refinement, allowing us to analyse the selected research problem and assess the artefact under investigation from a practitioner's point of view.

3.2.2.1.2 Identify Sample

The sample and the participants of the focus group should be chosen in accordance with the research problem and the objectives defined in step 1. According to literature, a focus group study should be continued until no new insights and knowledge can be collected (Ivanoff, Hultberg 2006). Tremblay et al. (2010) suggest conducting one pilot focus group and at least two explanatory focus groups. In this context, the pilot focus group study is used to understand timing issues and deficiencies of the questioning route. The ideal number of participants depends on the objective of the focus group study: smaller groups require each participant to be more active while larger groups may lead to social loafing (Morgan 1998). According to Tremblay et al. (2010) larger focus groups exceeding six participants may be tricky to apply in a design science project since the subject matter in such projects is more complex than topics of traditional focus groups.

As the application domain of the artefact is rather complex in its nature, participants, who are one the one hand familiar with the topic of innovation management but on the other hand are from different divisions of the respective partner organisation, are selected. By that, it is assured that participants know what they are talking about, but still have different points of views on the artefact under investigation (Brandtner et al. 2015a). In accordance with Tremblay et al. (2010), a sample size of 4 participants for the pilot and for each explanatory focus group was defined. Participants were informed about the project previously to focus group conduction. Participation was on a voluntary and not on a reward basis. Table 11 provides an overview of the background and number of the selected focus group participants:

Table 11: Sample of the focus group study

Type of focus group (FG)	***Partici-pants (FGP)***	***Back-ground FGP1***	***Back-ground FGP2***	***Back-ground FGP3***	***Back-ground FGP4***
Pilot FG (partici-pants from all 3 organisations)	4	R&D	Innovation Manager	Innovation Manager	R&D

Explanatory FG organisation 1	4	Innovation Manager	R&D	Business Develop-ment	R&D
Explanatory FG organisation 2	4	Product Manager	Project Manager	R&D	Innovation Manager
Explanatory FG organisation 3	4	Product Lifecycle Manage-ment	Marketing	Innovation Manager	R&D

Additionally, a short information presentation was provided prior to the study all participants in order to inform them about the subject and objectives of the focus group study (Brandtner et al. 2015a).

3.2.2.1.3 Identify Moderator

Identifying an appropriate moderator is a critical factor for successfully conducting a focus group study (Tracy 2013; Gibson, Arnott 2007; Hollander 2004). The moderator should be chosen in regard to skills and personality. Several points have to be taken into consideration in regard to the moderator's personality: their ability to listen, a respectful tone, communication skills, open mindedness, a friendly character and a sense of humour and last but not least the ability to involve and motivate the participants to contribute and actively take part in the focus group (Krueger, Casey 2009).

Compared to traditional focus group topics, design science project artefacts are often more complex in nature. In this context, the moderator should be able to focus on communication and interpersonal skills only. Providing a second observer who takes notes during the focus group and acts as a time coordinator is advisable. This does not only represent a major simplification for the moderator, but also facilitates the final result analysis (Tremblay et al. 2010; Bradley et al. 2002).

As the role of the moderator plays a key role for the success of focus groups, an experienced practitioner with background in innovation management and the required personal and communication skills was selected. Besides the moderator, a second observer (i.e. the author) took notes during the focus group to facilitate the final result analysis and to provide the moderator with the possibility to focus on communication and interpersonal attributes (Brandtner et al. 2015a).

3.2.2.1.4 Develop and Pre-Test Questioning Route

In a design science project, artefact evaluation and improvement is a core element. When conducting focus groups in such a context, the questioning route should at least be pre-tested once before applying it in the actual focus group. Tremblay et al. (2010) suggest testing the questioning route in the course of a pilot case study. Additionally, literature suggests using a rolling interview guide in explanatory focus groups to further develop and improve the aptitude of the questioning route by collecting and implementing feedback in each conducted focus group. Thereby, the questioning route can be adapted based on the learnings and experiences of the preceding focus group by e.g. revising, removing or adding certain questions or by changing the question order (Stewart et al. 2007; Dworkin et al. 2003). When conducting focus groups with the objective to confirm a developed artefact, a rolling interview guide must not be used as this would distort the results (Tremblay et al. 2010).

The questioning route itself should allow flexible ways of communication but yet provide a clear framework and structure for the moderator. Questions should be open ended and not suggestive, the moderator should be supported in only asking questions and should not need to indicate possible answers as this would bias participants. In the present case, a questioning route with the character of a rolling interview guide was developed. The questioning route consists of 6 question areas for each of the four process stages at the FEI as defined in section 3.2.2.1.1. To provide a high degree of flexibility, the question areas were developed independently from each other, so that various ways of answering the questions and spontaneous inputs and changes were possible. These six main question areas were developed based on the initial rough draft of the process model (cf. Figure 23, cf. section 3.1.4) and on the findings of sections 1.1 and 3.2.1.2. The areas defined relevant for each stage at the FEI were as follows (Brandtner et al. 2015a):

- **Scope**: How is the respective stage at the FEI influenced by other organisation elements (i.e. structures, regulations, strategy, visions, etc.) and vice versa?
- **Goals**: What are the goals (e.g. success indicators or organisation goals) defined for the respective stage?

- **Critical success factors and challenges**: What is considered a critical success factor for and what are the biggest challenges in the context of the respective stage?
- **Process**: Which steps are planned, taken and systematically followed in the respective stage?
- **Methods and tools**: which methods and tools are applied to support activities in the respective stage at the FEI?
- **In/outputs**: which inputs are collected and transformed to which outputs in the respective stage at the FEI?

These six main question areas were dealt with in each of the four stages of the relevant innovation process; the respective sub questions are adapted accordingly. Figure 24 depicts the structure of the interview guide, which is applied in the course of the pilot focus group and the three explanatory focus groups:

	Stages at the Front End of Innovation			
Main Question Area	Opportunity Identification	Opportunity Analysis	Idea Generation	Idea Evaluation
Scope	Influence of Vision / Mission	Scope	Scope	Scope
	Effects on Vision / Mission			
	Link to strategy			
Goals	Main reasons	Main reasons	Main reasons	Main reasons
	Aims	Aims	Aims	Aims
	Success Criteria	Success Criteria	Success Criteria	Success Criteria
CSFs & Challenges	Challenges	Challenges	Challenges	Challenges
	Critical Success Factors	Critical Success Factors	Critical Success Factors	Critical Success Factors
	Results	Results	Results	Results
Process	Initiation	Selection Criteria	Initiation	Selection Criteria
	Process	Process	Process	Process
	Roles	Decision Makers	Integration of Strategy	Decision Makers
Methods & Tools	Methods & Tools	Methods & Tools	Methods & Tools	Methods & Tools
	Integration of External Environment	Decision Support Techniques	Creativity Support Techniques	Decision Support Techniques
	Method Selection	Method Selection	Method Selection	Method Selection
In- & Outputs	Inputs	Inputs	Inputs	Inputs
	Outputs	Outputs	Outputs	Outputs
	Experiences of Method Application	Experiences of Method Application	Experiences of Method Application	Experiences of Method Application

Figure 24: Structural setup of the developed interview guide

The pre-test of this questioning route is conducted in the course of a focus group with participants from each of the partner organisations with the aim of improving the questioning route itself, addressing requirements and meeting expectations of the partner organisations. The participants involved in this pre-test are all R&D or innovation managers, enabling them to give detailed feedback (Brandtner et al. 2015a).

3.2.2.1.5 Recruit Participants in Partner Organisations

Participant recruitment is a critical success factor and a key element for focus groups. As the subject matter is usually rather complex in design science projects, participants should be familiar with the topic of the focus group. Nevertheless, the heterogeneity of the group could lead to new insights as things are not taken for granted and are discussed more deeply (Tracy 2013; Stewart et al. 2007; Bloor 2001). In the present context, the ideal focus group sample in a design science context consists of 4 to 6 participants.

The recruitment of participants is done directly through the contact partners in the partner organisations. Because of the experiences gained in the course of the pilot focus group, the selection of the right participants for the explanatory focus group is simplified. Together with the innovation and R&D managers who take part in the pre-test, the participants are selected and recruitment is done directly by their managers. An efficient and effective recruitment process can be achieved, allowing us to select and recruit participants who are familiar with the application environment of the artefact (innovation management) and yet have different backgrounds, e.g. from a different division or company location (Brandtner et al. 2015a).

3.2.2.1.6 Conduct Focus Groups

The sixth step is to conduct the focus group according to the defined setting and the developed questioning route. During the focus group, experience regarding the aptitude of the setting and the questioning route can be gained and transferred into subsequent focus groups for improvements. In order to make results traceable literature suggests using audio or video recording for documentation and evaluation purposes (Kidd, Parshall 2000; Sim 1998). The setup of the technical equipment needed in order to do so, should be tested beforehand (Gibson, Arnott 2007). Additionally, the moderator should provide some general information on the objectives of the focus group, the general rules and the timeline in the course of a short introductory presentation (Tracy 2013; Berg 2001).

In the present case, the focus group is conducted in the "Research and Transfer Centre Front End of Innovation" (Gaubinger et al. 2013; Perteneder et al. 2013), which provides a system of connected, interactive whiteboards as well as digital paper for further notes taking. This setting allows the moderator and the participants to take "digital notes" and reduces the time needed to digitise results. At the beginning, a short introductory phase is held, including a presentation about the artefact and the relevant topic, as well as an introductory round and a briefing on how to work with the interactive set of whiteboards and the digital paper (Brandtner et al. 2015a). The whole focus group is also filmed in order to make results traceable.

3.2.2.1.7 Analyse and Interpret Data

After having conducted a focus group, results need to be analysed and interpreted. Thereby, the scheme used to analyse the collected data should produce the same or similar results independent from the researcher conducting the analysis (Krueger, Casey 2009). Depending on the research objective and the confidentiality of the artefact, an appropriate scheme has to be chosen. In practice, there are various different approaches to analyse qualitative data (Green, Thorogood 2004). In the course of the current project, the framework analysis developed by Krueger and Casey (2009), which suggests a continuum of analysis ranging from the accumulation of raw data to deduction of descriptive statements and the interpretation of data, is applied. The analysis scheme is structured in accordance with the interview guide, allowing for a systematic and objective representation of results. Figure 25 provides an overview of the data gathered and its further processing:

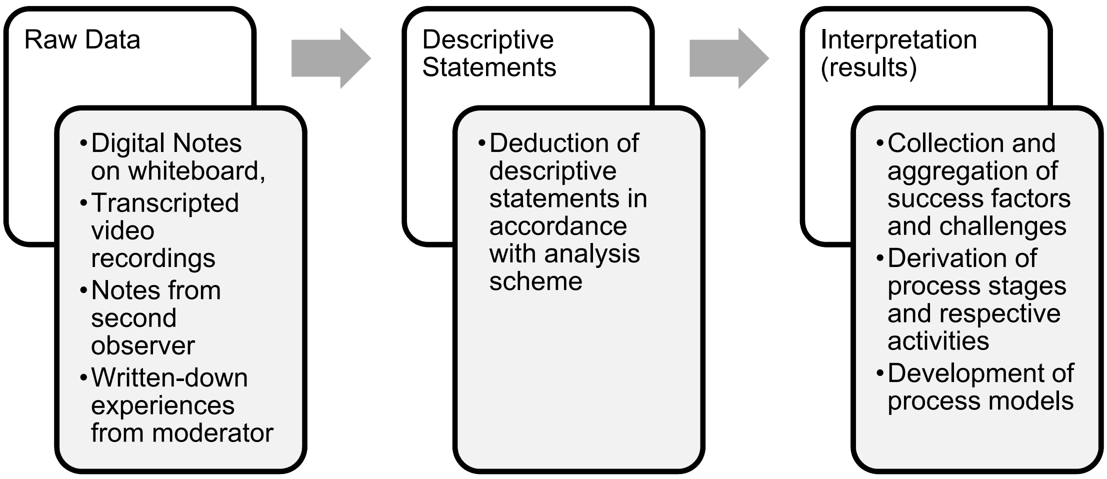


Figure 25: Data Analysis and Interpretation (Brandtner et al. 2015a)

In a first step, the video recordings are transcribed. In a second step, the transcripts of the second observer's protocol, the notes from the interactive whiteboards, the digital paper notes and the written-down experiences of the moderator are combined and collated. Subsequently, descriptive statements are derived based on the collected and aggregated raw data. Those statements are summarised in tables using the predefined scheme provided by the interview guide.

The last step is the development of the final results (data interpretation), which include the result tables and the processes observable in the respective organisation. The process visualisation is done in accordance with the widespread process modelling technique of Event-Driven Process Chains (EPC) (cf. section 4.2).

3.2.2.1.8 Report Results to Partner Organisations

According to the design science build-evaluate cycles, focus group results should be reported and evaluated thoroughly. The conduction of a final confirmatory focus group is advisable after the explanatory focus groups are done and the results gained in the course of these are aggregated and ready to be confirmed and evaluated. In the present case, this is done in the course of a group discussion similar to a confirmatory focus group. For each organisation, results are collected and presented to the innovation manager and the development manager or the head of R&D to evaluate the results and validate respectively revise them should it be necessary. This additional feedback loop provides the possibility for further enhancing findings on the one hand and on the other hand ensures the correctness of the results gained and the artefact adaptions incorporated.

In the following sections 3.2.2.2; 3.2.2.3 and 3.2.2.4 the individual focus group reports for the three selected organisations are described based on the results of the conducted studies. For each organisation, a general introduction to the organisation and the respective organisational embedment of innovation management is provided, followed by a result section for each of the six areas of the data collection and analysis protocol (cf. Figure 24). Subsequently, results are summarised in section 3.2.2.5 and practitioner FEI principles are presented in section 3.2.2.6.

3.2.2.2 Results of Focus Group Study Organisation 1 (FG1)

Organisation 1 is one of the biggest producers of concrete formwork worldwide and focusses on the development, sale and application of modern formwork and framing systems. With its headquarters in Austria, Organisation 1 aims at becoming the global market leader for formwork systems by consistently increasing its innovation capabilities. Continuous improvement of research and development related structures, tasks and activities as well as the establishment of a separate research department in addition to the classical R&D department are visible signs of this undertaking. Organisation 1 cooperates intensively with various universities, universities of applied sciences and other expert groups. The high degree of innovation management related activities and the dynamics of its R&D projects indicates the immense importance of R&D and innovation management for organisation 1. It has been awarded with several innovation and product management awards and can be considered an innovative and progressive organisation. That was another the reason why this organisation was approached in the course of the current research project.

3.2.2.2.1 Scope for FG1

Opportunity identification and opportunity analysis is conducted within the framework of the corporate strategy, which is defined in cycles of five years by the executive board. If necessary, the corporate strategy can be adapted - only up to a limited degree, once per year. In practice, it is only relatively seldom that adaptions to the corporate strategy are made. The overall focus provided by the strategy is that on formwork systems in six main fields, although other branches are considered relevant for e.g. cross-industry innovations. These main fields are 80% permanent, adaptions or additions are only possible in exceptional circumstances. All in all, the corporate strategy has a strong market orientation and does not provide more specific innovation management related sections or guidelines except the stated objective of pursuing and reaching technology leadership.

3.2.2.2.2 Goals for FG1

Except the goals of becoming a leader in innovation and of meeting customer requirements, there are no specific goals or key performance indicators provided for opportunity identification and analysis. In the context of idea generation, the organisation expects 1-2 suggestions per employee and per year in the course of the continuous improvement process; there are no goals, indicators or quantitative objectives defined for the actual generation of innovation management related ideas. Monetary incentives are given for the continuous improvement ideas and non-monetary rewards are granted for innovation ideas once they prove successful. A future development goal is the consolidation of information and data of different departments in the form of a common idea hub. Innovation controlling is done based on two key performance indicators: turnover generated by products younger than five years and the amount of new products introduced to market in the respective year.

3.2.2.2.3 Critical Success Factors and Challenges for FG1

The biggest challenges regarding the identification and analysis of opportunities in the organisational environment are a high degree of complexity, different maturity levels of global markets, varying traditions and technological standards in the national building industries and an enormous price and cost pressure. In this context, it is difficult to define what degree of customisation and complexity to allow and where to draw the line between national and global requirements and market specifications. The identification and evaluation of trends and their impact on organisational practice is a challenging task and urgent projects are often pursued in favour of more relevant ones (urgency vs. relevance). Critical success factors in this context are the organisation’s employees and their personal networks, regional product managers as connecting links between central and regional departments, up-to-date market data, commitment to and consistency of decisions and monitoring of patent databases and laws. Furthermore, observation of competing organisations, the integration of external experts, the coherency of information and knowledge flows and the integration of key customers is regarded as critical to success and offers high potential for improvement.

3.2.2.2.4 Process for FG1

Opportunity identification and analysis is usually triggered by Product Lifecycle Management, the R&D department and by the executive board. Additionally, employees – acting as scouts – are encouraged to address and monitor certain topics in their respective networks. Trends are captured trough networks and contact partners (customers, suppliers, etc.). As there are no organisational guidelines or frameworks, this is mainly done out of individual motivation and varies from case to case. Captured opportunities are evaluated based on their strategic relevance, required resources and capacities to pursue them and their potential contribution to total turnover. Opportunity analysis is done per product group based on defined sets of criteria. All in all, opportunity identification is done in an unsystematic way, arises out of particular occasions, strongly depends on individual employees and varies from department to department (there is no common information or knowledge sharing institutionalised). Although opportunity analysis builds on defined sets of criteria, there is no defined analysis process and the approach to opportunity analysis varies between product groups, departments and levels of hierarchy. Furthermore, there is no defined link between opportunity identification and analysis and idea generation. Idea generation happens largely unstructured and strongly depends on individual employees, their intrinsic motivation and their ability to identify problems and opportunities. The concrete results of depicting the FEI process of organisations one can be found in Appendix G.

3.2.2.2.5 Methods and Tools for FG1

Depending on particular occasions and requirements, methods and tools for identifying and analysing opportunities are applied in Organisation 1. There is no structured, systematic or planned approach on method selection and application provided by the organisation (this is mainly done based on particular circumstances and requirements and varies between departments, groups and individual employees). The following CF methods were applied once or only irregularly: customer workshops, trend radar, future workshops and R&D world cafes. Depending on the respective departments and the individual employees, monitoring of market and technological environment is done by intrinsically motivated scouting, patent monitoring, expert questioning and construction site analysis. In the context of idea generation, Organisation 1 developed and provides a commonly shared handbook of the most important creativity methods, which are mainly applied for solving very specific problems rather than for supporting the idea generation process. Furthermore, idea generation is supported by an IT-based software platform allowing for capturing, collecting and evaluating ideas from different departments.

3.2.2.2.6 In- and Outputs for FG1

The most important inputs for opportunity identification are patents, trends, legal restrictions, customer requirements and information from conferences and trade fairs. There is no structured approach defined for input collection and output generation, an innovation search strategy is not provided. Organisation 1 is aware of the importance of a structured and systematic approach to input collection and output generation and wishes to implement such in the future (e.g. in the form of systematic trend scouting or a defined innovation search strategy). Idea generation relies on inputs (ideas) from employees and suppliers; there are no specific innovation challenges or structured idea capturing processes defined.

3.2.2.3 Results of Focus Group Study Organisation 2 (FG2)

Organisation 2 is acknowledged today as a technology leader in its three main areas of business. The product spectrum ranges from developing and producing charging devices and solar electronics to the development, production and application of modern welding systems. With its headquarters in Austria, Organisation 2 is pursuing a sustainable growth strategy mainly based on equity financing. With more than 3000 employees, Organisation 2 considers R&D a core part of its daily business. Around 10% of its employees are directly involved in R&D related activities and between 7 to 12% of its total turnover are invested in the R&D department. A direct indicator of the importance of R&D and innovation management for Organisation 2 is the fact, that in 2011 nearly half of total turnover was generated by innovative products younger than three years. Organisation 2 has been awarded for its innovation activities several times and pursues a strategy of close collaboration with academia and industry.

3.2.2.3.1 Scope for FG2

With implicitly derivable topics and trend areas, the corporate strategy contains only limited specifications for innovation management related search activities. A feedback loop from opportunity identification to the corporate strategy level does not exist, findings obtained in the course of opportunity identification and analysis are not systematically included in the corporate strategy development process. However, employees are provided with the option to present innovative ideas or visions to their supervisors and if applicable to the executive board (so called bottom-up initiatives). Even though the corporate strategy does not provide clearly defined topic and trend areas for opportunity identification, it contains specific targets as regards opportunity analysis. This shall ensure that resources are not wasted for possibly irrelevant opportunities and ideas. Over the years, the success pattern of integrating cross-industry technologies and developments into the innovation process has emerged in Organisation 2. Overall, the corporate strategy was found to provide a clear technological focus but only implicitly derivable search fields for idea generation.

3.2.2.3.2 Goals for FG2

Opportunity identification and monitoring of corporate environment was found to be of essential importance for Organisation 2. First of all, opportunity identification is seen as an appropriate approach to identify developments and threats emerging in the corporate environment. In order to be able to react promptly to changing requirements and conditions, the identification and evaluation of influential factors as well as the understanding of their interconnectedness is crucial. Although Organisation 2 is aware of this, there are no specific goals or target measures defined for opportunity identification and analysis, and a structured approach to these activities is missing. The same applies to idea generation: the executive management does not provide quantitative or qualitative goals for this stage of the innovation process. As Organisation 2 emphasises the importance of intrinsic motivation, there are no extrinsic rewards granted for ideas and quantitative objectives are seen as counter-productive.

3.2.2.3.3 Critical Success Factors and Challenges for FG2

The most challenging aspect of opportunity identification and analysis is to identify just these factors of influence, which are in fact relevant for Organisation 2. While the identification of a large mass of factors was found to be relatively simple, it is the analysis and evaluation of relevant factors that poses the biggest problem. In this context, the integration of experts and customers in the course of e.g. future workshops was mentioned as a crucial success factor. However, this is not done systematically or regularly. The employees of Organisation 2, who act as scouts or "innovation sensors" in the corporate environment, are another success critical factor. Scouting is done structured and planned by assigned factors of influence which have to be monitored, as well as unstructured and intrinsically motivated. The integration of results and findings obtained in the course of scouting and monitoring activities into corporate strategy formulation was mentioned as a possible quick-win and as desired change of organisational practice. The most aggravated problem for opportunity identification and analyses was found to be the strictly defined technological focus of the corporate strategy. This could lead to the ignorance of other but potentially relevant technologies and markets, resulting in the danger of substitution. Another challenge in this context is the fact, that opportunity analysis as well as idea selection takes place in the field of tension between strategic relevance and operational urgency.

3.2.2.3.4 Process for FG2

There is no structured and systematic process or approach to opportunity identification in Organisation 2. The respective monitoring and scouting activities are mainly defined and conducted on an individual level (varying from employee to employee). Almost the same is true for opportunity analysis: although there are some employees assigned who monitor defined factors of influence, the majority of opportunity analysis activities are done based on intrinsic motivation rather than on defined guidelines or strategic specifications. In contrast, the idea generation and selection process was found to be well structured with defined roles, responsibilities and decision gates. Depending on the nature and scope of the idea, it is either forwarded to divisional committees or to the board of management. The concrete results of depicting the FEI process of organisations two can be found in Appendix H.

3.2.2.3.5 Methods and Tools for FG2

A structured application of methods or tools on a regular basis does not exist in Organisation 2. Rather, methods and tools are selected and applied based on particular requirements and for specific cases only. The following methods and tools have been applied at least once: technology radar, patent monitoring, expert networking, urgent reporting and internal topic related conferences. On a more regular basis, internal scouts are monitoring assigned factors of influence based on a given set of criteria and trade fairs are visited more or less regularly. All in all, method and tool application mostly depends on the individual employee; Organisation 2 does not apply methods or tools for supporting opportunity identification and analysis on a structured or regular basis. In contrast, there are several methods and tools used for supporting idea generation, ranging from idea profiles and providing informal meeting and communication points to an IT system based idea hub.

3.2.2.3.6 In- and Outputs FG2

The most important inputs are provided by the internal employees who act as scouts in the corporate environment. This includes the collection of feedback from customers, information from trade fairs, patent news, technological developments and legal regulations. However, an innovation search strategy providing guidelines on how to collect which inputs and how to create which outputs is not defined by Organisation 2. Opportunity analysis is mainly done based on experience of senior employees and supervisors. This is sometimes found to give the impression of only listening to signals which are welcome and ignoring others, but nevertheless potentially relevant ones. Positive signals are analysed and evaluated, negative input is put aside and often forgotten. The desired output of opportunity analysis is to create the basis for idea generation. In this context, customers are seen as an important input source by providing problem descriptions or product requirements.

3.2.2.4 Results of Focus Group Study Organisation 3 (FG3)

With more than 1300 employees and a turnover of around 280 million euro, Organisation 3 is the largest producer of agricultural machinery in Austria. Organisation 3 has set itself the goal to facilitate agricultural production by developing, producing and distributing innovative machinery and equipment in the areas of hay and forage harvesting and seed preparation and placement. The product spectrum ranges from mowers, silage trailers and round balers to ploughs, cultivators and sowing machines. The overall goal for each of its product groups is to become market and technology leader in the respective product segment. R&D and innovation management related resources and capacities have been steadily increased over the last years. A structured approach to the early stages of innovation represents an important success factor for Organisation 3. Intense collaboration with academia and external partners is a visible sign for the relevance of open innovation in Organisation 3, which has been awarded for its innovation management activities several times.

3.2.2.4.1 Scope for FG3

There is no process-driven, formalised connection between the vision and mission statement of Organisation 3 and opportunity identification and analysis. An innovation management strategy is not provided, but was clearly stated as a requested future change. Almost the same applies to the connection to corporate strategy: the only feedback loop between strategy and opportunity identification is the head of R&D, who could theoretically influence corporate strategy formulation through the extended management board. Furthermore, there is no connection between opportunity identification and selection and the ideation process. The findings obtained in the course of monitoring and analyses activities are not transferred to idea generation. Additionally, there is no possibility that ideas influence corporate strategy development, although this was stated as a required future change.

3.2.2.4.2 Goals for FG3

The main reason for conducting opportunity identification and analysis is to be able to monitor the corporate environment in order not to miss relevant developments and trends. There are no objectives or targets defined for these stages of the FEI. According to the participant, there are certain criteria for opportunity analysis, however, these are not formalised or written down but rather are of implicit nature. In the context of idea generation, the quantitative objective is one idea per R&D employee and year. Organisation 3 grants monetary incentives for continuous improvement ideas, while R&D ideas are not incentivised.

3.2.2.4.3 Critical Success Factors and Challenges for FG3

The biggest challenge identified by the focus group participants was the pressure of being innovative. Organisation 3 considers itself a very good early innovation follower but at the same time realises the potential value of becoming and maintaining an innovation leader status. The strict focus on production and technological development often inhibits the creation of radical ideas and products. Furthermore, the lack of a clear innovation strategy was found to be a big challenge for organisational practice, as well as the high staff turnover in R&D and innovation management. Another finding in the course of the focus group was that Organisation 3 often lacks the determination of clearly deciding for or against innovation opportunities and ideas. All in all, opportunity identification and analysis is done only in specific cases and when circumstances require it to be so (except regular patent monitoring). A formalised and process-driven connection between corporate strategy and the early stages of the innovation process was clearly mentioned as a required future change. The fact that there is no marketing for idea submission and that over 80% of ideas originate from the R&D department was another big challenge observable in Organisation 3. Missing input from technology monitoring further increases the challenging nature of idea generation. The collaboration with external experts, customers, suppliers and academia as well as the innovative spirit of own staff and their interconnectedness in networks represent critical success factors for Organisation 3.

3.2.2.4.4 Process for FG 3

There is no process-driven approach to opportunity identification and analysis. Organisation 3 has a reactive rather than a proactive way of dealing with trends and developments on the market. Except through patent monitoring, Organisation 3 does not systematically collect opportunities or innovation signals from the corporate environment. In contrast, the idea generation process is well structured: ideas can either be submitted through 1) an online form (for customers, suppliers and external experts), through 2) a product improvement form (paper-form for employees and for product related, incremental ideas only) and 3) through a general innovation form (paper-form for all kinds of ideas from internal sources). The concrete results of depicting the FEI process of organisations 3 can be found in Appendix I.

3.2.2.4.5 Methods and Tools for FG3

A structured application of methods or tools on a regular basis does not exist in Organisation 3. Rather, methods and tools are selected and applied based on particular requirements and when certain circumstances require it to be so. The following methods and tools have at least been applied once: trend radar, trade fair visits, future workshops and expert meetings. Patent monitoring is the only formalised method that is applied regularly in the course of opportunity identification and analysis. Idea generation is supported by the provision of paper-based input forms for internal idea sources and an online form for external ideas.

3.2.2.4.6 In- and Outputs for FG3

The main input sources for Organisation 3 are market developments, trade fairs, customer feedback, patents and input from the former business owner. Input collection happens informally and unstructured and is often based on implicit and case specific criteria. Outputs include possible future technologies and trends for agricultural industry. Participants stated the need for integrating and connecting strategy and innovation management activities. Furthermore, the necessity of monitoring defined input sources and of systematically generating relevant output was a clearly formulated required change. The most important input sources for idea generation are: customers, suppliers, employees, experts and partners form academia. Outputs of idea generation are new product ideas and potential starting points for predevelopment projects.

3.2.2.5 Summary of Focus Group Study Results for All Organisations

One of the main findings of the focus group study was that each of the analysed organisations seems to have a well established and structured idea generation and idea evaluation process. Opportunity identification and analysis on the other side was found to be unstructured, unsystematised and rather conducted in a “laissez-faire” kind of way. This is in line with the findings discussed in section 1 of the thesis and with the identified research and practical gaps (cf. section 1.2 and 1.6).

All organisations have a clear formulated and well communicated corporate strategy. The formal connection between this strategy and the innovation activities was found to be ranging from a corporate strategy that defines expectations from a market and sometimes technological perspective to no formal connections between both areas. However, it is noted, that there is no case of a formal link between corporate strategy and the definition of search fields. In one organisation there was no connection between opportunity identification and selection and the ideation process.

As a common feature, all three organisations do not set concrete goals or targets in their innovation activities, with the exception of idea generation in the context of continuous improvement, where a quantifiable amount of ideas are expected of all or a certain group of employees. Innovation controlling is formalised based on turnover with products younger than five years and by number of new product launches in one organisation, while the others do not controlled it in a similar manner.

The organisations differ in their approach to incentivising innovation efforts. One organisation argues that any extrinsic motivation is counterproductive and they are not using any at all. Another one is using monetary incentives for continuous improvement but not for R&D and innovation related areas and the third is using incentives in both.

Two organisations highlight opportunity identification and analysis as an appropriate approach to identify and track trends or other relevant developments in their environment. However, no organisation has implemented a formalised channel from any stage of the innovation process back to the corporate strategy or the innovation strategy was identified.

In two cases the informal linking element between the learnings from the innovation activates and the corporate or innovation strategy is the highest ranking R&D executive, as he can bring issues to the attention of the management board and influence strategy making.

3.2.2.5.1 Critical success factors and challenges in organisational practice

The results of the three focus group studies revealed, that each of the three organisations is facing similar problems and challenges at the stages of opportunity identification, analysis and idea generation. The following list provides an overview of the challenges observed in the course of focus group conduction, the detailed results are presented in 3.2.2.6.

- Definition of the degree of complexity and customisation to allow on global and complex markets with an enormous price and cost pressure.
- Identification and evaluation of trends and use of these for further steps with the background of high levels of uncertainty and implicit aspects.
- Evaluation of an opportunity's impact on the organisation.
- Effective, systematic gathering, sharing and use of data from market and technology research.
- Dealing with opportunities and ideas between the poles of strategic relevance and operational urgency.
- Identification of opportunities and generation of ideas with the background of a strict focus on manufacturing respectively operative excellence and a technological focus of the strategy.
- Evaluation of opportunities and ideas based on different maturity levels of regions and countries and geographically varying traditions and technological standards.
- Definition of search fields in the absence of a clear innovation strategy and of a formalised and process-driven connection between corporate strategy and innovation management.
- Coherent and long-term process orientation with the background of a high staff turnover in R&D and innovation management.
- Motivation of employees with the background of insufficient marketing for being innovative.
- Timely identification of actually relevant factors out of a plethora of irrelevant factors.
- Identification of potential substitute products due to a strict focus on existing products, technologies and markets.
- Final selection or de-selection of relevant opportunities, trends and ideas due to missing determination to clearly decide for or against some of them.
- Thinking through of a technology, its commercialisation and its customer benefit as basis for search field definition with the background of inconsistent customer requirements and varying target values.

Besides the challenges they have to face, the analysed organisations share common critical success factors. These are either they are already considered and implemented or at least known to be of relevance regarding the early stages of the innovation process:

- Constant, systematic and regular monitoring of company environment.
- Motivation of employees acting as scouts.
- Up-to-date market data.
- Intrinsically motivated and innovative staff.
- Integration of personal networks.
- Commitment and consistency of decisions.
- Interconnected departments and network-like structures.
- Regional project managers as a link between regional and central interests.
- Coherency of information and knowledge flows.
- Observation of competitors.
- Integration of and collaboration with external experts and academia.
- Feedback loops to corporate strategy.
- Integration of key customers and suppliers.

3.2.2.5.2 Processes at the FEI in organisational practice

Figure 26 depicts an overview of the activities and steps observable in the three organisations. Further details about the single process in the three organisations can be found in Appendix G, Appendix H and Appendix I. The intermittent lines represent process elements that are rather unstructured and are not part of the actual innovation process at the FEI of the analysed organisations. These unstructured and not process-driven activities were found to be described as an ideal process which in practice is only followed partially and irregularly or not at all and covers the stages of opportunity identification and analysis. The idea generation stage as well as the following stages of idea evaluation and concept development were found to be well structured and are systematically dealt with.

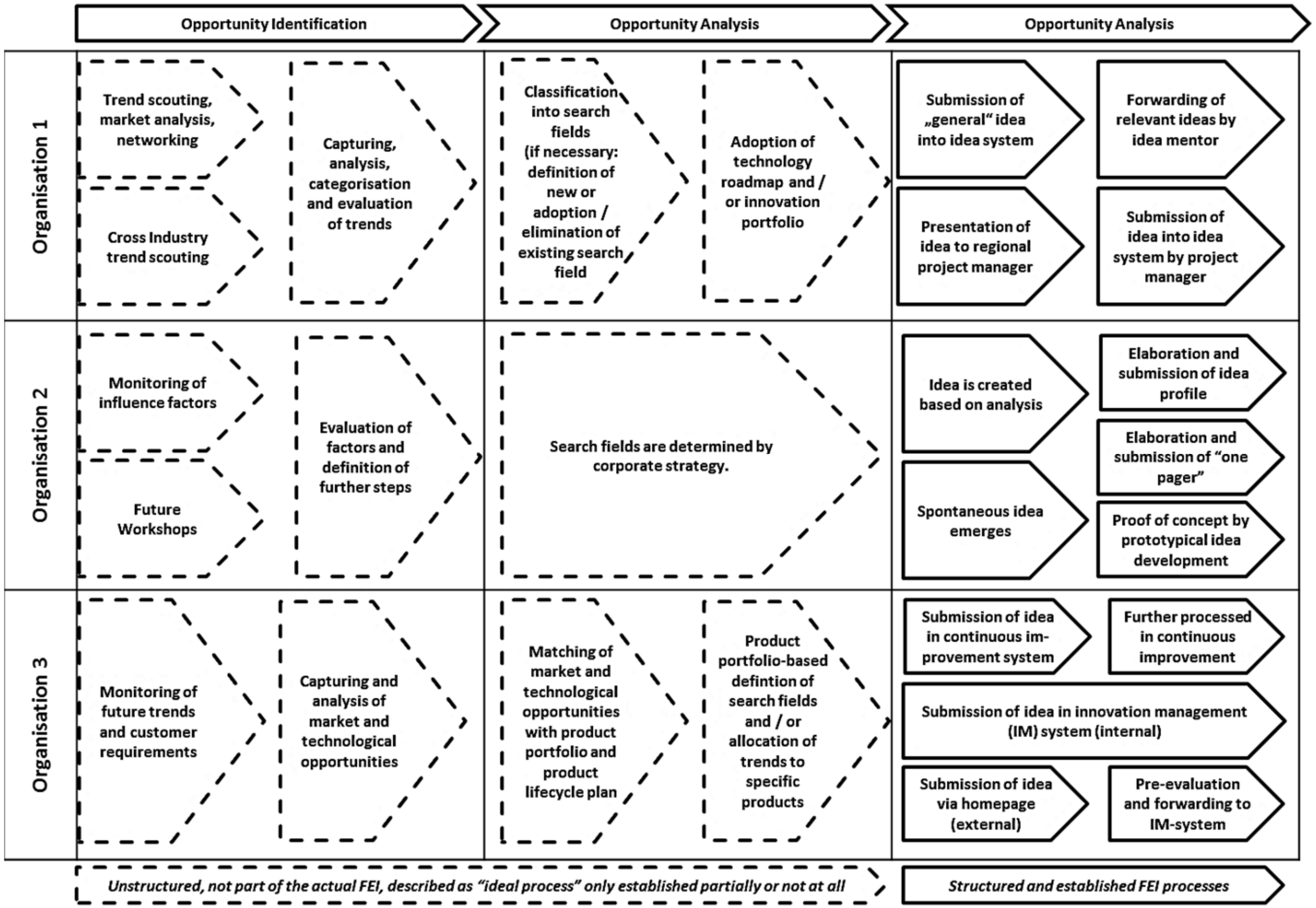


Figure 26: Process elements and activities at the FEI in organisational practice

The process steps depicted in the stages of opportunity identification and analysis represent ideal typical models of organisational practice. Results show that organisations implicitly follow or would like to follow a three to four step approach at this stage of the innovation process: Starting with information collection in the form of cross industry and customer monitoring and trend scouting or market analysis, organisations in a first step would identify relevant information at the strategic FEI. Subsequently, information unearthed during this would have to be captured and documented in order to be analysed and evaluated in the next step. One organisation has a break after information capturing and analysis and does not include the results gained in any further way. Rather, the innovation search fields determined by innovation strategy are dominating and seem to inhibit the integration of information collection and analysis results in the subsequent steps at the FEI. The remaining two organisations are also found to have a strict focus on existing search fields, but at least foresee adaption possibilities in the third and fourth step. However, the danger of excluding relevant information due to a too strict focus is high. Organisations are aware of this and clearly demand more transparent and open processes in this context.

In summary, the greatest potential for improvement were found to be in the stages of opportunity identification and analysis, which is in line with the identified research gap and the resulting focus of the thesis (cf. section 1.6).

3.2.2.6 Principles at the Front End of Innovation in organisational practice

Table 12 summarises the detailed FEI principles collected in the focus group study:

Table 12: FEI principles collected in the focus group study

Source	***Derived principle***	***ID***
FG2	Monitoring and reporting of selected factors of influence	PP1
	Identification of relevant influencing factors	PP2
	A traceable evaluation of qualitative influencing factors	PP3
	Identification of future developments on the end user market	PP4
	Cross-industry technology transfer	PP5
	Technology, commercialisation and customer benefits are key aspects.	PP6
	Balance between short-, mid- and long-term innovation projects	PP7

	Identification of substitute products despite a strong product focus	PP8
	Evaluation of influencing factors and identification of trends	PP9
	Exploitation of radical, outside the box ideas	PP10
	Time to be creative	PP11
	Detailed, objective and appreciating feedback	PP12
	Equal chances for all ideas	PP13
	Our organisational culture allowing for an innovation friendly environment	PP14
	Space and room to communicate informally	PP15
	Identification and integration of customer problems	PP16
	Our employees and their knowledge of our products	PP17
FG1	Identification of country specific requirements on a global market	PP18
	Monitoring of developments and trends in the organisational environment	PP19
	Integration of external experts	PP20
	Integration of strategical knowledge in the innovation activities	PP21
	Identification of long-term future developments	PP22
	Resource allocation planning	PP23
	Communication and Integration of market research data	PP24
	Objective identification and evaluation of trends	PP25
	Strategically oriented opportunity analysis	PP26
	Grouping of trends and combination of knowledge	PP27
	Structured, coordinated and coherent idea generation across countries	PP28
	Top-management support and an innovation friendly culture	PP29
	Transparent idea submission with timely feedback	PP30
	A unified reward system	PP31
	Structured procedure of dealing with multilingualism	PP32
	Transparent idea evaluation with a reasonable processing time	PP33

	Notification based re-evaluation of postponed ideas	PP34
FG3	Our employees, their intrinsic motivation and their networks	PP35
	Integration of external experts and establishing networks	PP36
	Long-term oriented resource allocation	PP37
	Definition of consistent and stable innovation goals	PP38
	Strategically oriented innovation processes	PP39
	Structured and strategically oriented opportunity analysis	PP40
	Criteria based opportunity analysis	PP41
	Clear and concise idea description	PP42
	Top management support and freedom for creativity	PP43
	Structured and IT-based re-evaluation of postponed ideas	PP44
	Open idea generation	PP45
	Innovation friendly organisational culture	PP46
	Integration of different structures and systems	PP47
	Transparent idea submission with timely feedback	PP48
	Marketing for idea submission	PP49
	Technology monitoring based idea generation	PP50
	Systematic approach to idea deletion	PP51
	Systematic approach to manage postponed ideas	PP52
	Strategically oriented idea evaluation and selection	PP53

3.2.3 Summary of FEI principles

The results gained by conducting the literature review concerning general principles at the FEI (cf. section 3.2.1.2) provide a rather comprehensive, theory grounded basis for further elaboration. The carrying out of the focus group study as described in the previous section 3.2.2 allows for additional collection of practitioner insights and requirements in form of the derived list of FEI principles observable in economic practice. Those principles are in a next step matched with the list of literature based FEI principles (cf. Table 13) and a final list of seven FEI principles can be generated. Again, this is done based on the step model of inductive category development proposed by Mayring (Mayring 2000) and the technique of peer-debriefing is applied (cf. section 3.2.1.1).

Matching FEI principles derived from literature (LP) with FEI principles collected as results of the focus group study (PP) represents the second ex-ante evaluation activity of the thesis (“Eval 2”, cf. section 2.2.3.1) and ensures the fidelity of FEI principles and the derived process model design requirements (cf. section 4) with real world.

Table 13: FEI principles derived from literature matched with principles from organisational practice

No.	*Description*	*Matched derived principles (IDs)*
1	Systematic uncertainty reduction	Matched principles from literature: LP1, LP11, LP12, LP13, LP14, LP17, LP18, LP19, LP20, LP22, LP23, LP32, LP37, LP41, LP44, LP48, LP49, LP56, LP60, LP61, LP68, LP70, LP81, LP85, LP86, LP90, LP91, LP95, LP97, LP99, LP101, LP105, LP108, LP110, LP112, LP113, LP114, LP124, LP128, LP129, LP136, LP137, LP142
		Matched principles from practice: PP1, PP2, PP3, PP4, PP5, PP6, PP8, PP9, PP16, PP18, PP19, PP20, PP22, PP24, PP25, PP26, PP27, PP35, PP36, PP40, PP41, PP50
2	Composition and management of roles and teams	Matched principles from literature: LP3, LP24, LP38, LP39, LP45, LP46, LP47, LP58, LP63, LP65, LP69, LP71, LP72, LP74, LP76, LP77, LP78, LP79, LP91, LP92, LP96, LP100, LP103, LP106, LP107, LP109, LP115, LP116, LP118, LP125, LP126, LP132, LP134, LP141, LP143, LP144, LP146, LP147
		Matched principles from practice: PP17, PP20, PP35, PP36, PP47
3	Creation and fostering of an innovation-friendly, motivat-	Matched principles from literature: LP5, LP6, LP26, LP40, LP59, LP63, LP65, LP66, LP67, LP68, LP73, LP74, LP91, LP98, LP106, LP117, LP121, LP122, LP127, LP132, LP133, LP139, LP140, LP143, LP144, LP145

	ing culture	Matched principles from practice: PP11, PP12, PP14, PP15, PP29, PP30, PP31, PP35, PP43, PP46, PP49
4	Definition of an innovation strategy and strategic alignment of innovation processes and projects	Matched principles from literature: LP8, LP9, LP21, LP25, LP27, LP28, LP29, LP30, LP35, LP36, LP42, LP48, LP54, LP55, LP57, LP64, LP69, LP87, LP88, LP90, LP93, LP101, LP104, LP111, LP119, LP120, LP123, LP128, LP135, LP138
		Matched principles from practice: PP7, PP11, PP12, PP14, PP15, PP21, PP23, PP26, PP29, PP30, PP31, PP35, PP37, PP38, PP39, PP40, PP43, PP46, PP47, PP49
5	Systematic idea generation and enrichment	Matched principles from literature: LP2, LP4, LP7, LP50, LP51, LP56, LP75, LP84, LP105, LP135
		Matched principles from practice: PP10, PP13, PP28, PP30, PP34, PP42, PP45, PP48, PP50, PP52
6	Systematic idea evaluation and selection	Matched principles from literature: LP53, LP56, LP62, LP68, LP81, LP105
		Matched principles from practice: PP13, PP32, PP33, PP34, PP44, PP48, PP51, PP52, PP53
7	Systematic concept development and selection	Matched principles from literature: LP10, LP15, LP16, LP31, LP33, LP34, LP43, LP52, LP56, LP68, LP80, LP81, LP82, LP83, LP89, LP102, LP105
		-

4 Design Requirements for Process Model Development

Based on the FEI principles derived from literature ("LP") and from the focus group study ("PP"), this chapter includes the identification of principles relevant for the thesis' focus (cf. section 4.1), an analysis of literature on business process management and the selection of a process modelling notation (cf. section 4.2), the categorisation of FEI principles into process and non-process elements (cf. section 4.3) and the derivation of process model design requirements (cf. sections 4.4 and 4.5).

4.1 FEI principles relevant for process model

As discussed in section 1.3 and summarised in section 1.6 of the thesis, previous work on the FEI mainly focused on idea generation only and neglected the preceding phases of opportunity identification and analysis. Idea generation, evaluation and concept development have already received quite some attention in scientific literature and numerous organisations have established structured and organised ideation and concept development processes. The thesis does not put an emphasis on these but specifically focusses on the stages of opportunity identification and analysis as well as on the transition to the idea generation process. Applied to the list of FEI principles presented in Table 13, FEI principles "systematic idea generation and enrichment", "systematic idea evaluation and selection" and "systematic concept development and selection" are neither part of opportunity identification nor of opportunity selection and hence do not fall into the strategic FEI. FEI principle "systematic uncertainty reduction" is reflected by opportunity identification and analysis, as theses stages of the FEI aim at collecting and analysing information and thus at reducing uncertainty (cf. section 3.1). Principles "composition and management of roles and teams", "creation and fostering of an innovation-friendly, motivating culture" and "definition of an innovation strategy and strategic alignment of innovation processes and projects" cannot be directly attributed to opportunity identification or analysis, but represent prerequisites respectively general success conditions at the FEI.

4.2 Business Process Management Literature

The selection of an appropriate modelling notation is crucial to depict and communicate the process model. To create the basis for process model development, a review of existing literature on process management and process modelling techniques was conducted. The results of this are presented in the following sections and include an overview of process management theory (cf. section 4.2.1) and the process modelling approach relevant for the current thesis (cf. section 4.2.2).

4.2.1 Business Process Management Theory

Although a plethora of definition approaches of what a "business process" is can be found in scientific literature, most definitions reflect a similar ontology. Basically, a business process is defined as a set of continuous or intermittent cross-functional activities that are performed based on a workflow in order to reach a defined goal and create a defined outcome (cf. e.g. vom Brocke et al. 2014; Scheer et al. 2005; Zairi 1997; Davenport 1993;). Table 53 (Appendix E) provides an overview of selected definition approaches.

Based on these existing definitions, a business process as understood in this thesis is defined by the following characteristics and requirements (BPR1-BPR4):

- A business process consists of sub-processes which encompass a finite set of key activities and tasks which are interrelated and sequential in nature or at least partially ordered (BPR1).
- A business process transforms inputs into specific outputs, delivers a defined result and is target oriented (BPR2).
- Business processes are horizontal and cross-functional (BPR3).
- A business process should have a wider purpose, e.g. to meet stakeholder requirements, customer needs or other interests (BPR4).

Following this and based on the objectives of the current thesis (cf. section 1.4) Business Process Management (BPM) can be defined as "*supporting business processes using methods, techniques, and software to design, enact, control, and analyse operational processes involving humans, organizations, applications, documents and other sources of information*." (Burattin 2015, p. 13)

In literature, various different categories of business processes can be found. Such classifications systems mainly build on the purpose respectively the function of a process. Out of the plethora of such classification approaches, one of the more comprehensive and acknowledged ones is that of Garvin (Vilkas, Stancikas 2015; Daniel 2008; Chapman 2001; Garvin 1998). Based on an extensive analysis of existing process theories from various research domains, Garvin divided organisational processes into three groups: work processes, behavioural process and change processes (Garvin 1998). Due to the high acknowledgement of the process classification system and due to its comprehensive and yet easy to communicate structure, the current thesis follows Garvin's way of categorising business processes.

According to Garvin, work processes focus on accomplishing tasks and can be further divided into operational processes (processes that produce customer relevant outputs in form of products and services, e.g. new product development processes) and administrative processes (processes that are necessary for running the business but do not directly produce customer relevant outputs, e.g. strategic planning). Both operational and administrative processes involve sequences of linked and interdependent activities in order to transform inputs into desired outputs, have defined start and end points and address either internal or external customers and stakeholders (Garvin 1998). The main difference between those two work process types lies in the nature of their results respectively outputs: operational processes aim at creating goods and services for customers, while administrative processes focus on the generation of information, data and plans for internal use. In the context of the current thesis, the seamless link between operational and administrative processes is especially relevant, as e.g. the New Product Developments does not only build on strategically oriented administrative but also on efficiently conducted operational product development and planning processes (Garvin 1998).

Behavioural processes have their roots in organisation theory and group dynamics and directly influence work processes by defining the patterns of organisational communication and decision making processes. According to Garvin, such patterns are normally deeply embedded and reflected by most organisational members. Behavioural processes have to be distilled from observations of everyday work, which makes them difficult to identify and model. Garvin distinguishes between three types of behavioural processes: decision making processes, communication processes, and organisational learning processes (Garvin 1998).

Change processes have their roots in strategic management, organisation theory, and social psychology and focus on sequences of events over time. According to Garvin, change processes are explicitly dynamic and intertemporal and describe how individuals, groups and organisations develop, adapt and grow (Garvin 1998). In contrast to work and behavioural processes, which are relatively static, change processes attempt to catch reality in flight (Pettigrew 1990) and consist of a combination of work and behavioural processes. Change processes can be divided into autonomuous and induced processes. Autonomuous change processes proceed due to internal dynamic and have a life of their own, while induced change processes encompass all planned change efforts (Ashurst 2015; Garvin 1998). Table 14 summarises the process types according to Garvin as described above:

Table 14: An organisational processes framework (Garvin, 1998)

	Work processes	***Behavioural processes***	***Change processes***
Definition	• Sequences of activities that transform inputs into outputs	• Widely shared patterns of behaviour and ways of acting / interacting	• Sequences of events over time
Role	• Accomplish the work of the organisation	• Infuse and shape the way work is conducted by influencing how individuals and groups behave	• Alter the scale, character, and identity of the organisation
Major categories	• Operational and administrative	• Individual and interpersonal	• Autonomous and induced, incremental and revolutionary
Examples	• NPD, order fulfilment, strategic planning	• Decision making, communication, organisational learning	• Creation, growth, transformation, decline

To allow for systematic management of business processes, they have to be depicted and modelled by using a process modelling approach (Sharma 2015; Zairi 1997) (cf. section 4.2).

4.2.2 Business Process Modelling in the thesis

Although business process modelling is popular in IS literature (Bititci et al. 2011; Jeston, Nelis 2008; Dumas et al. 2005), it is not unambiguously seen. Critics point out that most process modelling techniques have deficiencies regarding the integration of "soft factors" or "non-process factors", i.e. beliefs, motives or norms respectively behavioural and change processes as defined by Garvin, in the depiction of organisational business processes (Payyazhi 2014; Wynn et al. 2010; Sikdar, McGrath 2003).

The process model aims at improving the activities at the strategic FEI by increasing goal orientation, process consciousness and capability of organisations. This is reached by depicting the identified process factors using an acknowledged business process modelling notation. According to Bider, an appropriate process modelling technique applicable to model process factors should "*help in communicating the process knowledge to all participants of the process. […] it is particularly important to consider the background of the participants […]*" (Bider 2005, p. 11). Hence, the selection of an appropriate process modelling technique strongly depends on the intended use of the process model and on actual users' background. In the context of the current thesis, the main objective of the process model is to improve the structure, flexibility and strategic orientation at the early stages of the FEI.

Considering the background of the practitioners involved in this thesis, the most appropriate and understandable process modelling technique is the Event-Driven Process Chain (EPC) approach. Not only is this approach one of the most acknowledged and powerful ones (Betke et al. 2013; Kapuruge et al. 2013; Dietz, Habing 2004), but it is also frequently applied in different domains and easy to understand and capture for non-technical domain experts (Krumeich et al. 2015; Houy et al. 2014; vom Brocke, Sonnenberg 2014). Most important, partner organisations were already familiar with this notation, which facilitates and speeds up communication and evaluation of results.

The Event-Driven Process Chain approach is easy to understand and has communicably structure. That is one of the main reasons for EPCs big success was the fact, that it is a central part of the architecture of integrated information systems (ARIS) developed by August-Wilhelm Scheer (Dumas et al. 2005; Scheer, Nüttgens 2000). The EPC notation is based on the concepts of stochastic networks and Petri Nets (vom Brocke, Sonnenberg 2014). However, using this notation does not require a strong formal framework. According to Scheer, this could have been another reason that led to the successful adoption of EPCs in practical applications (Scheer et al. 2005). Event-Driven Process Chains consist of three main elements (Scheer et al. 2005; Keller et al. 1992):

- **Functions** are active nodes and are depicted as soft rectangular. They directly correspond to an activity (task, process step) which needs to be executed in order to transform input into desired output.
- **Events** are passive nodes and represent process-related states that correlate to the pre or post-condition of a function. They are depicted by hexagons and fulfil the two main purposes of triggering functions and describing the situation before and/or after a function is executed.
- **Connectors** are used to represent non-linear connections of functions and events. Basically, there are three types of connectors which are depicted as circles, showing their type in the center:
    - Conjunctional **AND**-connectors (**^**)
    - Exclusive **XOR**-connectors (**X**) and
    - Disjunctional **AND/OR**-connectors (**V**)

Functions, events, and connectors can be connected with edges in such a way that the following requirements (BPMR1-4, have to be fulfilled for syntactical correctness, cf. section 6.1.1) are met (Mendling et al. 2007c):

- events have at most one incoming edge and at most one outgoing edge, but at least one incident edge (i.e. an incoming or an outgoing edge) (BPMR1),
- functions have precisely one incoming and precisely one outgoing edge (BPMR2),
- connectors have either one incoming edge and multiple outgoing edges, or multiple incoming edges and one outgoing edge (BPMR3), and
- in every path, functions and events alternate (ignoring intermediate connectors) (BPMR4).

Figure 27 depicts an exemplary process model created by following this notation (“function 4” represents a process path, depicted by the white rectangular):

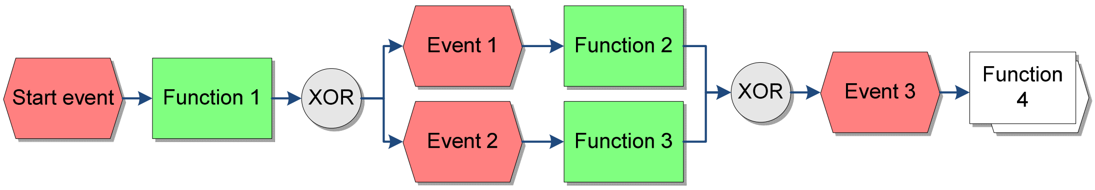
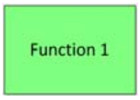
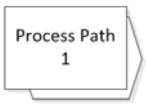
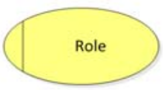


Figure 27: Exemplary Event-Driven Process Chain Model

The following table provides an overview of and explains the EPC symbols used to depict the process models of the three focus group organisations and to develop the final process model in the thesis:

Table 15: Overview and explanation of EPC symbols used in the thesis

Symbol	***Explanation***
	An event represents a process-related state that correlate to the pre or post-condition of a function. It fulfils the two main purposes of triggering functions and describing the situation before and/or after a function is executed.
	A function represents a process step and directly corresponds to an activity (task, process step) which needs to be executed in order to transform input into desired output.
	A process path represents the interface to or from another process.
  	Connectors are used to represent non-linear connections of functions and events. Basically, there are three types of connectors which are depicted as circles, showing their type in the center: • Conjunctional AND-connectors (^) • Exclusive XOR-connectors (X) and • Disjunctional AND/OR-connectors (V)
	A role represents an organisational unit or employee that is responsible for a certain function and the underlying activity.
	An information item represents either a required information-based input to perform a function and the underlying activity or an information-based output generated in the course of a function.

4.3 Classification into process and non-process FEI principles

Based on the definition of “business process” and the particularities of work, behavioural and change processes (cf. Table 14), the focus of the process model is on the integration of work processes rather than on depicting change or behavioural processes (cf. section 4.3). Behavioural processes as well as change processes are not completely according to the requirements for business processes (cf. BPR1-BPR4 in section 4.2.1), can hardly be identified and modelled based on appropriate existing business process modelling notations and are rather prerequisites or framework conditions of a process (“non-process factors”) (cf. section 1.1).

FEI principles P2 “Composition and Management of Roles and Teams” and P3 “Creation of an innovation-friendly, motivating culture” aim at infusing and shaping the way work is conducted by influencing how individuals and groups behave. They are characterised by widely shared patterns of behaviour and ways of how interaction takes place within an organisation. FEI principles P1 “Systematic Uncertainty Reduction” (cf. section 4.4) and P4 “Definition of an innovation strategy and strategic alignment of innovation processes and projects” (cf. section 4.5) comprise a finite set or sequence of activities that transforms inputs into outputs (cf. BPR 1-4 in section 4.2.1) and aim at supporting the accomplishment of organisational work. The following table contrasts the process type characteristics as proposed by Garvin (cf. section 4.2.1) to the FEI principles derived in chapter 3 (cf. Table 16).

Table 16: Process types acc. to Garvin (1998) matched to FEI principles

	Process characteristic according to Garvin (1998)	***P1***	***P2***	***P3***	***P4***
Definition	Sequences of activities that transform inputs into outputs.	x			x
	Widely shared patterns of behaviour and ways of acting / interacting.		x	x	
	Sequences of events over time.			x	
Role	Accomplish the work of the organisation	x			x

	Infuse and shape the way work is conducted by influencing how individuals and groups behave		x	x	
	Alter the scale, character, and identity of the organisation			x	
Major categories	Operational and administrative	x			x
	Individual and interpersonal		x	x	
	Autonomous and induced, incremental and revolutionary			x	

According to the characteristics presented above (cf. Table 16), Table 17 summarises the FEI principles, categorises them according to the classification scheme proposed by Garvin (cf. section 4.2.1) and classifies between process and non-process factors in the course of the current thesis.

Table 17: Classification of process and non-process FEI principles

FEI Principle	Type of process	Addressed in thesis as:
P1 - Systematic uncertainty reduction	Work process	Process factor
P2- Composition and management of roles and teams	Behavioural process	Non-process factor
P3 - Creation of an innovation-friendly, motivating culture	Behavioural process with elements of change process	Non-process factor
P4 - Definition of an innovation strategy and strategic alignment of innovation processes and projects	Work process	Process factor

FEI principles one and four can be classified as work processes according to Garvin, are addressed as process factors and are modelled based on the EPC notation in the thesis (cf. section 4.2.2). FEI principles 2 and 3 are classified as behavioural processes, which cannot be modelled based on standardised business process modelling notations. This is in line with current studies, which state that management processes and organisational culture in particular could be classified as behavioural process, but much more influence them and should rather be regarded to as the driving force behind these and not as typical business processes (Vilkas, Stancikas 2015). Subsequently, the FEI principles relevant for the thesis are described in more detail and corresponding process model design requirements are derived.

4.4 P1 – Systematic Uncertainty Reduction

4.4.1 Principle Background

As “systematic uncertainty reduction” is one of the main FEI principles in the course of the current thesis, the resulting goal of process model development is to define how and with which methods organisations can be supported in managing and reducing the above mentioned types and sources of uncertainties and how to fulfil the requirements derived from theory and practice (cf. section 3.2.3 and 4.4.2). Over the past decades, uncertainty has been a frequent issue in organisation theory. In innovation management, where a forward looking orientation is essential and a lack of predictability is given, the need for a systematic approach to deal with uncertainties is particularly high (Brandtner et al. 2014; Jalonen 2012; Afuah 2002;).

This is in line with the focus group study results, where organisations agreed that the identification and analysis of opportunities or signals and trends in the organisational environment are of crucial relevance at the FEI. However, none of the participating organisations has established formal and structured uncertainty reduction process steps. Methods and tools for collecting and analysing signals are only applied irregularly. Although there are criteria for analysing opportunities, these are not executed or applied in organisational practice. Opportunity analysis hence takes place in the area of tension between strategic relevance and operational urgency. This leads to the result, that in the vast majority of cases potentially relevant opportunities and signals are dismissed due to operational urgency of other ongoing developments. The challenge in this context and the process model requirement resulting from it is to establish formal, systematic, lean and flexible ways of identifying, collecting, analysing and forwarding relevant signals to the subsequent stages at the FEI (Brandtner et al. 2014). In this context, the two main elements respectively methods or approaches of uncertainty reduction are scanning and monitoring (Schuh et al. 2014; Peter, Jarratt 2013; Schoemaker et al. 2013).

The main purpose of scanning activities is to rapidly identify first weak signals of potential changes in the organisational environment and to aggregate these as a basis for further steps already at an early stage of their development. The notion of "weak signals" goes back to Ansoff (Ansoff 1975), who defined them as events, warnings or imprecise symptoms of impending future developments, problems or opportunities that are still too incomplete to allow for accurately estimating their impact. Scanning activities aiming at identifying weak signals in the organisational environment can be considered as a holistic approach and put a premium on individual intuition, informal attention and pattern recognition (Andreassen et al. 2015; Lyles 1987; Reinhardt 1984). Furthermore, scanning should not be limited to existing observation areas only, but should also allow for integrating additional, not yet defined ones (Camillus, Datta 1991).

Based on the indicators unearthed during scanning, monitoring involves detailed, long-term and focused tracking of strategic issues, their sequences and of identified trends (Fahey, Narayanan 1986).

Table 18 provides an overview of the characteristics of scanning and monitoring activities and as discussed above. In accordance with literature, it distinguishes between the formality (informal and formal) and direction (undirected and directed):

Table 18: Characteristics and types of scanning and monitoring activities

	Undirected	***Directed***	***Type of activities***
Informal	Thematically open search for signals outside defined search areas.	Thematically open search for signals inside defined search areas.	Scanning
Formal	Thematically focused search for signals outside defined search areas.	Thematically focused search for signals inside defined search areas.	
	Observation and search for further information outside defined search areas and with a thematic emphasis on a known signal.	Observation and search for further information inside defined search areas and with a thematic emphasis on a known signal.	Monitoring

Organisations with established formal monitoring systems can observe and track a larger amount of strategic issues than those without such systems (Lauzen 1995). A strategic issue in the present context is defined as either a trend (i.e. a series of innovation relevant signals pointing in the same direction) or a single relevant signal that, while not directly leading to, contributing to or contradicting a trend, may still be an influencing factor for strategic innovation management. Strategic issues should be described and documented in form of a strategic issue portfolio (Kunnas 2009).

A combination of undirected and directed scanning as well as undirected and directed monitoring activities is recommended in literature. Such a hybrid approach allows for identifying signals from both already regarded and not yet regarded search areas (Schoemaker et al. 2013). This could also be identified in the course of analysing focus group study results: Each of the organisations relies on informal scanning activities in the form of innovation scouts or so called innovation sensors. They strongly rely on individual employees and their intrinsic motivation. However, organisations are also aware of the importance of more formal and directed scanning and monitoring systems. Nevertheless, none of the participating organisations has established such system or processes. According to participants, this is mainly due to a lack of strategic guidance or to a too strictly defined corporate strategy, due to limited input from management and due to methodological weaknesses in this regard. One of the main requirements identified as result of the focus group study was to establish a formal and strategically aligned innovation search strategy and formally defined innovation goals as core parts of the innovation strategy (also cf. section 4.5).

Scanning as well as monitoring activities should not focus on external sources only, but should also allow for integrating internal information, sources, networks and structures as well (Schoemaker et al. 2013; Johnson-Cramer et al. 2007). Same applies to strategic issues, which may originate from internal as well from external sources. Internal issues occur within the organisation's boundaries and are strategic issues if they could alter organisational performance if left unnoticed or if not addresses correspondingly. External issues are collected via scanning and monitoring and include e.g. competitors' activities, market developments or technological issues (Dutton, Ottensmeyer 1987). The importance of integrating both internal and external sources is also reflected in I-PR2 and FEI-PR 7 (cf. section 4.6) as well as in FEI key principles and the derived process model design requirements (cf. section 4.4.2). Focus group results also highlight the relevance of internal and external knowledge sources. An overview of sources (literature ("LP") and practitioner principles ("PP") derived from focus group results) directly contributing to the identification of "systematic uncertainty reduction" as a FEI principle is provided in Appendix K.

4.4.2 Design requirements of P1 for process model development

A common view is that uncertainty is caused by a lack of information and that it must be reduced to provide clarity for the following steps of the NPD process. Uncertainty reduction can be initiated by management by fostering the acquisition of more data and information by means of scanning and monitoring activities (Saetre, Brun 2012, cf. section 4.4.1). This is in line with focus group study results, where each of the participating organisations was found to have realised the necessity and importance of systematically reducing uncertainty at the FEI. Forwarding information gathered and analysed in the course of uncertainty reduction to corporate strategy planning was also stated as key requirement by practitioners. Furthermore, focus group results showed the missing but required link between uncertainty reduction and idea generation.

As basis for process model development, the requirements that have to be addressed in order to reduce uncertainty are derived based on the discussion in section 4.4.1 and the results of section 3.2 (FEI principles). These are presented in the Table 19. For each design requirement, the respective principle from practice (“PP”) and literature (“LP”) are stated:

Table 19: Design requirements of P1 for process model development

Process model design requirement		***Principle ID***
P1-DR1	Strategic and systematic scanning for factors of influence	PP1, PP2, PP3, PP5 PP9, PP19, PP20 PP22, PP25, PP26, PP27, PP35, PP36, PP40, PP41, LP11, LP41, LP48, LP49, LP56, LP60, LP81, LP85, LP86, LP90, LP91, LP95, LP99, LP105
P1-DR2	Identification and monitoring of current and future market and technology factors of influence and trends	PP4, PP6, PP8, PP16, PP18, PP24, PP50, LP1, LP12, LP13, LP14, LP17, LP18, LP19, LP20, LP22, LP23, LP32, LP44, LP61, LP97, LP101, LP110, LP112, LP113, LP114, LP124, LP128, LP129,

		LP136, LP137, LP142
P1-DR3	Systematic and strategically oriented forwarding of selected factors of influence and trends	PP27, LP37, LP68, L70, LP95, LP108

Following these design requirements, the key activities of uncertainty reduction include systematic and strategically oriented scanning, identification and monitoring of future trends and developments and systematic forwarding of relevant signals factors of influence.

4.5 P4 - Definition of an innovation strategy and strategic alignment of innovation processes and projects

4.5.1 Principle Background

The importance of an innovation strategy at the FEI is particularly reflected in focus group results presented in section 3.2.2. The innovation strategy can be considered as the basis for successful, target-oriented innovation management and plays a crucial role at the FEI (Scheiner et al. 2014; Riel et al. 2013; Trotter 2011). If a clearly defined innovation strategy is missing or is not systematically integrated into the activities of the innovation process, decisions at the FEI become ineffective and uncoordinated (Gaubinger, Rabl 2014).

Although focus group study results showed that organisations are aware of the relevance of a framework in the form of an innovation strategy, none of them did actually have such. Rather, innovation management takes place within the general corporate strategy, which is relatively stable and provides only very limited innovation management related guidelines. Such guidelines were found to exist in the form of broadly defined search areas or innovation fields. A feedback loop or a formal interface between the FEI and the corporate strategy or the corporate strategy planning process does not exist. However, organisations are aware of the relevance of such an interface and a specifically defined innovation strategy is clearly stated as a requested future change. Innovation management related goals and targets are only defined on product level and address e.g. turnover with new products. Applied to the strategic FEI, such goals are by no means concise enough to be measurable or significant enough.

Based on these weaknesses in practice and according to literature, the main objective of the innovation strategy should be to 1) set the direction and provide the focus for an organisations R&D activities and to 2) define where to look and search for opportunities and ideas (Cooper 2011; Brunswicker, Hutschek 2010). By providing a clear and target oriented search strategy part, the innovation strategy represents the first gate at the FEI by controlling earliest innovation input (Poskela, Martinsuo 2009). As with uncertainty reduction, market and technology orientation as well as its integration into strategy definition play a key role for innovation strategy development (Gaubinger, Rabl 2014; Chesbrough 2003). Various definitions of the construct “innovation strategy” can be found in literature. Table 52 (Appendix D) provides a short overview of selected definition approaches. Based on these definitions and on the understanding of an appropriate “innovation strategy” in practice (cf. section 3.2.2), it is defined as follows in the thesis.

The innovation strategy of an organisation determines its strategic areas of focus for all innovation activities, provides an innovative vision and concrete innovation goals and is cross-functionally defined on a meta-strategy level. The innovation strategy must be aligned with the overall strategy and must include mechanisms and approaches for analysing the organisational environment (innovation search strategy).

When implementing an innovation strategy, several steps must be followed, starting with a comprehensive analysis of internal and external organisational environment. Based on the information gathered during the initial analysis, innovation opportunities, innovation goals and the final innovation strategy can be derived (Cooper 2011; Sánchez et al. 2011). When defining an innovation strategy, the conduction of a PESTEL analysis as well as of a SWOT analysis is advisable, as these instruments support the aggregation and collection of signals unearthed during the initial analysis. PESTEL analysis allows for categorising signals and factors of influence and supports the identification of strategic issues and trends, while SWOT analysis supports deriving concrete courses of actions based on the identified strength, weaknesses, opportunities and threats (Gaubinger, Rabl 2014). To support planning and conduction of environmental analysis, the definition of an innovation search strategy as part of the overall innovation strategy is recommended in literature (Alcalde Heras 2014; Huff et al. 2013; Bogers, West 2012; Lendel, Varmus 2011; Brunswicker, Hutschek 2010). The innovation search strategy should typically define what to search (concrete topics and issues), where to search (defined search areas) and how to search (recommended data sources and data gathering methods and tools) (Brunswicker, Hutschek 2010).

In this context, it is important to state that the overall corporate strategy provides the "strategic corridor" for the innovation strategy, and the interconnections between corporate and innovation strategy should continuously be monitored (Brunswicker, Hutschek 2010). The relevance of the overall corporate strategy for innovation strategy and for innovation search strategy could also be confirmed in focus group results. Organisations clearly requested a more innovation management related corporate strategy with clear links to opportunity identification and analysis. Vice-versa, organisations also stated the relevance of forwarding and including results from scanning and monitoring activities into corporate strategy planning.

An overview of sources (literature ("LP") and practitioner principles ("PP") derived from focus group results) directly contributing to the identification of "definition of an innovation strategy and strategic alignment of innovation processes and projects" as a FEI principle is provided in Appendix L.

4.5.2 Design requirements of P4 for process model development

In line with the derived definition of innovation strategy, the discussion presented in section 4.5.1 and based on the FEI principles derived from theory and practice (cf. section 3.2), the following Table 20 summarises the main design requirements (P4-DR1-P4-DR3) of FEI principle P4 for process model design and development. For each design requirement, the respective principle from practice ("PP") and literature ("LP") are stated:

Table 20: Design requirements of P5 for process model development

Process model design requirement		*Principle ID*
P4-DR1	Definition of innovation goals	PP7, PP38, PP37, LP25, LP54, LP55, LP87, LP88, LP94, LP101, LP104, LP120, LP111, LP119, LP120
P4-DR2	Definition of an innovation search strategy	PP21, PP26, PP39, PP40, LP9, LP54, LP55, LP57, LP64, LP90, LP104, LP111, LP119
P4-DR3	Formulation of an innovation strategy and alignment with innovation portfolio	PP23, PP37, PP47, LP8, LP21, LP27, LP30, LP35,

		LP36, LP48, LP69, LP93, LP123, LP128, LP135, LP138

Each of these design requirements is reflected in the focus group study results (cf. section 3.2.2.5) and practitioners had a common view: building on the definition of innovation goals and relying on information collected by following a defined innovation search strategy, the innovation strategy has to be defined in regard to overall corporate strategy and has to be aligned with current innovation projects respectively with innovation portfolio. These design requirements have to be addressed in the process model development.

4.6 Summary of Process Model Foundations

Following the findings of sections 3.2.3 and 4.3 the two main components of the process model are (1) systematic uncertainty reduction process and (2) innovation strategy definition and alignment process. FEI P2 and FEI P3 are considered as non-process FEI elements and are not depicted based on the EPC notation. Besides the process model design requirements derived from P1 (P1-DR1-P1-DR3, cf. section 4.4.2) and P4 (P4-DR1-P4-DR3, cf. section 4.5.2), general innovation process model requirements (I-PR1-I-PR5, cf. section 1.1.2) and FEI specific process requirements (FEI-PR1-FEI-PR6, cf. section 3.1.3) have to be considered as well.

Table 21 summarises the innovation process (I-PR) and the FEI specific (FEI-PR) foundations as well as the design requirements (DR) for process model development derived based on the FEI principles (P).

Table 21: Summary of process model foundations

Type	***Requirement***
Innovation Process Requirement (I-PR)	I-PR1 - Parallelisation of activities and tasks
	I-PR2 - Integration of external and internal knowledge sources
	I-PR 3 - Feedback-loops between stages and activities
	I-PR4 – Method based support
	I-PR5 - Market needs and technological developments as source for innovation input
FEI Process Requirement (FEI-PR)	FEI-PR1 – Iterative rather than strictly sequential
	FEI-PR 2 – Key activities and tasks as well as framework-conditions are considered
	FEI-PR 3 – Structured, problem solving oriented approach
	FEI-PR 4 – Practitioner oriented, applicable in practice and of perceived usefulness
	FEI-PR 5 – Method based support for key activities
	FEI-PR 6 – Includes internal as well as external factors of influence
P1-DR	P1-DR1 - Strategic and systematic scanning for factors of influence
	P1-DR2 - Identification and monitoring of current and future market and technology factors of influence and trends
	P1-DR3 - Systematic and strategically oriented forwarding of selected factors of influence and trends
P4-DR	P4-DR1 - Definition of innovation goals
	P4-DR2 - Definition of an innovation search strategy
	P4-DR3 - Formulation of an innovation strategy and alignment with innovation portfolio

5 Process Model for the Front End of Innovation

The derived FEI principles and the corresponding design requirements clearly indicate the importance of strategically orientated uncertainty reduction at the FEI. The current low performance of strategic level FEI activities (opportunity identification and opportunity analysis) was identified in the informal practitioner meetings conducted for discussing the research problem (cf. section 1.3) and was confirmed in the course of the focus group study (cf. section 3.2.2.5). This further enhances the importance of systematically integrating elements of strategic planning into the innovation activities. At company level, the corporate strategy developed in strategic planning process provides the general framework for an organisation's activities. Regarding the innovation process at the FEI, most organisations' corporate strategies fail to deliver concrete input and do not provide the required framework (Rohrbeck 2011; Cooper 2011) (cf. section 3.2.2.6). The following section introduces process model design and elements. Firstly, traditional strategic planning is contrasted to acknowledged approaches of uncertainty reduction and strategic foresight. Secondly, process model key terms are explained. Thirdly, process model structure is presented and process model elements are dealt with in detail.

5.1 Background and Key Terms of Process Model Development

5.1.1 Strategic Planning vs. Corporate Foresight and Strategic Issue Management

The definition of strategy and corporate strategy goes back to Chandler (Chandler 1990; Chandler 1962) and building on Chandler's work to Ansoff (Ansoff 1975). According to them, corporate strategy determines the basic long-term goals of an enterprise and comprises the definition of courses of action to and the allocation of resources required to reach these goals. Subordinated to corporate strategy, the innovation strategy sets the direction and provides the focus for an organisations R&D activities. It should include mechanisms and approaches for analysing the organisational environment and provides the basis for uncertainty reduction. The innovation strategy should be defined in such a way that it allows for coping with ever changing and complex internal and external organisational environment (cf. section 4.5). Hence, the corporate strategy provides the general framework for an organisation and also serves as a basis for innovation strategy. The innovation strategy has to fulfil additional, more precise requirements. The approach of strategic planning is applicable for corporate strategy definition, but is not suitable for innovation strategy definition, as it pursues different aims and purposes (Lee, Dale 1998): strategic planning concentrates on long-term futures and is derived based on strong and judgeable signals. Classical strategic planning seeks to apply existing solutions learned in different situations to the respective context at hand. It entails the danger of disregarding the intransigent, intrinsically unique and wicked character of weak signals and strategic issues by not defining how to recognise and approach more significant and complex signals and issues. It is not capable of dealing with individual, quickly and abruptly emerging changes, which are crucial for innovation management related activities. This is particularly true in dynamic and complex environments, where the nature of strategic issues often requires fundamental changes in how strategic planning is conducted (Rohrbeck et al. 2015; Cooper 2011; Rohrbeck 2011).

Two approaches better satisfying these requirements are Corporate Foresight (CF) and Strategic Issue Management (SIM). These two terms are often used synonymously and are strongly interconnected (cf. e.g. Rohrbeck et al. 2015; Förster et al. 2014; Schwarz 2005). Table 22 compares the characteristics of traditional strategic planning and CF respectively SIM based on the seminal work of Ansoff (1975), Camillus, Datta (1991), Chandler (1990) and Rohrbeck, Gemünden (2011):

Table 22: Strategic Planning vs. Corporate Foresight and Strategic Issue Management

Strategic planning	***Corporate Foresight and Strategic Issue Management***
Applicable for significant reorientations of the organisation	Applicable for dealing with specific uncertainties and the implications of signals and strategic issues
Focusses on the general corporate strategy	Focusses on potential signals and strategic issues
Builds and relies on judgeable, strong signals and defined information requirements	Builds on identifying and dealing with weak signals and strategic issues
Strong emphasis on products, markets and technologies	Emphasises signals and issues form all possible sources
Is conducted periodically	Is conducted continuously

Focusses on the organisation as a whole	Focusses on problems and issues
Aims at deriving strategic information based on decisions	Decisions are made based on existing information

Following this juxtaposition and taking into consideration the derived process model design requirements and the focus group results, CF and SIM are better suited to fulfil the specific challenges at the FEI than traditional strategic planning approaches would be. Especially the strong interrelation of these two approaches and their potential in providing input for each other provides a good starting point for developing the process model: while information gathered for SIM could also be integrated into CF, the scanning and evaluation activities of CF could also foster SIM (Förster et al. 2014; Kuhn et al. 2014). Following this position, the early detection of the emergence of strategic issues could be fostered by CF and SIM could provide input for interpreting the impact of issues and signals detected as part of CF. Corporate Foresight allows for identifying and monitoring medium- to long-term developments by applying e.g. scanning or monitoring. These developments can be forwarded to SIM. SIM allows for identifying short-term issues, which can be integrated into CF. Hence, the combination of CF and SIM increases the chance to identify, analyse and process relevant signals, opportunities and issues at an early stage (cf. Jissink et al. 2015; Rohrbeck et al. 2015; Förster et al. 2014; Kuhn et al. 2014). The conceptual proximity of these approaches is based on their mutual interest in capturing developments in the organisational environment and in providing input for (innovation) strategy planning with the aim of identifying opportunities and threats (Darkow 2015; Kuhn et al. 2014).

In the following sections, these two approaches are introduced and the basis for process model development is presented.

5.1.1.1 Corporate Foresight (CF)

CF has its roots in the term strategic foresight and lays a specific emphasis on foresight applied in private companies as opposed to its application in a public domain. First approaches underpinning the development of CF were presented in the 1970s by combining elements of environmental surveillance and forecasting with the aim of reducing uncertainty (Peter, Jarratt 2013). Various different definitions of the term can be found in scientific literature, an overview of selected ones is provided in Table 54 (Appendix F). In the thesis, CF is defined as an approach applicable for identifying and evaluating weak signals from the internal and external organisational environment at an early stage. It enables perceiving trends and strategic issues and the interrelations between these. By facilitating the interpretation of their consequences for the company, CF serves as a basis for corporate and innovation strategy planning and can therefore be considered a part of strategic innovation management.

Various foresight frameworks and approaches can be found in literature, e.g. the foresight process by Horton (1999), the Houston Foresight Framework by Hines and Bishop (2013), the five phases of foresight by Nugroho and Saritas (2009), the foresight cycle by Miles (2012) or the generic foresight process framework by Voros (2003). Figure 28 provides a short overview of existing foresight frameworks:

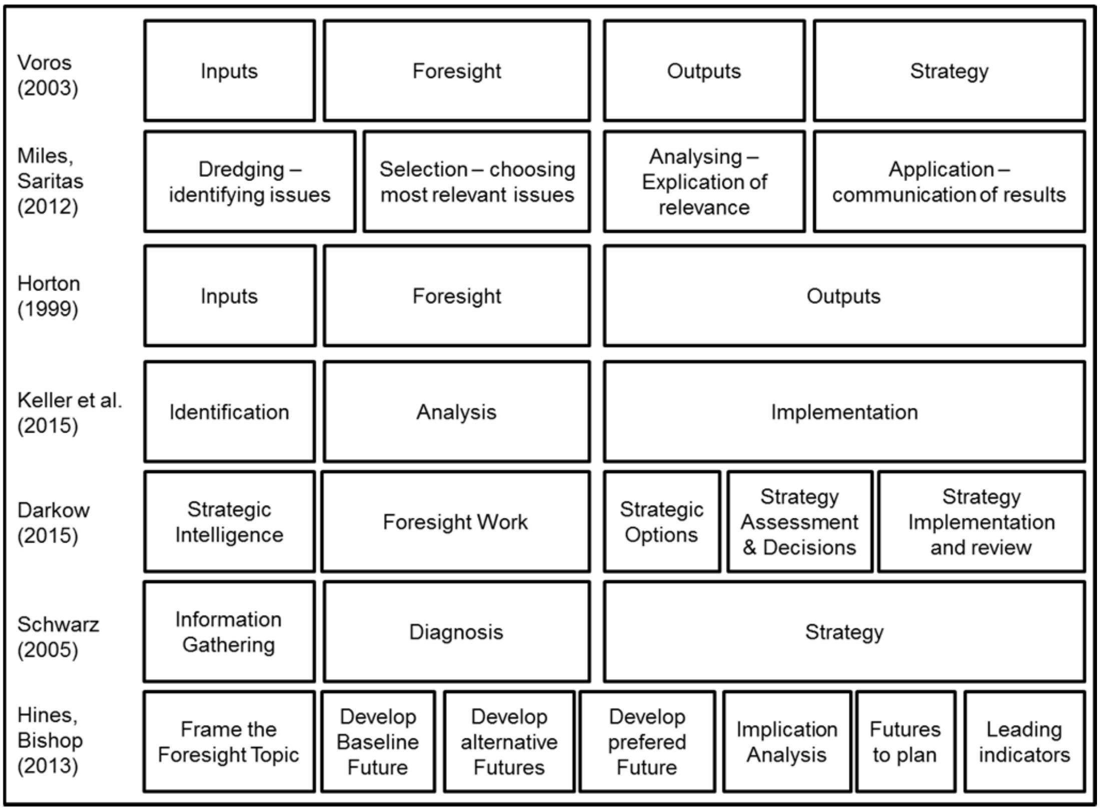


Figure 28: Overview of existing Foresight Frameworks

What most CF frameworks have in common is a three to five phase structure consisting of an input collection, an analysis, an output generation and / or a strategy-definition phase. Probably the most acknowledged CF frameworks are provided in the form of the “successful foresight process” by Horton (Horton 1999) and building on this process the “generic foresight process framework” by Voros (Voros 2003). The process framework by Voros represents an adaption of existing theory on CF and was developed based on the conceptual foundations of Horton (Horton 1999), the differentiation between strategic thinking, strategy development and strategic planning as introduced by Mintzberg (Mintzberg 1994) and the methodological inputs provided by Slaughter (Slaughter 1989). Similar to Horton's process it consists of several main layers: inputs, foresight work, outputs and strategy (Voros 2003) (cf. Figure 29).

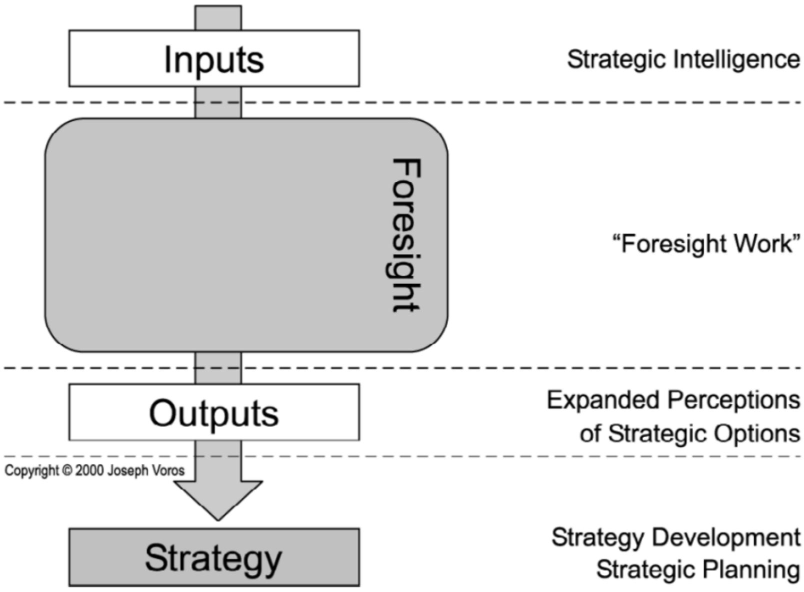


Figure 29: The generic foresight process framework by Voros (2003, p. 14)

Basically, there are three major research perspectives from which research on CF has been conducted: the strategic management perspective, the innovation management perspective and the future research perspective (Rohrbeck 2011). In accordance with the current thesis' focus on strategic level FEI activities (cf. section 1) CF is approached from the innovation management perspective. The relevance of CF for the FEI has already been emphasised in literature from this perspective, (cf. Brandtner et al. 2015b; Scheiner et al. 2014; Rohrbeck, Gemünden 2011). CF and its search for weak signals, opportunities and threats and its monitoring of strategic issues and trends can also be regarded to as the search for new innovations (Liebl, Schwarz 2010; Teece 2010; Paladino 2009; Tidd, Bessant 2009) and is hence closely linked to innovation management and the FEI. Especially in high-speed environments CF should go hand in hand with continuous innovation and has the potential to support organisations in generating more creative products leading to superior performance (McCardle 2005; Costanzo 2004). By establishing structured and systematically managed CF processes, organisations are able to generate valuable input and provide a solid basis for their innovation processes and especially for the FEI (Yokoo, Okuwada 2013; Magruk 2011; Liebl, Schwarz 2010; Daim et al. 2006).

Rohrbeck (2011) defined three main clusters of roles that foresight plays in regard to innovation management. Using a standard four-step innovation process, Rohrbeck positioned those three roles at the start of the innovation funnel (initiator role), outside the innovation funnel (strategist role) and along the innovation funnel (opponent role). Considering the focus of the current thesis, the innovation process used by Rohrbeck, which starts with idea generation, does not cover the thesis relevant Front End process as a whole. Hence, it is adapted it in accordance with the process model by Koen et al. (2001) to include strategic level FEI activities as well and to match the project relevant FEI process (cf. section 3.1.4). In the course of the thesis, CF is approached from the innovation management perspective and specifically from the perspective of the strategic FEI (cf. Figure 30).

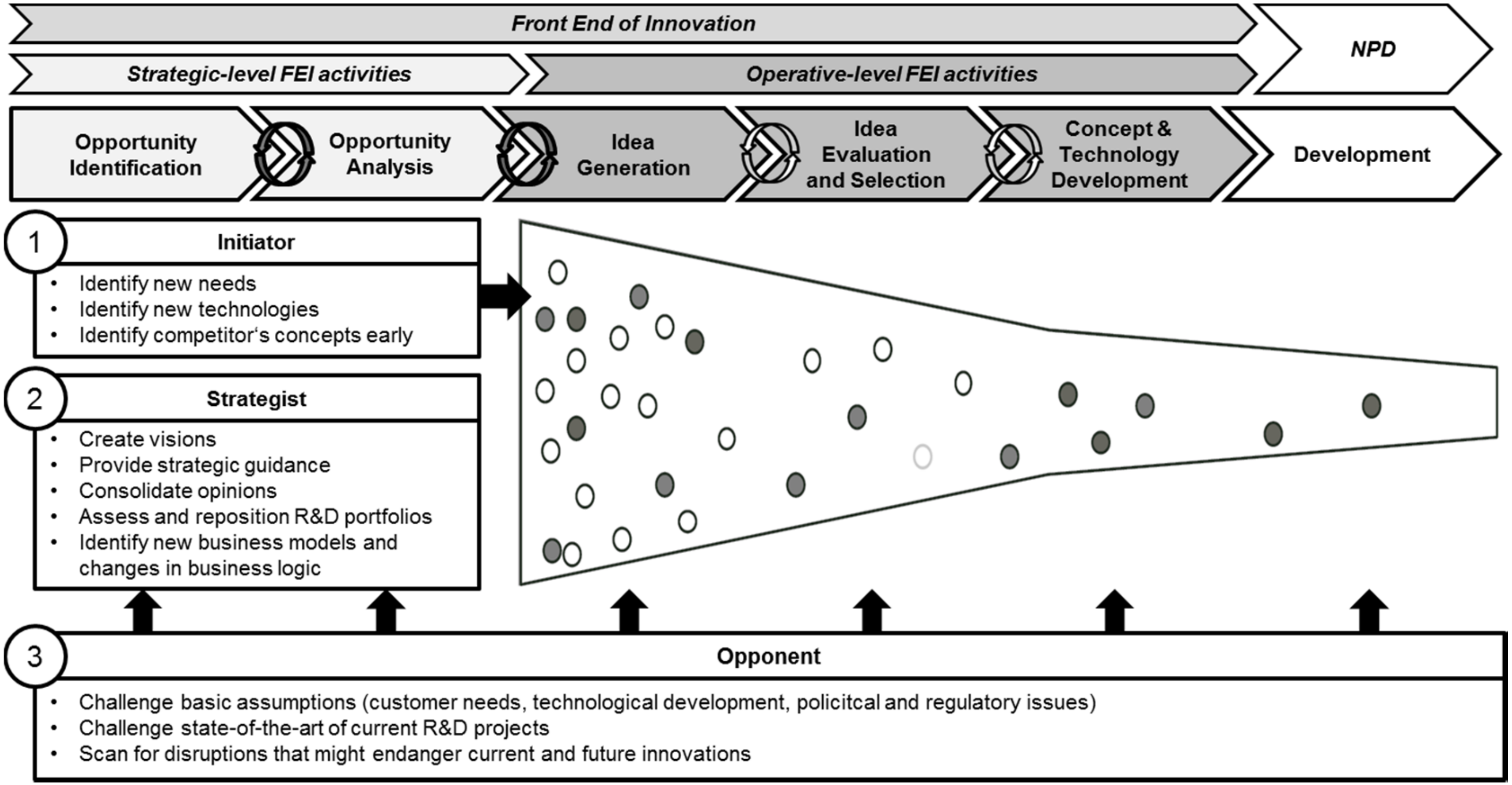


Figure 30: The three roles of CF in innovation management adapted from Rohrbeck (2011) and Koen et al. (2001)

As an important initiator for idea generation, CF is intended to deliver and identify new needs, technologies and developments in the relevant company environment. CF in its strategist role provides the organisation with the possibility to create and maintain a strategically oriented FEI and subsequently supports the further selection of the right ideas to be transferred into the actual NPD process. Thirdly, CF acts as an opponent, meaning that it constantly challenges basic assumptions and current innovation activities and projects. This in turn can result in a higher level of flexibility and shortened reaction times to developments in the relevant company environment (Rohrbeck 2011). Table 23 summarises the main impacts of CF at the FEI and matches them to the derived process model design requirements (PDRs, cf. section 3.2.3):

Table 23: Matching the roles of CF at the FEI based on Rohrbeck (2011) to process model design requirements (cf. section 3.2.3)

Role	***Impact of Role***	***Description***	***Matching PDRs***
Initiator	Identify new needs	Socio-cultural change and/or change in lead customer needs generate new requirements that in turn trigger innovation.	P1-DR1, P1-DR2, P1-DR3
	Identify emerging technologies	Scanning science and technology enables companies to create new products and brace against disruptive and substitution technologies.	P1-DR1, P1-DR2, P1-DR3
	Identify competitors concepts early	Monitoring the activities of competitors is the basis for anticipating their future actions and for planning their own innovation activities.	P1-DR2, P1-DR3
Strategist	Assessing and repositioning of innovation portfolios.	CF provides the future insights to change innovation portfolios.	P1-DR3, P4-DR3
	Providing strategic Guidance.	Future insights are used to define strategic directions.	P4-DR1, P4-DR2
	Identifying new business models.	Foresight exercises challenge current business models and provide insights into alternative ones.	P4-DR3

	Consolidating opinions.	The process of creating future insights is often used to trigger discussion and consolidate opinions throughout the company.	P1-DR3, P4-DR3
	Vision creation.	CF creates pictures of the future to create a common understanding of future directions.	P4-DR1, P4-DR3
Opponent	Challenging basic assumptions.	The foresight activity challenges current innovation activities to adjust to external changes.	P1-DR3, P4-DR1, P4-DR3
	Scanning for disruptions that could endanger current and future innovations.	CF provides information about wild cards, i.e., potential disruptive change.	P1-DR1, P1-DR2
	Challenging the state of the art of current R&D projects.	Foresight projects show how current R&D projects need to be refocused to adapt to changes in the environment.	P1-DR3, P4-DR3

Contrasted to the FEI principles classified in section 4.3 and the process model design requirements derived in sections 4.4 and 4.5, the three roles of CF provide high potential to support these principles and requirements: The initiator role and the opponent role of CF reflect the basic design requirements of FEI principle 1 “Systematic Uncertainty Reduction”. The strategist role and also partly the opponent role of CF address the design requirements of FEI principle 1 and FEI principle 4 “Definition of an innovation strategy and strategic alignment of innovation processes and projects”.

Hence, CF is not only regarded as a valuable and highly useful approach at the FEI in literature, but also reflects the process model design requirements derived in the thesis. Besides CF, Strategic Issue Management (SIM) is regarded to as FEI processes.

5.1.1.2 Strategic Issue Management (SIM)

SIM has been established by Ansoff in the early 1980ies (Ansoff 1980) building on the concept of “strategic issues” (Ansoff 1975). According to Ansoff and as defined in the thesis, a strategic issue is “*a forthcoming development, either inside or out-*

side of the organisation, which is likely to have an important impact on the ability of the enterprise to meet its objectives" (Ansoff 1980, p. 133). A strategic issue may either be positive (e.g. an opportunity to be grasped) or negative (e.g. an unwelcome external threat).

SIM systems are responsible for systematically identifying and capturing signals and trends at an early stage and also for defining first responses to these. Hence, such systems aim at preventing strategic surprises and at enabling the definition of appropriate responses and reactions to opportunities and threats (Ansoff 1980). Systematically monitoring strategic issues contributes to uncertainty reduction at the FEI (cf. section 4.4). Strategic issue management can be supported by collecting and documenting issues in a strategic issue portfolio, which equally comprises external (opportunities and threats) and internal strategic issues (strengths and weaknesses) (Perrott 2011) and represents an interface to the organisation's general strategy framework (cf. Figure 31).

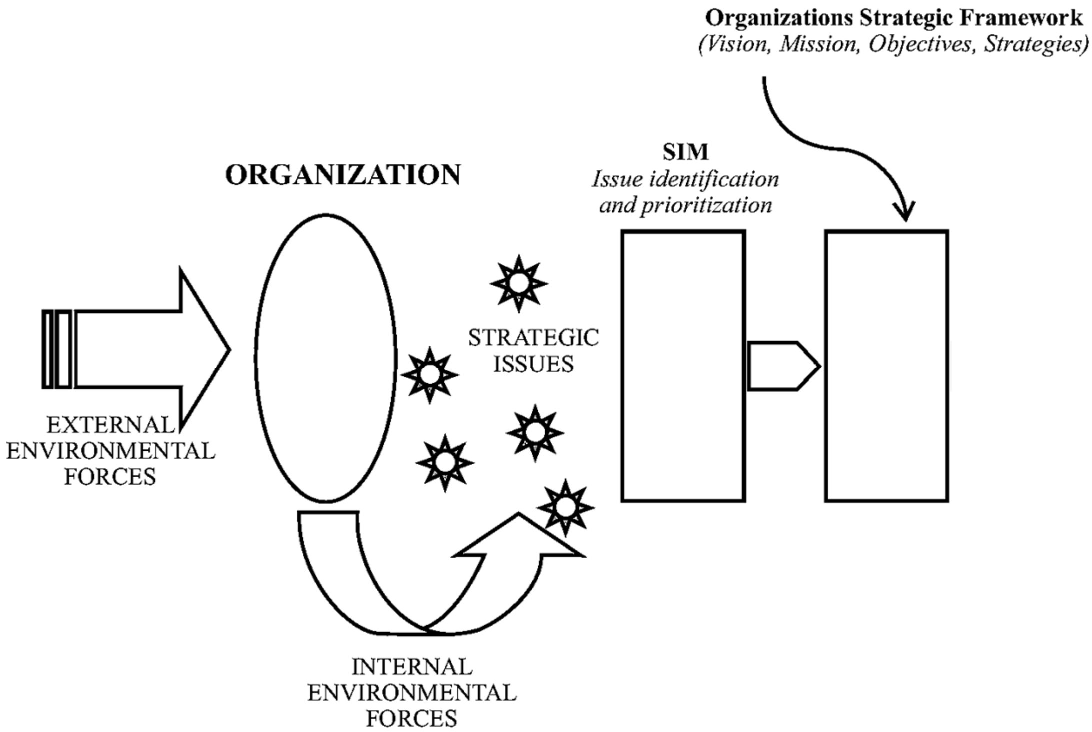


Figure 31: SIM and the organisation's strategic framework (Perrott 2011, p. 23)

In the context of the thesis, the combination of the concept of strategic issues and the systematic approach of CF as discussed in section 5.1.1.1 would allow for benefiting from the synergetic effects of both SIM and CF and increases the chance to identify, analyse and process relevant signals, opportunities and issues at the early stages of the innovation process (Jissink et al. 2015; Förster et al. 2014; Kuhn et al. 2014; Graefe et al. 2010).

5.1.1.3 Summary

By introducing the concept of strategic issues into CF and by merging these concepts into one process model for the strategic FEI, strategic orientation as well as uncertainty reduction can be fostered. Hence, the concept of CF as understood in the thesis draws on the findings of section 5.1.1.1, integrates the concept of strategic issues (cf. section 5.1.1.2) and provides the basis for process model structure.

5.1.2 Process Model Key Terms

Before process elements are defined and its structure is developed, some key terms have to be clarified. Based on the findings of literature (cf. section 1.1, 1.2, 1.6, 3.2 and 5.1) and building on the FEI approaches observable in practice and identified through focus group study (cf. section 3.2.2), the following key terms (cf. Table 24) are included in the process model (also cf. section 4.4 and 4.5).

Table 24: Process Model Key Terms

Key term	***Definition***
Signal	A signal is a potentially relevant opportunity, threat or change in the organisational environment. Hence, signals are warnings or imprecise symptoms of impending future developments, problems or opportunities that are still too incomplete to allow for accurately estimating their impact. In accordance with the derived design requirements, a signal can either emerge from internal or external sources of influence. An organisation should not wait until a trend or change is visible for everyone, but should rather start by detecting signals at an early stage.
	Examples for signals: patents, documents, customer feedback, changes in customer requirements, publications, discussion notes, technological developments, trade fairs, supplier input, legal and political restrictions, competitor activities, social megatrends, etc.
Spark	A “spark” is a signal that has been defined as relevant in the course of an initial signal analysis. By introducing the notion of “spark” into the model, the aim is to clearly distinguish between internal or external signals, which may have been identified but are not relevant and signals, which may influence the organisation and are further referred to as sparks.

	Examples for sparks: patents indicating new technologies in relevant areas, important customer feedback with implications on product portfolio, input from trade fairs indicating cross-industry innovation opportunities, new regulations threatening current businesses, etc.
Strategic issue	A strategic issue is defined as a forthcoming development, either inside or outside of the organisation, which is likely to have an important impact on the organisation's ability to meet its innovation goals. This may either be a trend or a single observation, which may influence the organisation. Strategic issues are described and documented in the strategic issue portfolio of an organisation.
	Examples for strategic issues: an identified and relevant technological trend, identified market developments with implications on current businesses / products / projects, a new patent from a competitor not yet granted but applied for, etc.
Scanning	Scanning includes the general surveillance of internal and external organisational environment in order to (1) detect environmental change already under way and (2) identify early signals of possible internal and external strategic issues. Scanning can either be conducted formally or informally.
	Examples for scanning activities / methods: literature review, analysis of internal and external documents, discussions and presentations on trade fairs, customer and supplier conversations, internal discussions, patent research, scenario workshops, Delphi studies, etc.
Monitoring	Monitoring as defined in the process model involves tracking the evolution of strategic issues unearthed during scanning.
	Examples of monitoring activities / methods: monitoring of defined patent classes, systematic literature reviews, monitoring of legal databases and sources, trend monitoring, social media analysis, etc.
Innovation opportunity	An innovation opportunity represents a potential starting point for deriving strategic issues, for defining and / or adapting innovation goals, for providing further information to already running innovation projects or for serving as in input for corporate strategy definition and / or adaption. Innovation opportunities can either be positive (e.g. an opportunity for improvement or for creating something new and / or better) or negative (take advantage of an opportunity to reduce threats and risks).

	Examples for innovation opportunities: new cross-industry developments providing potential for improvement of current products, change in customer requirements threatening existing products if not dealt with, internal changes providing new strength or weaknesses, etc.

5.2 Process model elements and structure

Based on the results of focus group study, building on existing FEI processes in organisational practice and following the structural requirements of CF and SIM as presented in section 5.1, the structure of the process is developed. More precisely, the basic structure of the process model derives from the FEI processes existing in organisational practice and the ideal typical process structure in practice (cf. Figure 26), the six process model design requirement blocks ("key activities", cf. section 4.6) and the general structure of CF frameworks (Input-Analysis-Output-Strategy, cf. section 5.1.1.1). The combination of the results of these building block leads to a four-step structure: inputs have to be collected, information gathered has to be analysed and findings or output has to be forwarded to the subsequent stages at the FEI respectively to innovation strategy definition. The structure of the process model also addresses the general innovation process and the FEI specific process requirements (cf. Table 21). These requirements, which call for e.g. parallel tasks, interconnections, loops and iterative rather than strictly sequential activity chains, influence process model structure at sub-activity level.

Figure 32 provides the structural overview of the six key activity groups (represented by the EPC symbol for process-paths), their interconnections and the linkage to the subsequent processes of corporate strategy planning, idea generation and the operative NPD process.

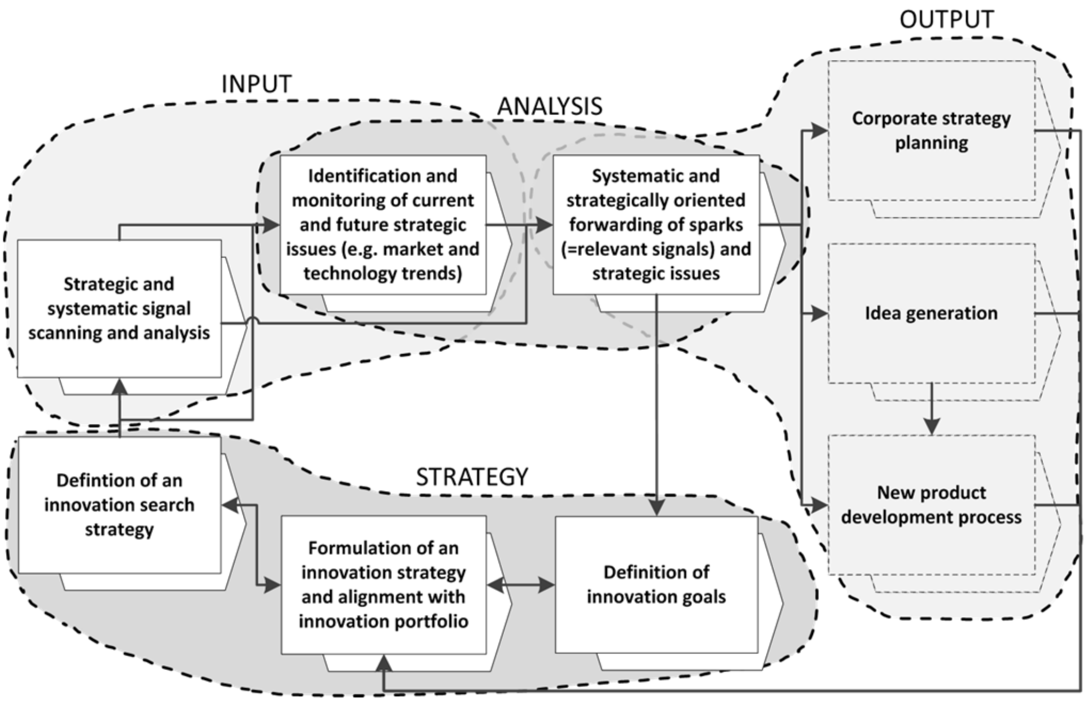


Figure 32: Overview and structure of process model

Subsequently, these single key activity groups and the corresponding sub-activities of the process model are presented in detail. The complete process model depicted in EPC notation is presented in Appendix J.

5.2.1 Strategic and systematic signal scanning and analysis

Uncertainty reduction was found to be the most crucial principle at the FEI (cf. section 3.2.3). The discussion of uncertainty in the context of innovation management and as elaborated in the focus group studies revealed that uncertainty can be reduced by strategically oriented and systematically conducted scanning and monitoring of defined and undefined search areas. Informal scanning activities constitute the earliest part of the process model and are triggered by employees who have realised the necessity for uncertainty reduction and for collecting information from defined as well as from undefined sources even without the provision of concrete topics and themes by innovation management or the organisation. In contrast to informal scanning, formal scanning focusses on defined themes which can be provided e.g. in the form of an innovation search strategy or by innovation management or superiors. Formal and especially informal scanning strongly depends on individual employees or “scouts” conducting it. The main output of signal scanning and analysis are sparks (= relevant signals, cf. section 5.1.2) which represent the basis for subsequent alignment with strategic issues and for deciding further processing of spark. Figure 33 depicts this key activity “Strategic and systematic signal scanning and analysis” of the process model.

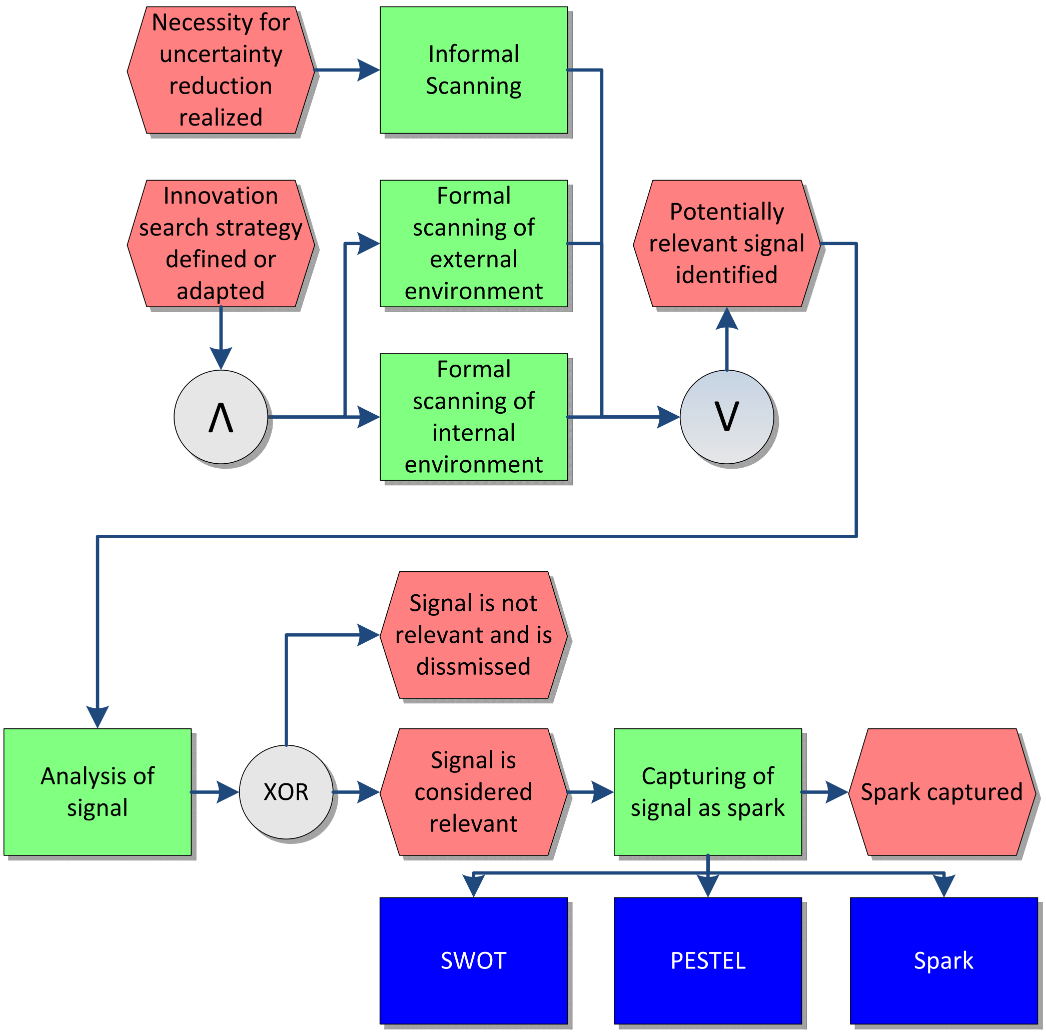


Figure 33: Strategic and systematic signal scanning and analysis

The following tables 25 to 29 in sections 5.2.1.1 to 5.2.1.5 provide detailed descriptions of the single activities, their triggering events and follow-up activities, the in- and outputs, the roles involved, the methods and tools applicable and the data items and documents processed.

5.2.1.1 Informal scanning

Table 25: "Informal scanning" activity

Title of activity:	Informal scanning
Corresponding key activity:	Strategic and systematic signal identification and analysis
Description:	Informal scanning comprises the thematically open search for signals outside as well as inside (informally) defined scanning areas and domains. Scanning areas can either be inside (scanning for internal signals) or outside an organisation (scanning for external signals in the organisational environment) and its domain. Informal scanning does not prescribe defined methods or systematic approaches to signal identification and hence allows for an open, uninhibited signal collection. It puts a premium on individual intuition, informal attention and pattern recognition and relies on the abilities of “scouts” acting as sensors in the internal and external organisational environment. The same applies to directed informal scanning, but this type of informal scanning focusses on defined scanning areas respectively take place within the organisational domain.
Triggering event(s):	Necessity for uncertainty reduction realised
Triggered follow-up activity / activities:	Analysis of signal
Roles:	Individual employees acting as “scouts”
Data item / document:	Informal scanning does not build on or produce defined data items or documents but rather depends on individuals’ way of conducting scanning.
Input:	Internal and external signals from inside and outside the organisation and defined scanning areas or domains.
Outputs:	Potentially relevant signals

5.2.1.2 Formal scanning of external environment

Table 26: "Formal scanning of external environment" activity

Title of activity:	Formal scanning of external environment
Corresponding key activity:	Strategic and systematic signal identification and analysis
Description:	Internal formal scanning can be directed and undirected and comprises the thematically focussed search for signals outside (undirected) as well as inside (directed) defined scanning areas. Scanning areas in this instance specifically cover the external organisational environment only. Formal scanning of external environment builds on the topics and themes provided by the innovation search strategy (cf. key activity “Definition of an innovation search strategy”) and includes the identification of topic related signals outside the organisation.
Triggering event(s):	Innovation search strategy defined or adapted
Triggered follow-up activity / activities:	Analysis of signal
Roles:	Individual employees acting as formal “scouts”; Innovation Management providing topics for formal scanning activities
Data item / document:	Innovation search strategy
Input:	Signals from inside or outside defined scanning areas or domains from outside the organisation, Innovation search strategy;
Output:	Potentially relevant signals

5.2.1.3 Formal scanning of internal environment

Table 27: "Formal scanning of internal environment" activity

Title of activity:	Formal scanning of internal environment
Corresponding key activity:	Strategic and systematic signal identification and analysis
Description:	Internal formal scanning can be directed and undirected and comprises the thematically focussed search for signals outside (undirected) as well as inside (directed) defined scanning areas. Scanning areas in this instance specifically cover the internal organisational environment only. Formal scanning of internal environment builds on the topics and themes provided by the innovation search strategy (cf. key activity “Definition of an innovation search strategy”) and includes the identification of topic related signals inside the organisation.
Triggering event(s):	Innovation search strategy defined or adapted
Triggered follow-up activity / activities:	Analysis of signal
Roles:	Individual employees acting as “scouts”
Data item / document:	Innovation search strategy;
Input:	Signals from inside or outside defined scanning areas or domains from inside the organisation, Innovation search strategy;
Output:	Potentially relevant signals

5.2.1.4 Analysis of signal

Table 28: "Analysis of signal" activity

Title of activity:	Analysis of signal
Corresponding key activity:	Strategic and systematic signal identification and analysis
Description:	Signal analysis represents the first "soft gate" in the process model. Signals deemed potentially relevant by a scout or by innovation management are analysed in regard to their actual relevance for the organisation. Being a soft gate, this initial analysis stage allows for a plethora of signals to be discussed and considered further in the course of subsequent activities and does not "kill" potential sparks too early. Signals are captured by scouts or innovation management. In unclear situations, the first analysis of a signal should also be supported by external experts in order to access external knowledge and competencies at this stage.
Triggering event(s):	Potentially relevant signal identified
Triggered follow-up activity / activities:	Capturing signal of spark
Roles:	Individual employees acting as "scouts"; Innovation Management; External experts
Data item / docu-ment:	Implicit description of signal as basis for analysis
Input:	Signals captured in the course of scanning and monitoring activi-ties; Innovation search strategy
Output:	Relevant or irrelevant signal

5.2.1.5 Capturing of signal as spark

Table 29: "Capturing of signal as spark" activity

Title of activity:	Capturing of signal as spark
Corresponding key activity:	Strategic and systematic signal identification and analysis
Description:	Capturing signal as spark is the final stage of signal identification and analysis and represents the link to the subsequent stages of identifying strategic issues and of forwarding sparks. Signals captured during scanning or monitoring and considered relevant in signal analysis are described and documented as “spark”. Independent of signal source, a spark is a unified document that captures the main elements of the signal and provides the basis for further activities regarding spark processing and integration of sparks into the subsequent stages of the innovation process. Where applicable, sparks should be matched to an organisation’s PESTEL and / or SWOT portfolio. Hereby, a summary of sparks can be built over time and a decision basis for innovation goal definition, innovation search strategy development and hence the general innovation strategy is provided.
Triggering event(s):	Signal is considered relevant
Triggered follow-up activity / activities:	Deciding further processing of spark; alignment of spark with strategic issues
Roles:	Individual employees acting as “scouts”; Innovation Management
Data item / document:	Implicit description of signal as basis for analysis; Spark; PESTEL; SWOT
Input:	Signals considered relevant in the course of first signal analysis
Outputs:	Sparks (= relevant signals), Adaption of SWOT and PESTEL

5.2.2 Identification and monitoring of current and future strategic issues

Identifying and systematically monitoring strategic issues is of crucial relevance at the FEI (cf. sections 3.2.3 and 4.4). Strategic issues are either already known or they are defined based on sparks unearthed during scanning activities. Sparks can indicate the necessity for defining new strategic issues or they can support or contradict existing ones. Once identified and captured in the strategic issue portfolio, strategic issues have to be continuously monitored allowing for tracking their evolution over time. In the course of strategic issue monitoring, new signals can be identified and relevant sparks can be captured. The iterative structure of the process model allows for an ongoing and continuous adaption of the strategic issue portfolio. The main output of "identification and monitoring of current and future strategic issues" are sparks, which in a next step are used to define new or adapt existing strategic issues and which are further processing corresponding to the process model. Figure 34 depicts this key activity "Identification and monitoring of current and future strategic issues" of the process model.

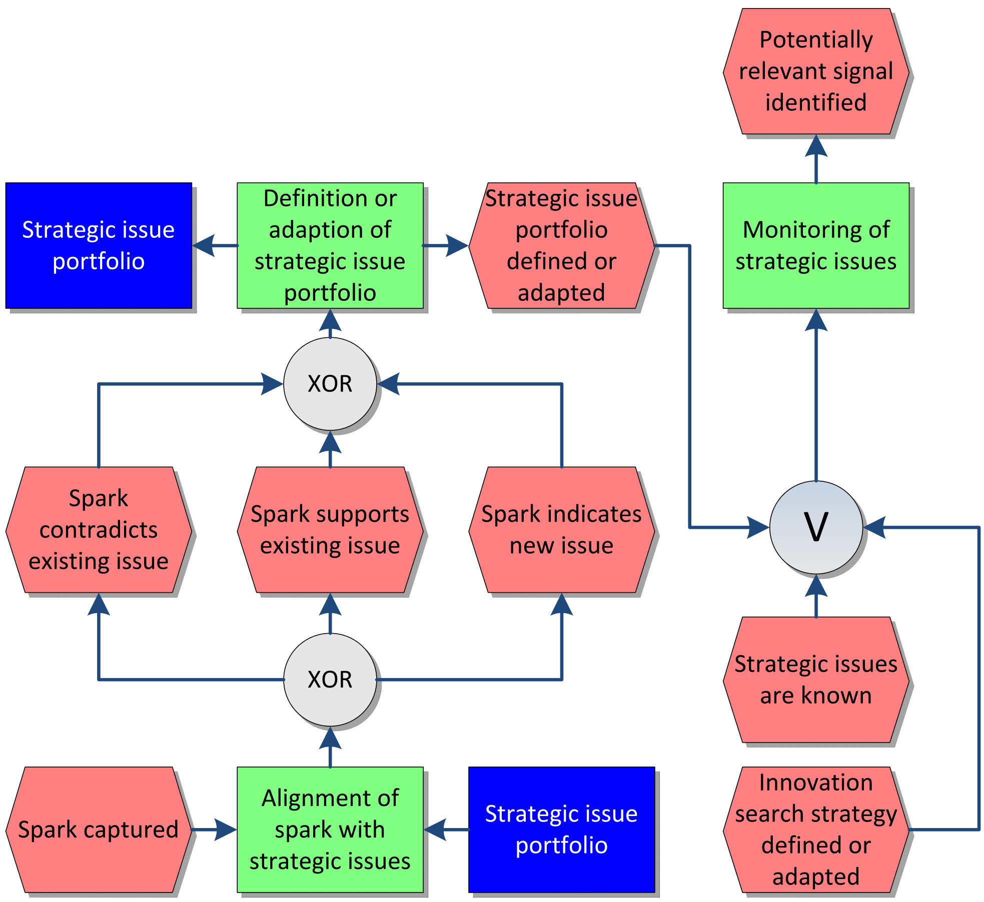


Figure 34: Identification and monitoring of current and future strategic issues

The following tables 30 to 32 in sections 5.2.2.1 to 5.2.2.3 provide detailed descriptions of the single activities, their triggering events and follow-up activities, the in- and outputs, the roles involved, the methods and tools applicable and the data items and documents processed.

5.2.2.1 Alignment of spark with strategic issues

Table 30: "Alignment of spark with strategic issues" activity

Title of activity:	Alignment of spark with strategic issues
Corresponding key activity:	Identification and monitoring of current and future strategic issues
Description:	Alignment of sparks with existing strategic issues aims at identifying overlaps and dependencies between the captured spark and already identified strategic issues. This allows for (1) determining contradictions between sparks and strategic issues, (2) identifying sparks that support existing strategic issues and (3) for uncovering new strategic issues indicated by the respective spark. Based on the previously created spark document and the portfolio of strategic issues (if already existing), sparks and strategic issues are contrasted and aligned by innovation management.
Triggering event(s):	Spark captured
Triggered follow-up activity / activities:	Definition or adaption of strategic issue portfolio
Roles:	Innovation Management
Data item / document:	Spark; Strategic issue portfolio
Input:	Signals considered relevant in the course of first signal analysis;
Outputs:	Sparks (= relevant signals), Adaption of SWOT and PESTEL

5.2.2.2 Definition or adaption of strategic issue portfolio

Table 31: "Definition or adaption of strategic issue portfolio" activity

Title of sub-activity:	Definition or adaption of strategic issue portfolio
Corresponding key activity:	Identification and monitoring of current and future strategic issues
Description:	Definition or adaption of strategic issue portfolio comprises the documentation of a spark's (process path: Identification and monitoring of current and future strategic issues) respectively an innovation opportunity's (process path: Definition of innovation goals) implications on strategic issues. This allows for strategic issues portfolio adaption both based on captured sparks as well as based on innovation opportunities derived in the course of innovation goal definition. Based on the previously created spark document and the innovation opportunities document, the portfolio of strategic issues is adapted or defined. If applicable, the integration of external experts is recommended.
Triggering event(s):	Spark contradicts strategic issue; Spark supports strategic issue; Spark indicates strategic issues; Fit (of innovation opportunity) to current corporate strategy identified
Triggered follow-up activity / activities:	Monitoring of strategic issues
Roles:	Innovation Management; External experts
Data item / document:	Spark; Strategic issue portfolio; Innovation opportunities
Input:	Sparks; Innovation opportunities; Strategic issues portfolio
Outputs:	Defined / adapted strategic issue portfolio

5.2.2.3 Monitoring of strategic issues

Table 32: "Monitoring of strategic issues" activity

Title of activity:	Monitoring of strategic issues
Corresponding key activity:	Identification and monitoring of current and future strategic issues
Description:	Monitoring of strategic issues comprises • the formal and undirected observation and search for further information outside defined search areas and • the formal and directed observation and search for further information inside defined search areas with a thematic emphasis on a known strategic issues. This allows for a detailed, long-term and focused tracking of strategic issues and their sequences. Hereby, information value of sparks gathered in the course of scanning activities or of already known trend and strategic issues can be increased and additional signals in the defined monitoring areas can be identified. Based on the previously created strategic issue portfolio, implicitly known trends and on the innovation search strategy, monitoring activities are conducted by scouts or by innovation management.
Triggering event(s):	Strategic issues portfolio defined or adapted; Strategic issues are known; Innovation search strategy defined or adapted
Triggered follow-up activity / activities:	Analysis of signal
Roles:	Innovation Management; Scouts
Data item / document:	Strategic issue portfolio; Innovation search strategy
Input:	Strategic issues portfolio; Innovation search strategy
Outputs:	Potentially relevant signals

5.2.3 Systematic and strategically oriented forwarding of sparks

Sparks captured in the course of scanning and monitoring activities have to be further processed corresponding to their implications. Based on the spark document, corporate strategy, innovation project portfolio and innovation strategy, spark implications are analysed by innovation management. Depending on the outcome of this analyses, sparks are either forwarded to strategic planning, are aligned with innovation strategy or with existing innovation projects. The main outputs of key activity "systematic and strategically oriented forwarding of sparks" are detailed information about a spark's implications on 1) innovation project portfolio, on 2) innovation strategy and on 3) corporate strategy. Figure 35 depicts the key activity "Systematic and strategically oriented forwarding of sparks" of the process model.

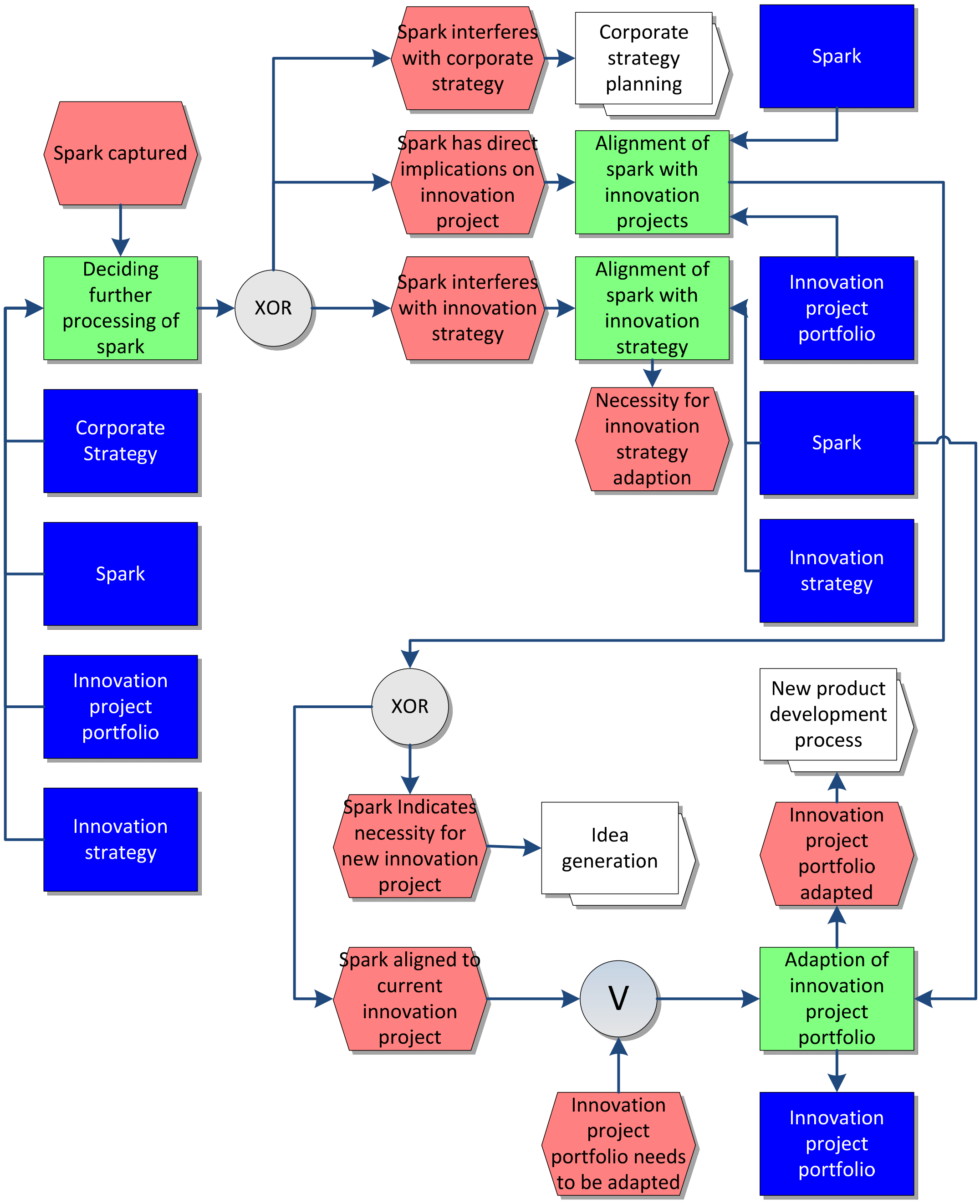


Figure 35: Systematic and strategically oriented forwarding of sparks

The following tables 33 to 36 in sections 5.2.3.1 to 5.2.3.4 provide detailed descriptions of the single activities, their triggering events and follow-up activities, the in- and outputs, the roles involved, the methods and tools applicable and the data items and documents processed.

5.2.3.1 Deciding further processing of spark

Table 33: "Deciding further processing of spark" activity

Title of activity:	Deciding further processing of spark
Corresponding key activity:	Systematic and strategically oriented forwarding of sparks
Description:	Deciding further processing of spark represents a decision gate and aims at defining how to further process a spark based on its implications. Possible process paths include the following options: • In case the spark interferes with the corporate strategy, it is forwarded to corporate strategy planning which is not part of the process model • In case the spark has implications on a current innovation project, it is forwarded to "Alignment of spark with innovation projects" • In case the spark interferes with the innovation strategy, it is forwarded to "Alignment of spark with innovation strategy" This allows for a strategically and oriented systematically conducted forwarding of sparks.
Triggering event(s):	Spark captured
Triggered follow-up activity / activities:	Alignment of spark with innovation projects; Alignment of spark with innovation strategy; Corporate strategy planning
Roles:	Innovation Management
Data item / document:	Spark; Innovation project portfolio; Innovation Strategy; Corporate Strategy
Input:	Innovation strategy; Innovation project portfolio; Corporate strategy; spark
Outputs:	Decision of further spark processing

5.2.3.2 Alignment of spark with innovation strategy

Table 34: "Alignment of spark with innovation strategy" activity

Title of activity:	Alignment of spark with innovation strategy
Corresponding key activity:	Systematic and strategically oriented forwarding of sparks
Description:	Alignment of spark with the organisational innovation strategy aims at identifying possibilities for adaptions to innovation strategy. Corresponding to the spark's implications on innovations strategy, it is forwarded to the subsequent key activity "Definition of innovation goals". Thereby, sparks directly influencing innovation strategy are in the subsequent step of "Formulation or adaption of innovation strategy" integrated in strategy definition and adaption process. Based on the spark document and on the innovation strategy, the spark's implications are evaluated by innovation management and corresponding information is forwarded to innovation goal definition-stage.
Triggering event(s):	Spark interferes with innovation strategy
Triggered follow-up activity / activities:	Aggregation and description of innovation opportunities
Roles:	Innovation Management
Data item / document:	Spark; Innovation Strategy
Input:	Innovation strategy; Spark
Outputs:	Information about sparks implications on innovation strategy

5.2.3.3 Alignment of spark with innovation projects

Table 35: "Alignment of spark with innovation projects" activity

Title of activity:	Alignment of spark with innovation projects
Corresponding key activity:	Systematic and strategically oriented forwarding of sparks
Description:	Alignment of spark with innovation project portfolio aims at identifying possibilities for adaptions to innovation strategy. Corresponding to the spark's implications on existing innovation projects, it can be forwarded as follows: • If the spark can be aligned to an existing innovation project because it e.g. provides further information or insights to a current project, it is forwarded to the subsequent key activity "Adaption of innovation project portfolio" • If the spark cannot be aligned to existing innovation projects but indicates the necessity for a new project, it is forwarded to idea generation process, where e.g. an innovation challenge could be initiated based on the spark Based on the spark document and on the innovation project portfolio, the spark's implications are evaluated by innovation management and corresponding information is forwarded to innovation project portfolio adaption stage.
Triggering event(s):	Spark has direct implications on innovation project portfolio
Triggered follow-up activity / activities:	Adaption of innovation project portfolio; Idea generation; New product development process
Roles:	Innovation Management
Data item / document:	Spark; Innovation project portfolio
Input:	Innovation project portfolio; Spark
Outputs:	Information about sparks implications on innovation project portfolio; Spark as initiator for idea generation process

5.2.3.4 Adaption of innovation project portfolio

Table 36: "Adaption of innovation project portfolio" activity

Title of activity:	Adaption of innovation project portfolio
Corresponding key activity:	Systematic and strategically oriented forwarding of sparks
Description:	Adaption of innovation project portfolio aims at integrating a spark (process path: "Systematically and strategically oriented forwarding of spark") or an innovation opportunity (process path: "Definition of innovation goals") and its information into current or planned innovation projects of the innovation project portfolio. This allows for enriching the information density of innovation projects and for identifying possibilities for adaptions or further steps regarding the respective projects. Based on the spark document respectively the innovation opportunities document and depending on their implications as evaluated by innovation management, the innovation project portfolio is adapted and corresponding information is forwarded to the respective innovation projects.
Triggering event(s):	Innovation project portfolio needs to be adapted; spark aligned to current innovation project
Triggered follow-up activity / activities:	Adaption of innovation project portfolio; Idea generation; New product development process
Roles:	Innovation Management
Data item / document:	Spark document; innovation opportunities document; Innovation project portfolio
Input:	Innovation project portfolio; Spark
Outputs:	Information about spark's or innovation opportunity's implications on innovation project portfolio; Spark or innovation opportunity as initiator for idea generation process

5.2.4 Definition of innovation goals

The definition of innovation goals is a key pre-requisite for defining an innovation search strategy and for developing the innovation strategy. Innovation goals are derived based on innovation opportunities. These opportunities need to be strategically aligned with the corporate strategy and vision and the current innovation project portfolio (cf. section 4.5). Depending on the outcome of this step, innovation opportunities are subsequently used to adapt the innovation project portfolio, are forwarded to strategic planning or provide the basis for defining or adapting innovation goals and the portfolio of strategic issues. The main outcome of this stage are strategically aligned innovation opportunities, adapted strategic issues and defined innovation goals which provide the basis for subsequent innovation search strategy and innovation strategy definition. Figure 36 depicts this key activity "Definition of innovation goals" of the process model.

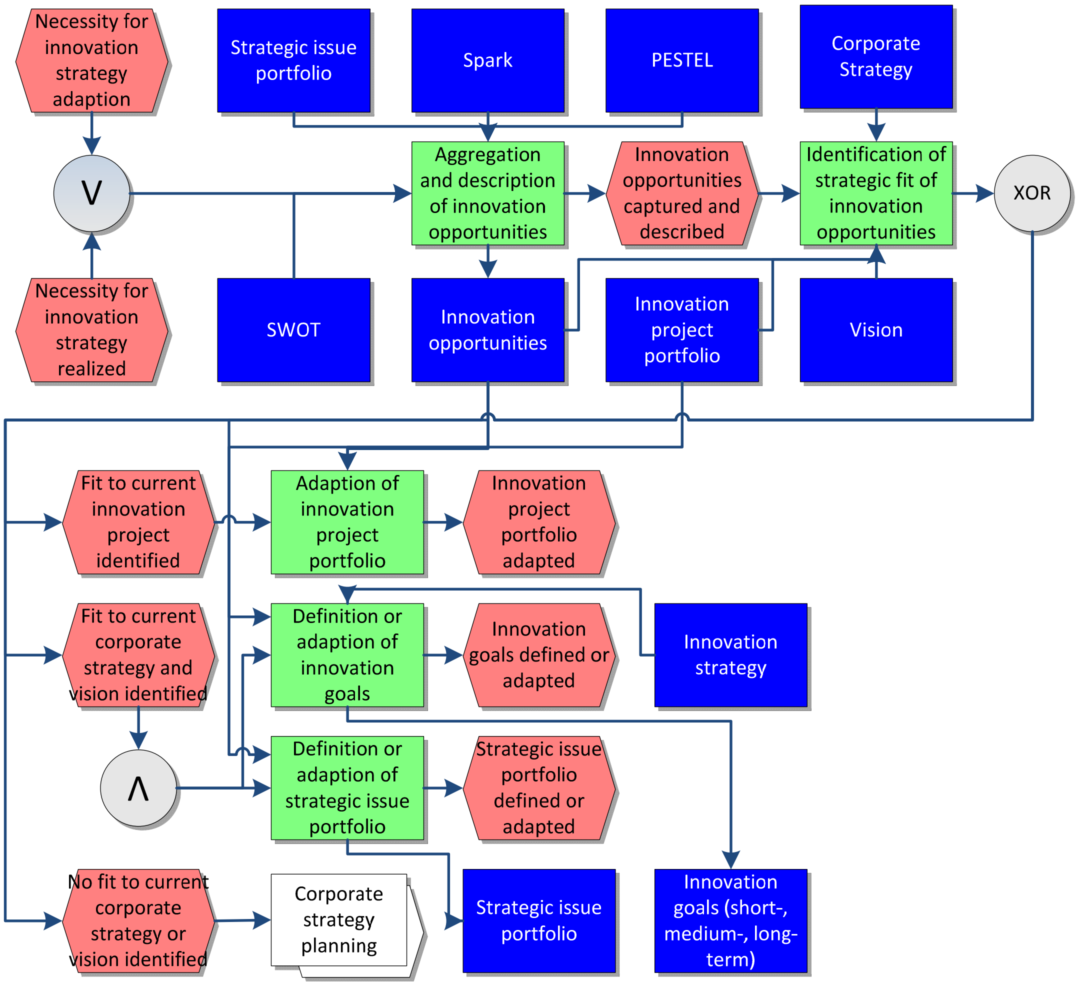


Figure 36: Definition of innovation goals

The following tables 37 to 39 in sections 5.2.4.1 to 5.2.4.5 provide detailed descriptions of the single activities, their triggering events and follow-up activities, the in- and outputs, the roles involved, the methods and tools applicable and the data items and documents processed.

5.2.4.1 Aggregation and description of innovation goals

Table 37: "Aggregation and description of innovation goals" activity

Title of activity:	Aggregation and description of innovation opportunities
Corresponding key activity:	Definition of innovation goals
Description:	Aggregation and description of innovation opportunities aims at identifying and collecting existing innovation opportunities for the organisation. Basis for this activity are: • the strategic issues identified and monitored in the course of key activity "Identification and monitoring of current and future strategic issues" • the SWOT and PESTEL portfolio of the organisation developed in the course of "Strategic and systematic signal scanning and analysis" • (3) the spark documents forwarded as outcome of activity "Systematic and strategically oriented forwarding of sparks Innovation opportunities are derived based on these sources and aggregated in the innovation opportunities document. This activity can either be triggered regularly by the outcome of "Strategic and systematic signal scanning and analysis" or initially by the general awareness of defining an innovation strategy.
Triggering event(s):	Necessity for innovation strategy adaption; Necessity for innovation strategy realised
Triggered follow-up activity / activities:	Identification of strategic fit of innovation opportunities
Roles:	Innovation Management
Data item / document:	Spark; innovation opportunities document; PESTEL; SWOT; Strategic issues portfolio
Input:	Spark; PESTEL; Strategic issues portfolio; innovation opportunities document (if already existing)
Outputs:	Collection and description of innovation opportunities based on sparks, PESTEL, SWOT and strategic issues

5.2.4.2 Identification of strategic fit of innovation opportunities

Table 38: "Identification of strategic fit of innovation opportunities" activity

Title of activity:	Identification of strategic fit of innovation opportunities
Corresponding key activity:	Definition of innovation goals
Description:	Identification of strategic fit of innovation opportunities aims at defining, how the collected innovation opportunities fit to corporate strategy and current innovation projects. Based on the collected opportunities, the vision and the corporate strategy of the organisation and based on current and already planned innovation projects, innovation opportunities can be further process as follows: • In case a fit to a current or planned innovation project is identified, the innovation opportunity is forwarded to subsequent activity "Adaption of innovation project portfolio" • In case the innovation opportunity does not fit to an already planned or current innovation project, but fits to the general corporate strategy and vision, it is forwarded to subsequent activity "Definition or adaption of innovation goals" • In case the innovation opportunity falls outside respectively does not fit to corporate strategy or vision, it has to be forwarded to corporate strategy planning process This allows for further innovation opportunity processing according to its implication.
Triggering event(s):	Innovation opportunities captured and described
Triggered follow-up activity / activities:	Adaption of innovation project portfolio; Definition or adaption of innovation goals; Definition or adaption of strategic issue portfolio;
Roles:	Innovation Management
Data item / document:	Corporate strategy; Vision; Innovation project portfolio; innovation opportunities document
Input:	Corporate strategy; Vision; Innovation project portfolio; innovation opportunities
Outputs:	Classification of innovation opportunities based on their implications as basis for their further processing.

5.2.4.3 Adaption of innovation project portfolio

As explained in section 5.2.3.4, adaption of innovation project portfolio can either be triggered via process path “Systematically and strategically oriented forwarding of spark” or via the current process path “Definition of innovation goals”. Independent from the triggering process path, the activity is the same; refer to section 5.2.3.4 and to Table 36 for further information.

5.2.4.4 Definition or adaption of innovation goals

Table 39: "Definition or adaption of innovation goals" activity

Title of activity:	Definition or adaption of innovation goals
Corresponding key activity:	Definition of innovation goals
Description:	Definition or adaption of innovation goals aims at deriving the goal statements respectively the targets of an organisation’s innovation activities. Besides the innovation search strategy, the definition of concrete innovation goals provides the main basis for innovation strategy definition. Vice versa, an existing innovation strategy also influences innovation goal-definition. Innovation goals are derived based on the innovation opportunities document and defined or adapted based on the existing innovation strategy by innovation management. Innovation goals directly influence innovation search strategy.
Triggering event(s):	Fit to current corporate strategy and vision identified
Triggered follow-up activity / activities:	Definition or adaption of innovation search strategy
Roles:	Innovation Management
Data item / document:	Innovation opportunities document; Innovation strategy; Innovation goals document
Input:	Innovation opportunities; Innovation strategy
Outputs:	Innovation goals

5.2.4.5 Definition or adaption of strategic issue portfolio

As explained in section 5.2.2.2, definition or adaption of strategic issue portfolio can either be triggered via process path "Identification and monitoring of current and future strategic issues" or via the current process path "Definition of innovation goals". Independent from the triggering process path, the activity is the same; refer to section 5.2.2.2 and to Table 31 for further information.

5.2.5 Definition of an innovation search strategy

The innovation search strategy provides the framework for formal scanning and monitoring activities and is defined based on an organisation's innovation goals, its corporate strategy and the portfolio of strategic issues. The innovation search strategy is a main element of the innovation strategy and supports its operationalisation (cf. section 4.5). The main output of this stage is a documented innovation search strategy which provides the framework for scanning and monitoring activities. Figure 37 depicts this current part of the process model:

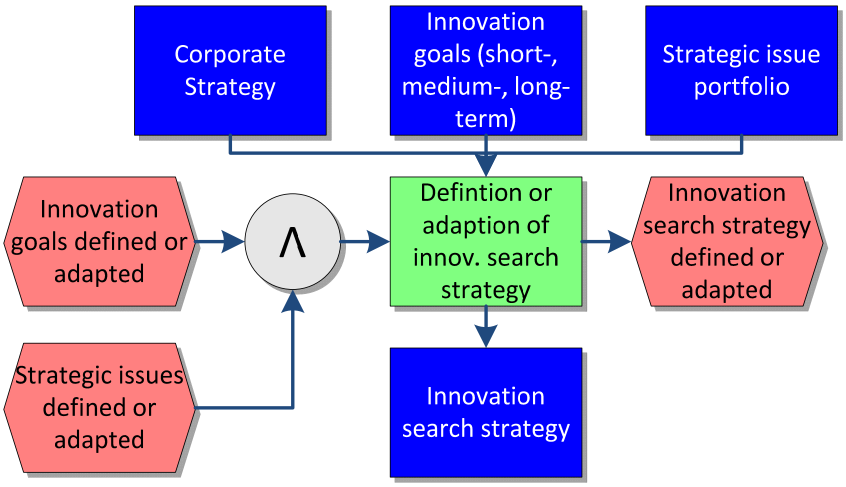


Figure 37: Definition of an innovation search strategy

Table 40 provides a detailed description of this activity, its triggering events and follow-up activities, the in- and outputs, the roles involved, the methods and tools applicable and the data items and documents processed.

Table 40: "Definition or adaption of innovation search strategy" activity

Title of activity:	Definition or adaption of innovation search strategy
Corresponding key activity:	Definition of an innovation search strategy

Description:	Definition or adaption of an innovation search strategy aims at providing the framework for formal scanning and monitoring activities. The innovation search strategy is defined based on an organisation's innovation goals, its corporate strategy and the portfolio of strategic issues. The innovation search strategy includes: • Concrete topics and issues for formal scanning and for monitoring activities, • defined search areas for directed formal scanning and directed monitoring and • recommended data sources and data gathering methods and tools for formal scanning and monitoring activities. Besides the innovation goals, the innovation search strategy is a key element of the overall innovation strategy. Innovation search strategy adaption or definition can either be triggered by a change in innovation goals (process path: "Definition of innovation goals") or an adaption of the strategic issue portfolio (process path: "Identification and monitoring of current and future strategic issues").
Triggering event(s):	Strategic issues defined or adapted; Innovation goals defined or adapted.
Triggered follow-up activity / activities:	Formulation or adaption of innovation strategy
Roles:	Innovation Management
Data item / document:	Corporate strategy; Innovation goals document; Strategic issues portfolio; Innovation search strategy
Input:	Corporate strategy; Innovation goals; Strategic issues
Outputs:	Innovation search strategy as one of the two main elements of innovation strategy

5.2.6 Formulation of innovation strategy & alignment with innovation portfolio

Based on the innovation goals, the innovation search strategy and corporate strategy the innovation strategy is defined. It represents the basis for successful, target-oriented innovation management and plays a crucial role at the FEI. The main objective of the innovation strategy is to set the direction and provide the focus for an organisation's R&D activities, determines its strategic areas of focus for all innovation activities and provides an innovative vision and concrete innovation goals. When implementing an innovation strategy, several steps have to be followed (cf. section 4.5). Figure 38 depicts this key activity "Formulation of an innovation strategy and alignment with innovation portfolio" of the process model. The main output of this stage is a well-defined, documented and strategically aligned innovation strategy.

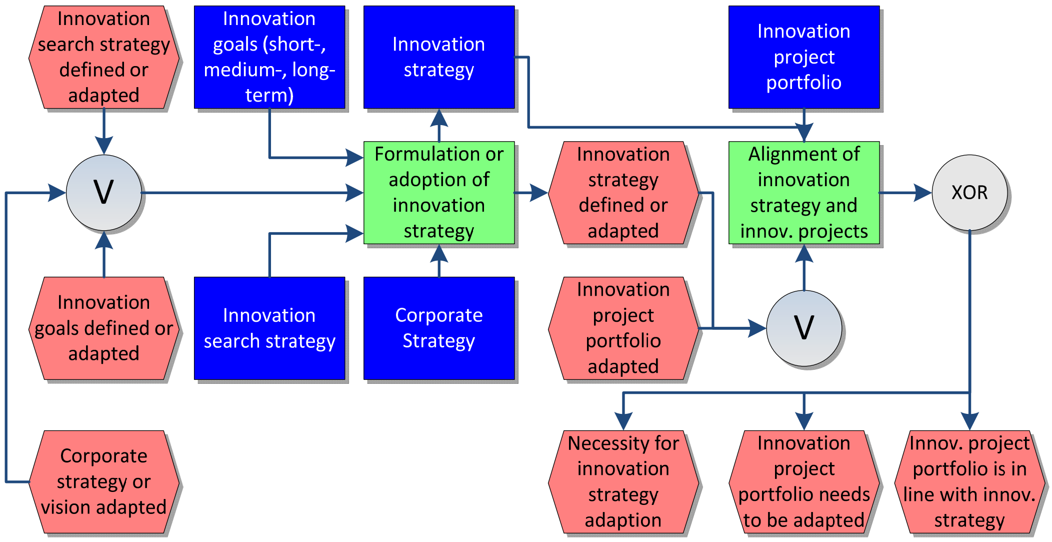


Figure 38: Formulation of an innovation strategy and alignment with innovation portfolio

The following tables 41 and 42 in sections 5.2.6.1 and 5.2.6.2 provide detailed descriptions of the single activities, their triggering events and follow-up activities, the in- and outputs, the roles involved, the methods and tools applicable and the data items and documents processed.

5.2.6.1 Formulation or adaption of innovation strategy

Table 41: "Formulation or adaption of innovation strategy" activity

Title of activity:	Formulation or adaption of innovation strategy
Corresponding key activity:	Formulation of an innovation strategy and alignment with innovation portfolio
Description:	Formulation or adaption of an innovation strategy aims at providing the framework for an organisation's innovation activities and endeavours. The innovation strategy is defined based on an organisation's innovation goals, its corporate strategy and the innovation search strategy. Hence, the innovation strategy includes: • Innovation goals of the organisation • The innovation search strategy • A clear linkage to corporate strategy and vision The innovation strategy is subordinated to corporate strategy and should be defined respectively redefined or adapted in close collaboration between the board of management and innovation management. Besides that, innovation strategy adaption or formulation can either be triggered by a change in innovation goals or an adaption of innovation search strategy which also reflects adaptions of strategic issue portfolio.
Triggering event(s):	Innovation search strategy defined or adapted; Innovation goals defined or adapted; Corporate strategy or vision adapted
Triggered follow-up activity / activities:	Alignment of innovation strategy and innovation projects
Roles:	Innovation Management; Board of Management
Data item / document:	Corporate strategy; Innovation search strategy; Innovation strategy; Innovation goals
Input:	Corporate strategy; Innovation goals; Innovation search strategy
Outputs:	Innovation strategy as overall framework for an organisation's innovation activities and endeavours

5.2.6.2 Alignment of innovation strategy and innovation projects

Table 42: "Alignment of innovation strategy and innovation projects" activity

Title of activity:	Alignment of innovation strategy and innovation projects
Corresponding key activity:	Formulation of an innovation strategy and alignment with innovation portfolio
Description:	Alignment of innovation strategy and innovation projects aims at assuring the integration of innovation strategy into the actual new product development process by aligning strategy to current and planned innovation projects. By contrasting the innovation strategy and the focus and themes of innovation projects, overlaps, dependencies and necessities for innovation project portfolio or innovation strategy adaptions can be identified by innovation management.
Triggering event(s):	Innovation strategy defined or adapted; Innovation project portfolio adapted;
Triggered follow-up activity / activities:	Adaption of innovation project portfolio; Aggregation and description of innovation opportunities
Roles:	Innovation Management
Data item / document:	Innovation strategy; Innovation project portfolio
Input:	Innovation strategy; Innovation project portfolio
Outputs:	Trigger for adapting the innovation project portfolio respectively the innovation strategy

5.3 Summary of Process Model Development

The developed process model is based on the process model foundations presented in section 4.6, builds on existing FEI processes in organisational practice and follows the structural requirements of CF and SIM as presented in section 5.1. The combination of these results leads to a solid and comprehensive process model, consisting of six key activity groups and 19 sub-activities. For each key activity, an overview of sub activities is depicted in the form of the respective part of the EPC-based process model. Each sub-activity is then described in detail in table-form.

6 Ex-Post Process Model Evaluation Approach

The first part of the evaluation approach (ex-ante evaluation) has already been explained and presented in section 2.2.3. The results of ex-ante evaluation “Eval 1” have been presented in section 1.2 and 1.3 and contributed to deriving and defining a rigorously grounded and practically relevant problem statement and research gap as starting point for process model design requirements derivation. Likewise, the results of ex-ante evaluation “Eval 2” were presented in sections 3.2.2.2 to 3.2.2.4 and were summarised in section 3.2.2.5.

The current section 6 discusses and presents a suitable approach for the ex-post evaluation, which allows for analysing the quality and usefulness of the constructed artefact in the form of the final process model in its application environment. Ex-post evaluation with suitable criteria allows for final artefact legitimisation (Cleven et al. 2009) and enables checking the model by comparing it with the audience’s interpretation of the model (Krogstie et al. 1995). The FEI is characterised by unstable requirements, complex relationships and interactions among subcomponents of the problem and constraints based upon ill-defined environmental contexts. At this stage of the innovation process, implicit knowledge and non-standardised processes and activities dominate organisational practice (cf. section 1). The FEI hence has a high degree of complexity and an appropriate evaluation approach of a process model for this part of the innovation process should allow for grasping this complexity (Stevens 2014; Akbar, Tzokas 2013; Ho, Tsai 2011; Jörgensen et al. 2011).

Following the distinction between artificial and naturalistic evaluation presented in section 2.2.3 it can be stated that naturalistic evaluation better allows for embracing the complexities of real user, real systems and real problems than artificial evaluation does (cf. section 2.2.3). Hence, the most appropriate ex-post evaluation in this thesis is a naturalistic one. Subsequently, the evaluation criteria (section 6.1), the evaluation methods (section 6.2) and a summary of ex-post evaluation (section 6.3) is presented.

6.1 Evaluation Criteria

Previous research states that artefacts can be evaluated e.g. in terms of consistency, accuracy, reliability, fit with the organisation, usefulness and other relevant quality attributes (Hevner et al. 2004; March, Smith 1995;). The application of appropriate evaluation criteria is of essential importance in scientific research in general and in particular in design science projects where artefacts have to be assessed against criteria of value or utility (March, Smith 1995). Utility of artefacts is a complex deliverable and may depend on various attributes of the outcomes of artefact use or the artefact itself (Ostrowski, Helfert 2012). The term utility is used synonymously to the term usefulness in literature (cf. e.g. Prat et al. 2014) and utility has often been assessed through perceived usefulness (cf. Adipat et al. 2011; Reeder et al. 2011; Featherman 2001). Therefore, the term usefulness or perceived usefulness is selected rather than the term utility. Artefact evaluation is quite specific to each artefact, its purpose and the purpose of evaluation. In this context, literature divides between two types of artefacts: product and process artefacts (Ostrowski, Helfert 2012; McNaughton et al. 2010; Pries-Heje et al. 2008). Product artefacts include e.g. tools, software or diagrams which can be by applied by users to solve certain problems. A process artefact is a method, procedure or model that guides users during the process of problem solving. The artefact (the process model developed) in this thesis can be classified as process artefact and evaluation criteria should be defined accordingly. Process artefact usefulness should be evaluated in the course of user-artefact interaction (Ostrowski, Helfert 2012).

Content measures for artefact evaluation are often closely linked with quality criteria, as quality can be described in terms of more or less measurable sets of criteria (Pries-Heje et al 2008). Differences in quality measurement results reflect differences in the state or quantity of specific artefact attributes (Venable et al. 2016). Various definitions of quality can be found in literature (Basu, 2016). The underlying assumption of process based quality is that a good process will lead to a good process outcome respectively result or product (Pries-Heje et al. 2008). In terms of conceptual model quality, most approaches focus on three core levels of quality (cf. e.g. Helfert et al. 2012; Liu et al. 2012; Rittgen 2010; Maes, Poels 2007; Mendling et al. 2007b; Moody et al. 2003; Moody et al. 2002; Venkatesh, Davis 2000; Krogstie et al. 1995; Lindland et al. 1994; Davis et al. 1989):

- Syntactic Quality (SNQ),
- Semantic Quality (SMQ) or Perceived Semantic Quality (PSQ), and
- Pragmatic Quality (PMQ) or Perceived Usefulness (PU).

These three levels of quality are supported by a plethora of references and are used as the three main evaluation dimensions for the thesis (cf. Figure 39).

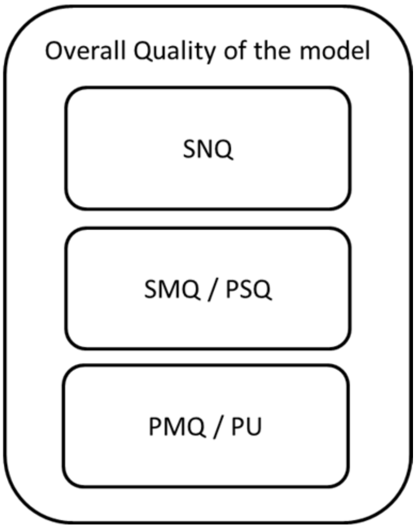


Figure 39: Process Model Quality Dimensions of the Thesis

A good summary is provided by Mendling, who states that "*syntactic quality relates to model and modelling language; semantic quality to model, domain, and knowledge; and pragmatic quality relates to model and modeling and its ability to enable learning and action*" (Mendling et al. 2007b, p. 50).

According to literature, syntactical issues are well controlled and can be measured objectively. The main evaluation effort would therefore be directed towards semantic and pragmatic model quality, which are potentially harder to measure and evaluate (Mohagheghi et al. 2009; Krogstie et al. 2006; Poels et al. 2003). Subsequently, syntactic and semantic quality is presented in detail in section 6.1.1 and 6.1.2, pragmatic quality respectively process model usefulness is discussed in section 6.1.3.

6.1.1 Syntactic Quality of Process Model (SNQ)

The syntactic quality of a model refers to the extent to which it observes the rule of its underlying modelling language (Event-Driven Process Chain notation in the present case, cf. section 4.2.2) (Rittgen 2010). In the syntactic quality dimension, only one quality characteristic – namely syntactical correctness is to be evaluated. A model is correct from a syntactical point of view if all statements of the model are according to the syntax and vocabulary of the modelling language and the underlying notation (Krogstie et al. 1995). An EPC process model has to fulfil certain syntactic criteria, which have already been presented in section 4.2.2 (BPMR 1 – BPMR 4). A number of approaches that used modelling conventions as a metric for syntactic quality can be found in literature (cf. Rittgen 2010).

Different tools support the verification of EPC soundness and offer automatic consistency checks, syntax checks, animations and filtering features and layout placements (Mendling et al. 2007a; Rosemann et al. 2001). A prominent example of such a tool is e.g. the "bflow* toolbox" (http://www.bflow.org/) developed in close collaboration between numerous Universities and Universities of Applied Sciences (cf. e.g. Böhme et al. 2010; Gruhn, Laue 2010; Hogrebe et al. 2009; Laue et al. 2009). The bflow* toolbox is constantly revised and maintained and has been applied in various settings and research projects to evaluate syntactical correctness of EPC based process model. This tool allows for modelling EPC based processes and provides the user with immediate feedback regarding the syntactical correctness of the model. It takes into account the requirements defined for evaluating syntactical correctness of process models and is applied in this quality dimension of the thesis.

6.1.2 Perceived Semantic Model Quality (PSQ)

Semantic quality of a conceptual model (the FEI process model in the present case) is defined as the degree of correspondence between the externalised model and the domain of the model (Krogstie et al. 1995). In other words, semantic quality refers to the correspondence between the information that users deem necessary for the conceptual model based on their domain knowledge and the knowledge they think the process model actually contains, i.e. user interpretation (Maes, Poels 2007). Hence, semantic quality measures model quality in terms of what the model includes that is not present in the domain and of what the model does not include that is present in its domain (Liu et al. 2012; Bolloju, Leung 2006). According to Krogstie et al. (1995) the primary goal for semantic quality is reaching the highest degree of correspondence between these two dimensions possible.

Evaluating the semantic quality of a conceptual model or schema is more difficult than evaluating its syntactical correctness of a model. The evaluation of semantic quality can only refer to process model users' perception of reality, and evaluation results strongly depend on factors like cognitive abilities, previously acquired knowledge, and ontological and epistemological standpoints taken (Maes, Poels 2007; Poels et al. 2005b). Various studies tried to quantify the level of semantic quality in regard to a specific reference theory or modelling benchmarks serving as substitutes for the real domain (Gemino, Wand 2003). One weakness of such approaches could be the fact, that such studies ignore user beliefs of if and how well the model supports and fosters their understanding of the underlying reality (Poels et al. 2005b). According to e.g. Krogstie et al. (1995), Maes, Poels (2007), Rittgen (2010) or Poels et al. (2005b) user perception based measurements of semantic quality are more suitable to determine whether benefits will result from using a conceptual model than verified but theoretical quality measurements. As the correspondence between model and domain cannot be checked or established directly, what has to be done at quality control is not to analyse the actual semantic quality, but the perceived semantic quality of the process model based on comparisons of users interpretation of the model and users domain knowledge. The perceived semantic quality in the present case serves an operational surrogate of semantic quality and directly verifies the correspondence between users' domain knowledge and their interpretation of the model.

Relying on the idea of reasoned action (Fishbein, Ajzen 1977) perceived semantic quality was introduced by Shanks et al. (Shanks et al. 2003) and extended respectively revised by other researchers. It has since that undergone substantial empirical validation and has been redefined in experiments based on reliability and validity tests (e.g. in Rittgen 2010). Depending on the respective source, four to seven indicators are used for evaluating perceived semantic quality (Poels et al. 2005a). Maes and Poels proposed and validated a four-indicator measurement system including correctness, completeness, authenticity (realistic) and relevance (Poels et al. 2005b). Shanks et al. (2003) added the attributes conflict and redundancy free, stating that the semantics represented in the single parts of the model should not contradict one another and should not contain redundant semantics (Shanks et al. 2003). These two attributes of semantic quality were subsumed under the indicator of consistency by Lindland et al. (1994). In further studies, Maes as well as Lindland found that consistency is subsumed by both correctness and completeness, and derived and validated the consolidated four-indicator PSQ-system described above (Rittgen 2010; Maes, Poels 2007; Lindland et al. 1994;). Figure 40 depicts these different indicators applied for evaluating the Perceived Semantic Quality (PSQ) of the process model. It is important to state that these indicators have already undergone substantial empirical validation in the course of experiments based on reliability and validity test (e.g. in Maes, Poels 2007 or Shanks 2003).

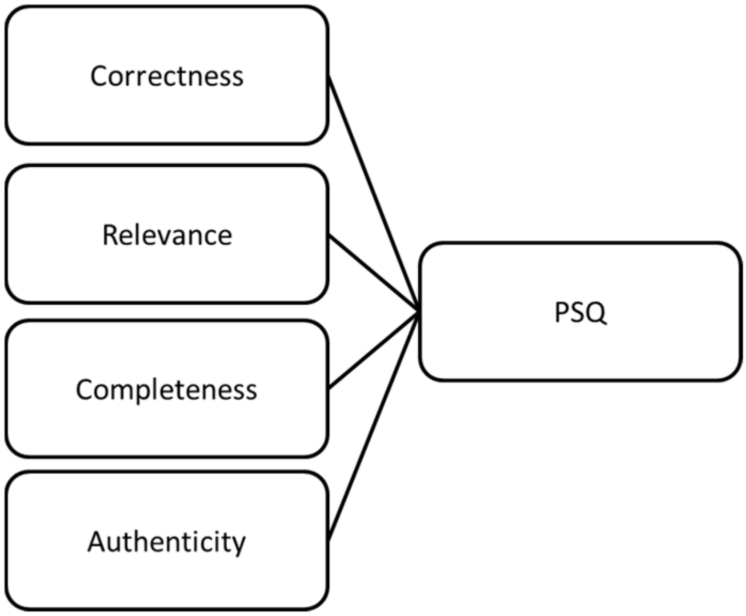


Figure 40: Indicators for PSQ acc. to Rittgen (2010), Maes and Poels (2007) and Poels et al. (2005b)

The items of PSQ and the sources stating their relevance as well as the statements to be measured are presented in the following table. The concrete statements were taken from the validated PSQ measurement system of Rittgen (Rittgen 2010), which was validated and further developed by Rittgen based on Maes and Poels (2007) and based on Maes et al (2005). All items are measured on a 7-point Likert scale, where 1 - strongly disagree, 2 - moderately disagree, 3 - somewhat disagree, 4 - neutral (neither disagree nor agree), 5 - somewhat agree, 6 - moderately agree, and 7 - strongly agree.

Table 43: Items and measurement statements for PSQ

Item				**Statement to be measured**
Abbr.	Title	Description	Sources for item	
CORR	Correctness	All statements in the representation are correct.	Rittgen 2010; Maes, Poels 2007; Poels et al. 2005a; Moody et al. 2002; Krogstie et al. 1995; Lindland et al. 1994.	The conceptual model represents the business process correctly.

REL	Relevance	All statements in the representation are relevant to the problem.	Rittgen 2010; Maes, Poels 2007; Moody et al. 2002; Krogstie et al. 1995.	All the elements in the conceptual model are relevant for the representation of the business process.
COMP	Completeness	The representation contains all statements about the domain that are correct and relevant.	Rittgen 2010; Maes, Poels 2007; Poels et al. 2005a; Moody et al. 2002; Krogstie et al. 1995; Lindland et al. 1994.	The conceptual model gives a complete representation of the business process.
				Entities, relationships or structural constraints must be added to adequately represent the business process.
AUTH	Authenticity	The representation gives a true account of the domain.	Rittgen 2010; Maes, Poels 2007; Poels et al. 2005a.	The conceptual model is a realistic representation of the business process.

6.1.3 Perceived Usefulness (Pragmatic Quality of Process Model)

Pragmatic process model quality describes a process model's ability or usefulness to facilitate learning and action in an organisational context (Burton-Jones, Gallivan 2007; Krogstie et al. 2006; Gemino, Wand 2005). Applied to the current thesis, pragmatic process model quality describes the usefulness of the model in real organisational FEI processes. Several measures have been proposed for evaluating the pragmatic quality of process models, ranging from analysing comprehension task accuracy to measuring user perceptions of model pragmatics (Burton-Jones, Gallivan 2007; Gemino, Wand 2005; Maes et al. 2005; Bodart et al. 2001; Siau et al. 1997). Users perceptions of pragmatic process model quality have often been measured with instruments for user information satisfaction and ease of use as well as with instruments for usefulness or utility (Burton-Jones, Gallivan 2007; Gemino, Wand 2005; Maes et al. 2005).

Usefulness or utility of artefacts represents probably the most relevant evaluation criterion in DSR, since this research paradigm postulates for its outputs to be above all useful for practitioners (Hevner et al. 2004). In other words, useful means that the artefact built has to benefit to its application environment (the FEI in the present case) and must assist in achieving certain goals of the organisation in this environment (e.g. achieving a reduction of uncertainty, cf. 3.2.2.5). Usefulness has often been assessed through PU (e.g. in Adipat et al. 2011; Reeder et al. 2011). Useful is hereby defined as proposed by Davis, who stated that a system or model is useful, if it is capable of being used advantageously (Davis 1989). In the context of the evaluation approach, pragmatic process model quality is measured based on the PU of the model as rated by real users. A system or a process model that is high in PU is one for which its actual users believe "*in the existence of a positive use-performance relationship*" (Davis 1989, p. 320).

In the course of the current thesis, perception-based measurements for pragmatic process model quality respectively for usefulness are chosen for several reasons. Firstly, perceptions of senior executives and middle managers were found to be a good proxy for organisational performance of IT and process models in prior research (Nair et al. 2012; Rittgen 2010; Elbashir et al. 2008; Tallon, Kraemer 2007; Zhuang, Lederer 2003). A high convergence between perceptual data collected from senior as well as form lower level management and objective performance measures can be stated (Elbashir et al. 2008; Ray et al. 2005; Venkatraman, Ramanujam 1987). Secondly, some of the benefits from the process model are intangible or qualitative in nature and are therefore not available as objective measures. Furthermore, most of the data items are strategic and confidential in nature and are not publicly available. Thirdly, the actual implementation of such a comprehensive and wide-ranging process model would require a substantial period of time. The main reason why perception-based evaluation of process model usefulness is chosen is because of the fact that the effects of process model implementation and the benefits to the innovation process would not be reliably relatable to specific outcomes, would hence not be measureable and would mainly be of intangible nature. The use of perception-based measurements is most reasonable in the current context and provides opportunities for insights into these intangible, quality-related future benefits.

Evaluation of PU may be done qualitatively or quantitatively (Prat et al. 2014). Quantitative evaluation of PU leads to a perceived numeric value of usefulness. Perception of usefulness can either be estimated directly or through defined items that contribute to overall usefulness (Prat et al. 2014; Rittgen 2010; Davis 1989).

In the area of conceptional modelling, PU has e.g. been applied in prior studies of Prat et al. (2014), Rittgen (2010), Maes et al. (2005) or Moody et al. (2003). Some authors applied an adaption of the Technology Acceptance Model (further referred to as TAM) by Davis (Davis (1987) and Venkatesh, Davis (2000), which has been widely used for different types of artefacts and also for conceptual models (cf. e.g. Adipat et al. 2011; Recker, Rosemann 2010b).

The measurement items of the TAM for PU have been shown to be robust and have displayed high levels of validity and reliability in a variety of settings and research domains (Recker, Rosemann 2010b; Schepers, Wetzels 2007; King, He 2006; Lee et al. 2003). In accordance with the discussion of PU presented above, an adaption of the TAM in its second version (Venkatesh, Davis 2000) is used to evaluate PU of the artefact. The reasons for this are as follows: Firstly, the development of a new measurement instrument for the present case would bring only limited new insights to the research domain and it would be difficult and not reasonable to validate such a new collection of constructs and items. Secondly, the TAM and adaptions of it have been applied in various settings in the context of conceptual models (cf. e.g. Tan, Siau 2006, Riemenschneider et al. 2002; Chau 1996) and have shown to produce robust, reliable and valid results (Recker, Rosemann 2010b). According to the TAM by Davis (Venkatesh, Davis 2000; Davis 1989; Davis 1987), PU directly influences the actual intention to use a system - respectively a process model in this instance (cf. e.g. Recker, Rosemann 2010b; Rittgen 2010 or Moody 2002).

Perceived Usefulness (PU) is „*the degree to which a person believes that using a particular system would enhance his or her job performance*" (Davis 1989, p. 320). Applied to the current thesis PU is the degree to which a person believes that applying the developed process model would enhance his or her performance at the FEI and directly addresses the proposed design hypothesis of the thesis (cf. section 1.3). Validated measures are needed in order to evaluate PU. A literature review revealed several validated multi-item measures for PU, most of them building on the TAM by Davis (Davis 1989; Davis 1987). Based on the original TAM by Davis, Venkatesh and Rittgen proposed specific measures and items for evaluating PU of systems and conceptual models (Rittgen 2010; Venkatesh, Davis 2000). Figure 41 depicts the items of PU.

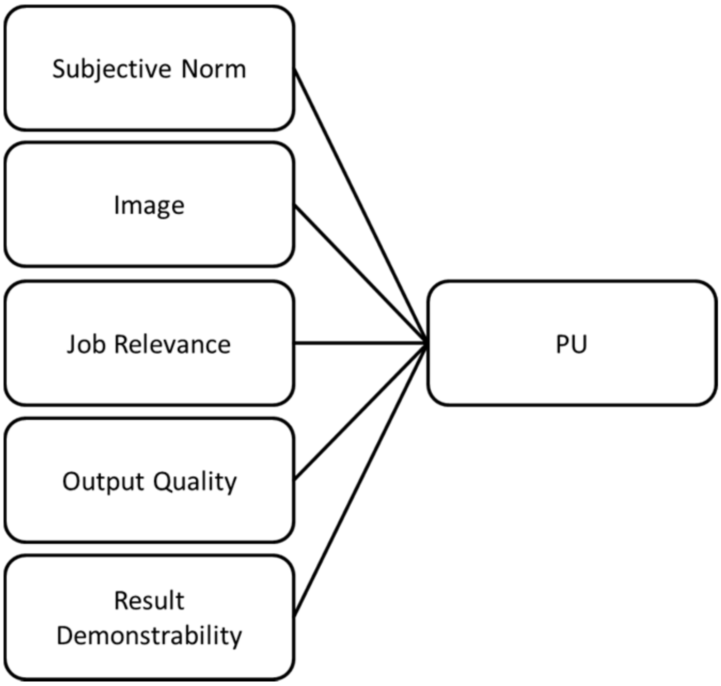


Figure 41: Indicators for PU of Conceptual Models acc. to Rittgen (2010), Recker (2010) and Venkatesh (2000)

The items of PU and the sources stating their relevance as well as the statements to be measured are presented in Table 44. The concrete statements were adapted to the current research background based on the original statements of Venkatesh and Davis (Venkatesh, Davis 2000) by replacing the notion “system” with the notion “process model”. All items are measured on a 7-point Likert scale, where 1 - strongly disagree, 2 - moderately disagree, 3 - somewhat disagree, 4 - neutral (neither disagree nor agree), 5 - somewhat agree, 6 - moderately agree, and 7 - strongly agree.

Table 44: Items and measurement statements for PU

Item			**Statement to be measured**
Abbr.	Title	Sources for item	
SN	Subjective Norm	Horst et al. 2007; Schepers, Wetzels 2007; Venkatesh, Davis 2000; Taylor, Todd 1995.	People who influence my behaviour think that I should use the process model
			People who are important to me think that I should use the process model.

IM	Image	Venkatesh, Davis 2000.	People in my organisation who use the process model would have more prestige than those who do not.
			People in my organisation who use the process model would have a high profile.
			Working with the process model would be a status symbol in my organisation.
JR	Job Relevance	Rittgen 2010; Venkatesh, Davis 2000; Davis 1989.	In my job, usage of the process model is important.
			In my job, usage of the process model is relevant.
OQ	Output Quality	Moody 2003; Venkatesh, Davis 2000; Davis 1989.	The quality of the output I get from the process model is high.
			I have no problem with the quality of the process model's output.
RD	Results Demonstrability	Moody 2003; Venkatesh, Davis 2000.	I have no difficulty telling others about the results of using the process model.
			I believe I could communicate to others the consequences of using the process model.
			The results of using the process model are apparent to me.
			I would have difficulty explaining why using the process model may or may not be beneficial.
PU	Perceived Usefulness	Rittgen 2010; Moody 2003; Venkatesh, Davis 2000; Davis 1989.	Using the process model would improve my performance in my job.
			Using the process model in my job would increase my productivity.
			Using the process model would enhance my effectiveness in my job.
			I find the process model to be useful in my job.

6.2 Evaluation Methods

Various different evaluation methods applicable in design science projects can be found in literature (Helfert et al. 2012; Ostrowski, Helfert 2012; Venable et al. 2012; Cleven et al. 2009). As the goal of the evaluation approach is to evaluate the artefact in its actual application domain with real users, real systems and facing real problems, naturalistic evaluation methods best fit for the current ex-post evaluation activities (cf. section 2.2.3). This allows for embracing all the complexities which are predominant not only in real application settings but which also dominate organisational practice at the FEI (cf. section 1.1). The following DSR evaluation method selection framework (cf. Table 45) provides an overview of ex-ante and ex-post evaluation methods and further categorises these into naturalistic and artificial:

Table 45: DSR Evaluation Method Selection Framework by DSR Evaluation Method Selection Framework by Venable et al. (2012)

	Ex-ante	***Ex-post***
Naturalistic	• Action Research • Focus Group	• Action Research • Case Study • Focus Group • Participant Observation • Ethnography • Phenomenology • Survey (qualitative or quantitative)
Artificial	• Mathematical or Logical Proof • Criteria-Based Evaluation • Lab Experiment • Computer Simulation	• Mathematical or Logical Proof • Lab Experiment • Role Playing Simulation • Computer Simulation • Field Experiment

Considering the nature of the evaluation criteria, the research methodology applied and the experiences and recommendations regarding the evaluation of PSQ and PU in research community, a survey method is chosen for ex-post evaluation (as e.g. in Venable et al. 2012; Siau, Rossi 2011; Recker, Rosemann 2010b; Rittgen 2010; Cleven et al. 2009; Maes et al. 2005; Poels et al. 2005a). More precisely, a semi-quantitative, questionnaire based survey with qualitative comment fields (cf. section

6.3) is used for data gathering and collection The questionnaire contains all the statements presented in Table 43 and Table 44 and the additional comment fields for PU and PSQ presented in section 6.3. All items are measured on a 7-point Likert scale, where 1 - strongly disagree, 2 - moderately disagree, 3 - somewhat disagree, 4 - neutral (neither disagree nor agree), 5 - somewhat agree, 6 - moderately agree, and 7 - strongly agree.

As target groups for the survey, middle and executive management-level domain experts in the area of innovation management and strategic planning, which represent the actual users and beneficiaries of the process model, are approached. This is in accordance with literature presented and discussed in section 6.1.3, where perceptions of senior executives and middle managers from the respective application domain were found to be a good proxy for organisational performance of conceptual process. Before the actual questionnaire, the process model is introduced and presented to survey participants. In order to reduce bias caused by different and varying forms of process model presentation and different accompanying explanations of its modules and activities, this is done in the form of one identical introduction presentation for all participants presented via a web based survey tool, like e.g. in Krogstie, Nossum (2014), Rothe et al. (2010) or Nicholas et al. (2004).

Subsequently, the questionnaire is be presented to participants. Web based surveys allow for an efficient and effective way to reach a large population of potential participants (Schonlau et al. 2002). They have been applied in a variety of settings and with different populations (Brown et al. 2016; Moossdorff-Steinhauser et al. 2015; Kiernan 2005; Sills, Song 2002; Cobanoglu et al. 2001). Surveys in general, and web based surveys in particular represent a good evaluation technique for design methods and conceptual models, especially if the objective is to gather perception information from practitioners (Siau, Rossi 2011). Furthermore, survey and questionnaire design, dissemination and data storage and analysis are efficient and well supported by different survey tools (Greenlaw, Brown-Welty 2009). Participants are invited by e-mail, the selection of potential respondents (experts in the area of innovation management and strategic planning) is done via two innovation management related organisations. More precisely, with the Platform of Innovation Management (PFI, http://www.pfi.or.at/) and the Product Development and Management Association (PDMA, http://www.inknowaction.com/pdma). As a survey tool for data collection, SoSci Survey (http://www.soscisurvey.de) is selected. This tool allows for creating online questionnaires and for integration of additional media files (Leiner 2014).

Data analysis and evaluation is done using Microsoft Excel. Validity of results is ascertained by applying the validated and acknowledged statements and items presented in section 6.1.

6.3 Summary of Evaluation Approach

Figure 42 depicts the three quality dimensions of the evaluation approach, ranging from evaluating syntactic model quality (modelling notation, cf. section 6.1.1), to semantic quality (domain knowledge, cf. section 6.1.2) and to pragmatic model quality (perceived usefulness of the model in its application domain, cf. section 6.1.3):

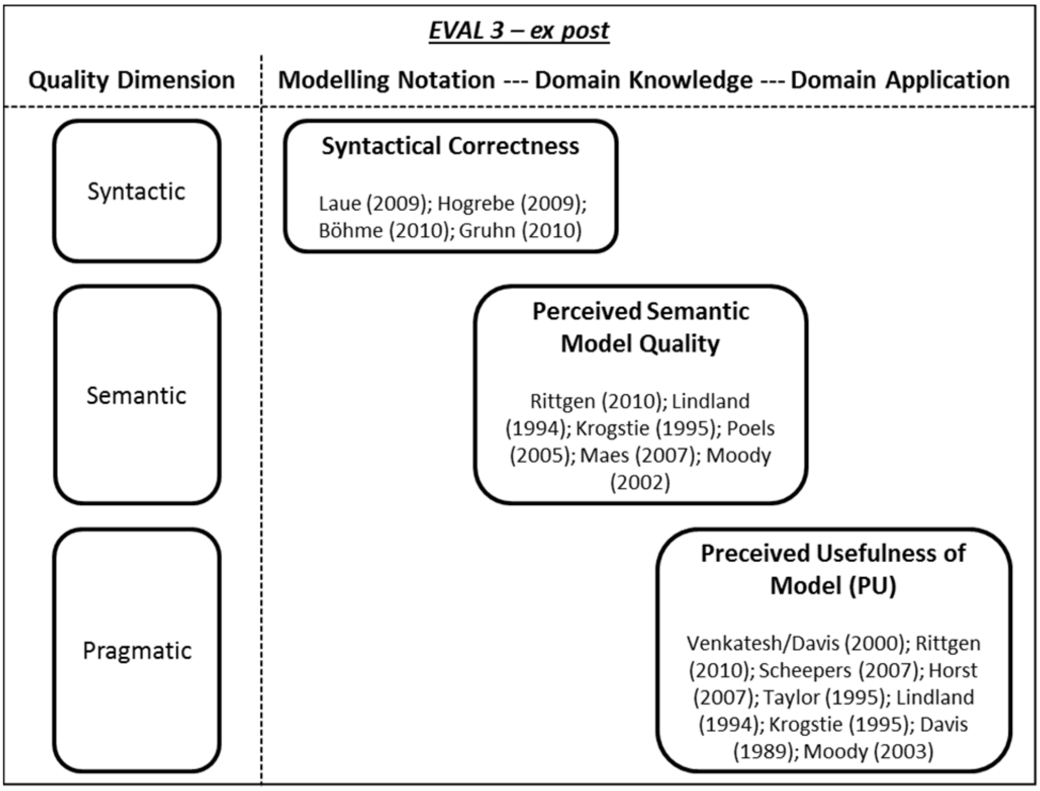


Figure 42: Evaluation dimensions of the thesis

Syntactical correctness is binary, meaning the model is either correct and in accordance with the EPC notation, or is incorrect and reveals semantic errors. Perceived Semantic Quality (PSQ) and Perceived Usefulness (PU) is measured based in the items and statements presented in sections 6.1.2 and 6.1.3. Figure 43 provides an overview of the quality dimensions and their respective items as defined based on validated literature.

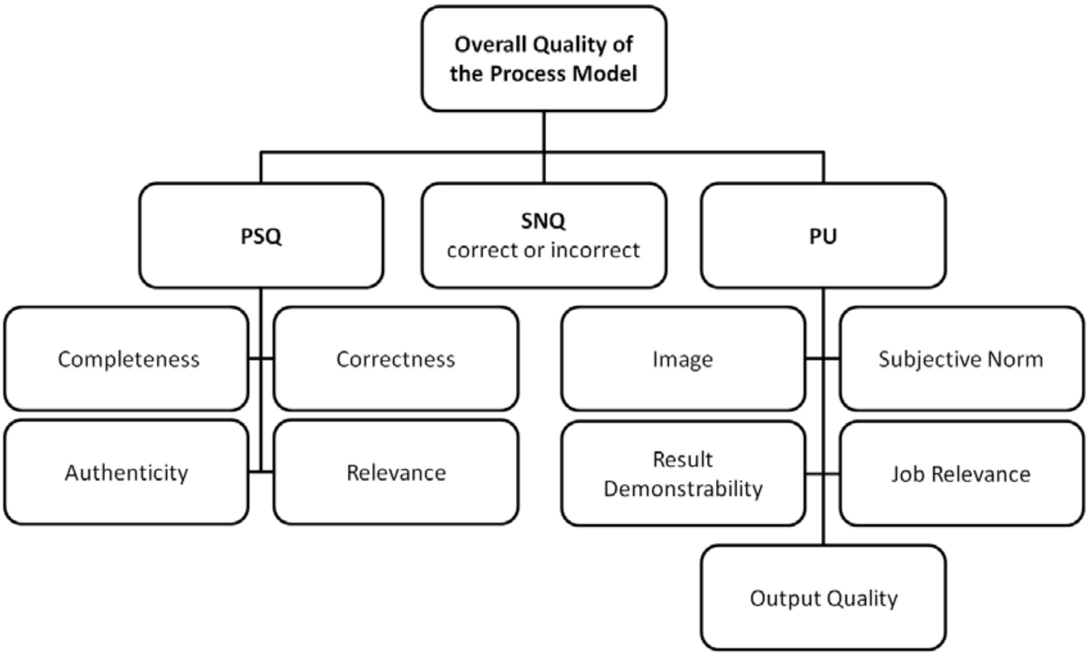


Figure 43: Summary of quality dimensions of the process model and their respective items

In order to gain additional feedback and qualitative input for process model discussion, textual comments are collected for selected items. Comment fields are shown based on triggering answer options of participants, as summarised in the following table (cf. Table 46).

Table 46: Textual comment questions based on triggering options

Item	**Item statement**	**Textual comment question**	**Triggering options**
PSQ relevance	All the elements in the conceptual model are relevant for the representation of the business process.	What elements of the process model are not relevant for the representation of the business process?	1,2,3,4,5,6
PSQ completeness	The conceptual model gives a complete representation of the business process.	What elements would have to be included in the process model to give a complete representation of the business process?	1,2,3,4,5,6
PU job relevance	In my job, usage of the process model is relevant.	How and for which purposes would you use the process model?	2,3,4,5,6,7

PU result demon-strability	I would have difficulty explaining why using the process model may or may not be beneficial.	Why would you have difficulties explaining why using the process model may or may not be beneficial?	4,5,6,7

Collecting additional textual input provides us with the possibility of considering qualitative aspects as well, allows for further interpretations of survey results and ultimately provides us with the possibility to gain further learnings and insights. This combination of qualitative and quantitative input can lead to new insights and modes of analysis and corresponds to the philosophical stance and epistemological underpinning of the thesis (cf. section 2.4).

Following the evaluation of the process model based on the statements and measurement scale proposed in sections 6.1 and the textual comment questions, the second part of the survey covers the evaluation of innovation capability maturity of participants' organisations (Corsi, Neau 2015; Esterhuizen et al. 2012;). The level of innovation capability maturity is evaluated based on the acknowledged ICMM in its second version (Essmann 2009; Essmann, Du Preez 2009). This allows for drawing inferences between the levels of organisational innovation capability maturity and the results of process model quality evaluation and provides further points for discussion in section 7 of the thesis. Due to the length of the survey, the evaluation of the innovation capability maturity is not mandatory but optional. In summary, the results of the ex-post evaluation consist of the evaluation of the 9 items and the corresponding 22 statements (cf. sections 6.1.2 and 6.1.3), the additional textual statements (cf. Table 46) and the innovation capability maturity of the organisations.

Before the conduction of the actual survey, a test survey with participants from academia was done in order to check the general structure of the questionnaire, the performance and suitability of the survey tool, the measurement scale proposed and the textual comment functionality of the survey. The collected pre-test comments confirmed the design and structure of the questionnaire and the survey tool. Only minor adaptions were necessary, i.e. adaptions to the introduction text and to the general part of the survey regarding participant and organisational background.

After its launch, the survey is open till saturation is reached. In literature, saturation is defined as the point at which no new insights would be observed because the researcher is observing phenomena, i.e. textual statements and comments in the present case, seen before (Eisenhardt, 1989).

7 Ex-Post Evaluation Results and Discussion

The ex-post evaluation of process model quality was conducted via a web based survey (cf. section 6.2) which was open for participation for about one month (August 23rd 2016 to October 7th 2016). In total, 53 participants from different industries (ranging from manufacturing, automotive, engineering, telecommunication and energy to IT services, construction, software, biotechnology, paper industry and steel industry) completed the survey. Figure 44 depicts the different industries of participants categorised into the industry supersectors of the industry classification benchmark (ICB, http://www.icbenchmark.com):

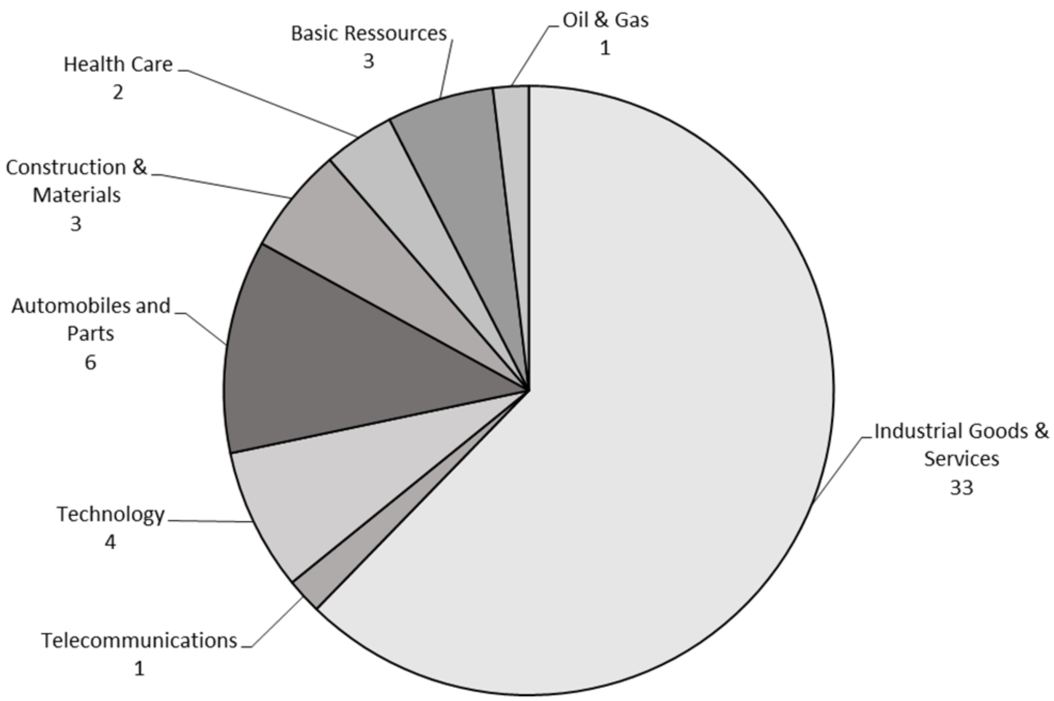


Figure 44: Industry supersectors of participating organisations

Participating organisations from different countries (mainly Austria but also Ireland, Germany, Italy and Great Britain) completed the mandatory part of the survey regarding PSQ and PU of the process model. Figure 45 provides an overview of the countries of participating organisations:

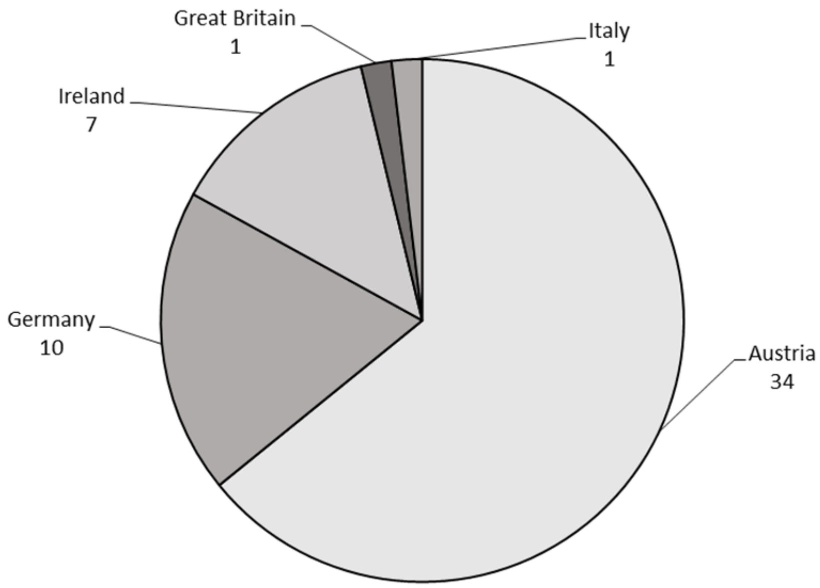


Figure 45: Countries of headquarters of participating organisations

Regarding the size of participating organisations, most organisations fell into the category of large enterprises (≥ 250 employees; > € 50 m turnover), 9 can be classified as medium sized enterprise (< 250 employees; ≤ € 50 m turnover) and 7 as small enterprise (< 50 employees; ≤ € 10 m turnover) (cf. Figure 46).

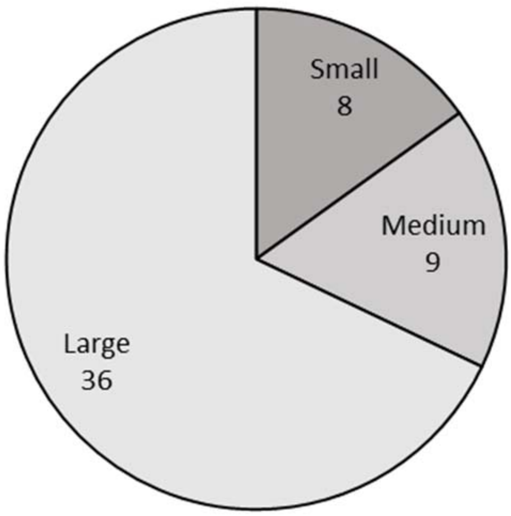


Figure 46: Size of participating organisations

Participants consisted of domain experts only (cf. section 6.2) and included e.g. R&D Managers, Innovation Managers and Product Managers. In total, 11 of the 53 participants completed the optional questionnaire regarding innovation capability maturity. This resulted in the fact, that innovation maturity levels had to be excluded from final result analysis and inferences between innovation maturity levels and perceived process model quality could not be taken as additional points for discussion.

The following sections 7.1 to 7.3 present the results of the ex-post evaluation of syntactic model quality (SNQ), perceived semantic model quality (PSQ) and perceived usefulness (PU) of process model. For both PSQ and PU of process model, average results were interpreted according to the following scheme (cf. section 6.2): 1-1,49 = strongly disagree, 1,5-2,49 = moderately disagree, 2,5-3,49 = somewhat disagree, 3,5-4,49 = neutral, 4,5-5,49 = somewhat agree, 5,5-6,49=moderately agree and 6,5-7 = strongly agree.

7.1 Syntactic Quality of Process Model (SNQ)

The syntactical correctness of the EPC process model was evaluated using bflow* toolbox (cf. section 6.1.1). The error log (cf. Figure 47) did not show any syntactical errors or inconsistencies and the process model is in compliance with the standard notation of Event-Driven Process Chains.

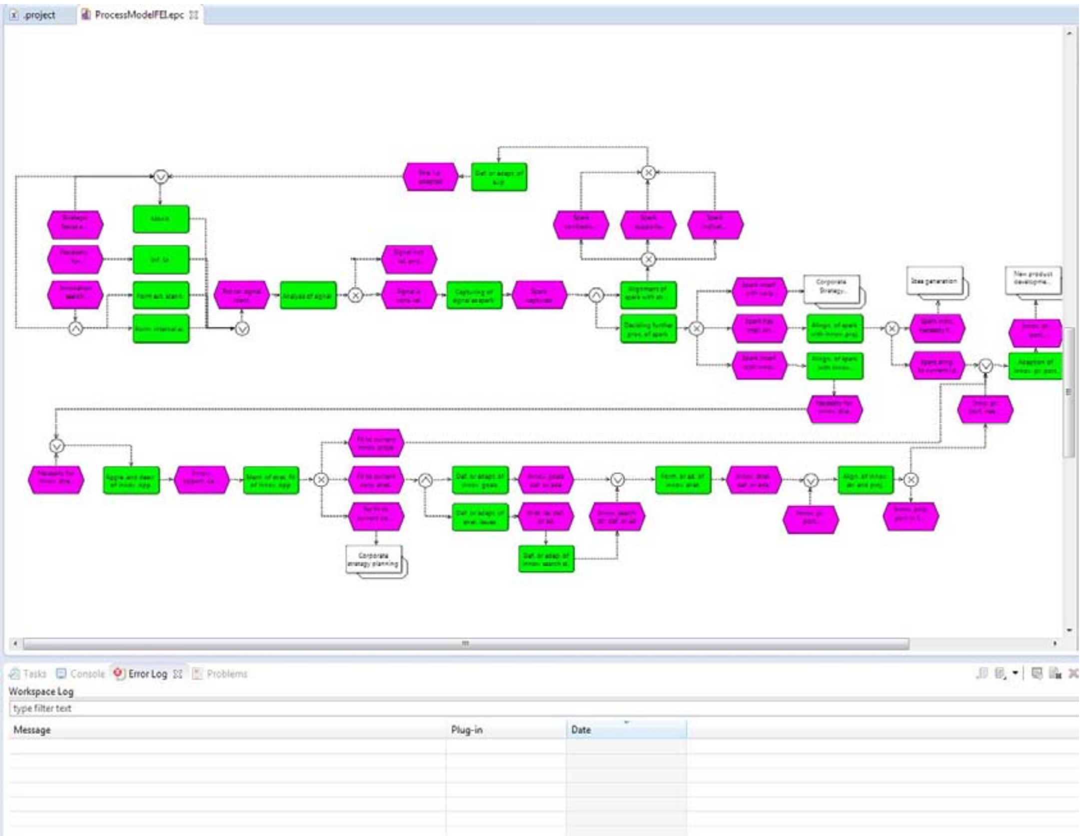


Figure 47: bflow* depiction and error log of the process model

Hence, the syntactical quality of the process model is given and it is accordance with the Event-Driven Process Chain notation (BPMR1-BPMR4) (cf. sections 4.2.2 and 6.3).

7.2 Perceived Semantic Model Quality (PSQ)

The perceived semantic model quality was evaluated based on correctness, relevance, completeness and authenticity (cf. section 6.1.2). Table 47 provides an overview of survey results. Based on the single statements the number of mentions for answers 1-7 (strongly disagree to strongly agree) are presented, the mode is depicted in italic.

Table 47: Main results from the PSQ-part of the questionnaire with numbers per value (mode in italic)

ITEM		Statement	Number of answers for value (mode in *italic*)						
			1	**2**	**3**	**4**	**5**	**6**	**7**
Perceived Semantic Quality	CORR	1. The conceptual model represents the business process correctly.	0	0	1	1	5	14	*32*
	REL	2. All the elements in the conceptual model are relevant for the representation of the business process.	0	1	0	0	6	17	*29*
	COMP	3. The conceptual model gives a complete representation of the business process.	0	0	0	2	1	11	*39*
		4. Entities, relationships or structural constraints must be added to adequately represent the business process.	*31*	8	1	4	4	1	4
	AUTH	5. The conceptual model is a realistic representation of the business process.	0	0	0	1	3	18	*31*

The results collected in the survey clearly show the high level of approval ratings for PSQ of the process model. If average answers and item results are normalised and depicted on a scale from -3 (representing the most negative answer option) and 3 (representing the most positive answer option), the following results are gained (cf. Figure 48).

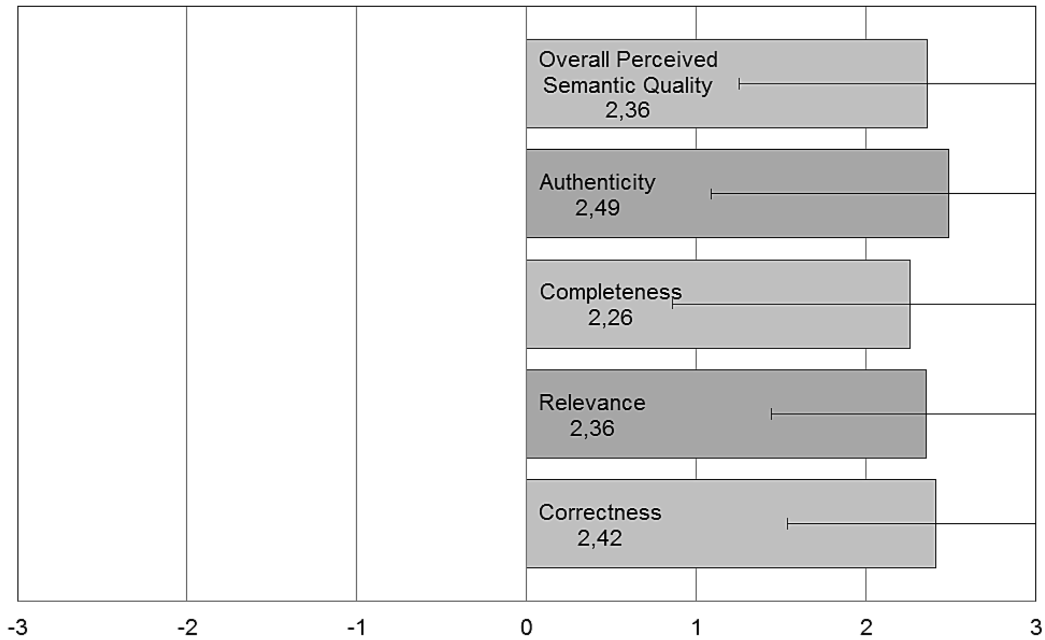


Figure 48: Normalised average and standard deviation for PSQ items

This shows that each of the analysed items was rated between the two most positive values of the normalised scale, especially process model authenticity scored high. Examining the textual comments collected in addition to the answer options, data can be further interpreted.

For the item of PSQ relevance respectively for statement 1 (“The conceptual model represents the business process correctly”; mode: strongly agree) one participant stated (provided that the organisation has enough resources), that all of the elements are relevant. If the organisation would lack resources he or she would omit formal scanning of internal and external environment (cf. section 5.2.1.3 and 5.2.1.2) and would rely on informal scanning (cf. section 5.2.1.1) only. Other participants stated that although all of the defined activities are relevant, their relevance may depend on the respective setting and industry of process model application, that innovation search strategy definition (cf. section 5.2.5) and innovation goal definition (cf. section 5.2.4) should be merged with and subsumed under innovation strategy formulation (cf. section 5.2.6) or that the model is very complex and that maybe some parts of it could be deleted (they did not explain which parts exactly). Although one participant evaluated PSQ relevance of the process model with “somewhat disagree”, he or she did not explanation as to what elements are not relevant for the business process. Other textual comments stated that informal scanning could be omitted, as this part of the process happens anyway and does not need to have a separate part in the process model or that monitoring (cf. section 5.2.2.3) and scanning (cf. section 5.2.1) could be merged. One participant mentioned that the term “strategic issue” is not relevant and should be replaced by the notion of “trend”, which would be more popular in his organisational and industrial background.

For the item of PSQ completeness, respectively for statement 4 (“Entities, relationships or structural constraints must be added to adequately represent the business process”; mode: strongly disagree) one participant stated that handling of innovations and ideas that would not fit to strategy should be added to the model. However, examining the model, this step is included in activity “Systematic and strategically oriented forwarding of spark”, cf. section 5.2.3): sparks which would interfere with corporate strategy are forwarded to corporate strategy planning and would have to be included there. Other participants stated that the model is already “over complete”, others that the step of interpretation should be explained in more detail and others again mentioned missing process model implementation and industry-specific guidelines. Further textual comments addressed the issue of including aspects of organisational culture, communicational and interpersonal skills: Participants stated their relevance, but at the same time also stated that such aspects cannot be modelled in a process like this and that this issue should probably be dealt with individually for each organisation. This corresponds to findings of section 4.3, where cultural and communicational FEI principles where found to be better addressed and depicted in other ways than in a formal business process. One participant stated the need to include idea generation and evaluation as well, although it was presented in the course of survey introduction that this part of the FEI is not in the focus area of the thesis.

Figure 49 summarises average results and standard deviations of the statements evaluated as part of PSQ of the process model (cf. Figure 49).

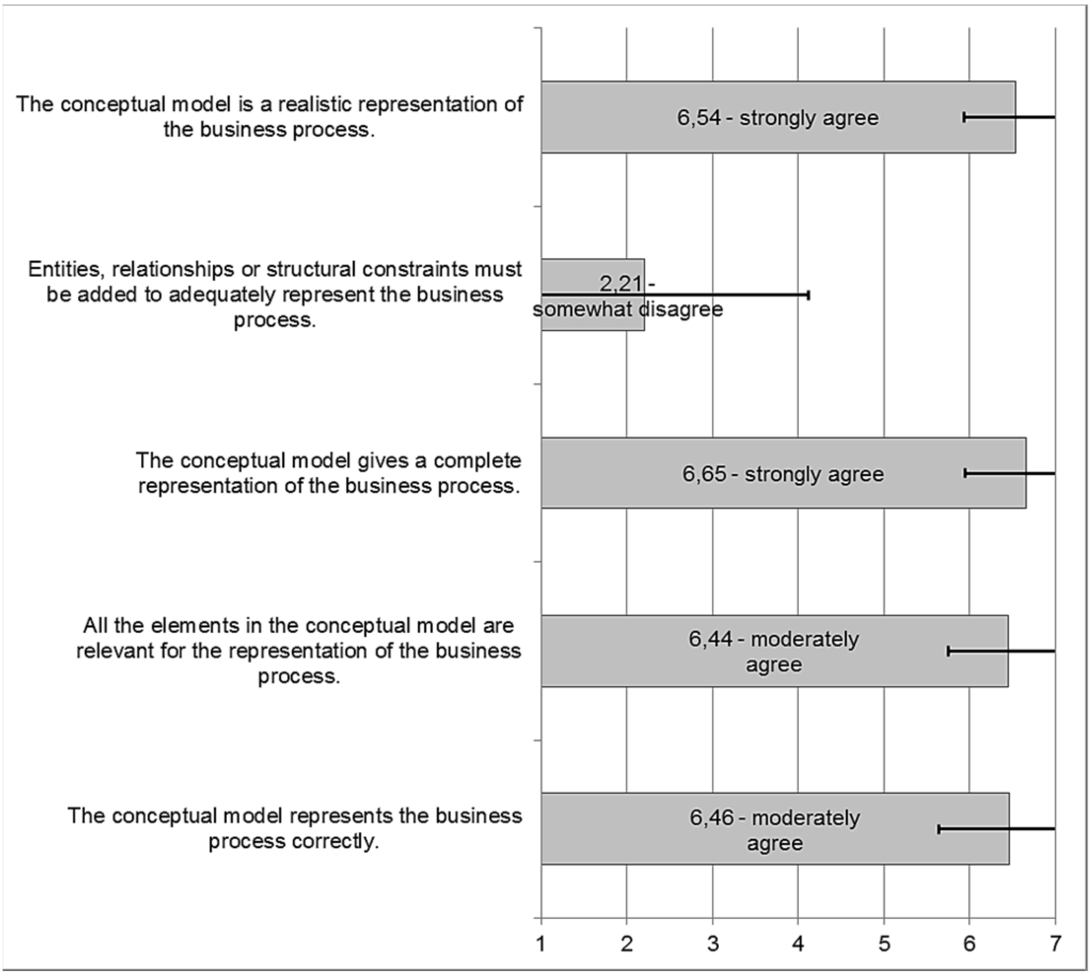


Figure 49: Average and standard deviation of PSQ statements results

In summary, approval ratings for PSQ of the process model are found to be high and the model can be considered of high semantic quality.

7.3 Perceived Usefulness of Process Model

The perceived usefulness of the process model was evaluated based on subjective norm, image, job relevance, output quality and results demonstrability (cf. section 6.1.3). Table 48 provides an overview of survey results. Based on the single statements the number of mentions for answers 1-7 (strongly disagree to strongly agree) are presented, the mode is depicted in italic:

Table 48: Main results from the PU-part of the questionnaire with numbers per value (mode in italic)

ITEM		Statement	Number of answers for value (mode in *italic*)						
			1	**2**	**3**	**4**	**5**	**6**	**7**
Perceived Usefulness	SN	6. People who influence my behaviour think that I should use the process model.	0	1	1	8	*16*	15	12
		7. People who are important to me think that I should use the process model.	0	1	1	9	15	*15*	12
	IM	8. People in my organisation who would use the process model would have more prestige than those who do not.	3	2	3	*25*	12	7	1
		9. People in my organisation who would use the process model would have a high profile.	3	0	1	*21*	18	8	2
		10. Working with the process model would be a status symbol in my organisation.	9	3	4	*29*	6	2	0
	JR	11. In my job, usage of the process model would be important.	0	0	1	0	6	15	*31*
		12. In my job, usage of the process model is relevant.	0	0	0	1	5	14	*33*
	OQ	13. The quality of the output I would get from the process model is high.	0	0	0	1	11	16	*25*
		14. I would have no problem with the quality of the process model's output.	1	0	0	0	11	16	*25*

	RD	15. I have no difficulty telling others about the results of using the process model.	0	0	1	7	4	17	*24*
		16. I believe I could communicate to others the consequences of using the process model.	0	0	2	5	11	14	*21*
		17. The results of using the process model are apparent to me.	0	0	0	4	9	16	*24*
		18. I would have difficulty explaining why using the process model may or may not be beneficial.	*20*	16	6	5	3	3	0
	PU	19. Using the process model would improve my performance in my job.	0	0	1	2	11	9	*30*
		20. Using the process model in my job would increase my productivity.	0	1	2	11	11	*16*	12
		21. Using the process model would enhance my effectiveness in my job.	0	0	2	2	9	13	*27*
		22. I find the process model to be useful in my job.	0	0	0	1	8	10	*34*

The results collected in the survey clearly show the high level of perceived usefulness of the process model. If average answers are normalised and items are depicted on a scale from -3 (representing the most negative answer option) and 3 (representing the most positive answer option), the following results are gained (cf. Figure 50).

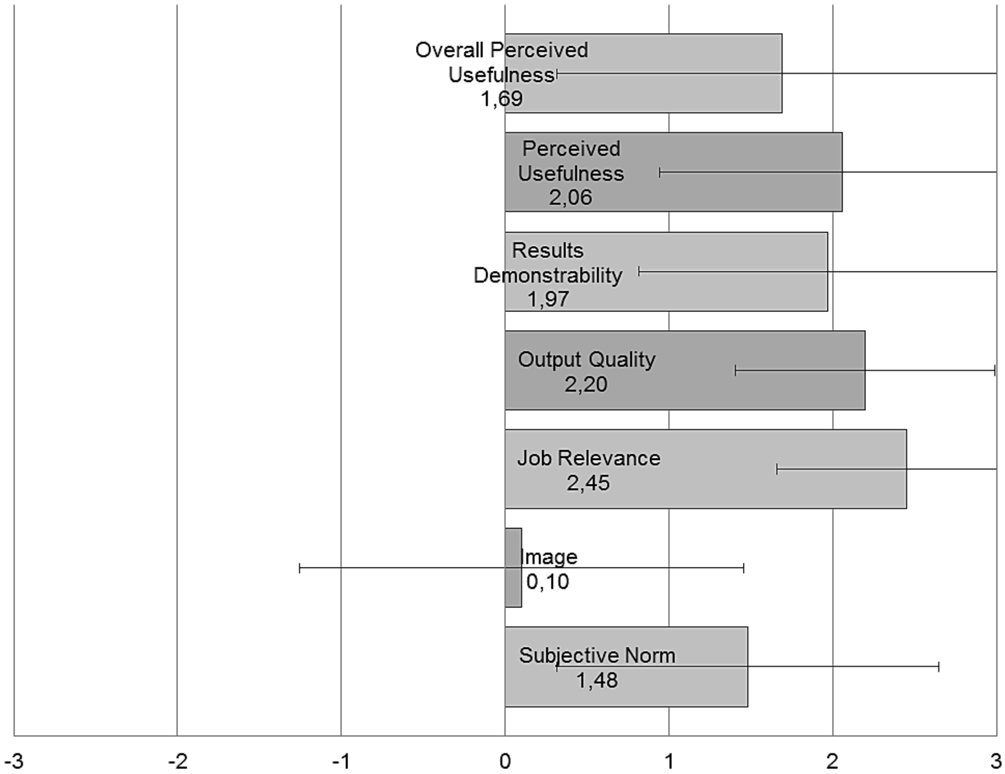


Figure 50: Normalised average and standard deviation for PU items

This shows that except the item of image (which scored neutral) each of the analysed items was rated between the three positive values of the normalised scale, especially process model authenticity scored high. Examining at the textual comments collected in addition to the answer options, data can be further interpreted.

For the item of PU job relevance, respectively for statement 12 ("In my job, usage of the process model is relevant"; mode: strongly agree), most participants stated that they would use the process model for fostering strategic orientation at the FEI, for identifying and managing signals, innovation opportunities, trends and disruptive changes and for establishing organisational structures at the early stages of the innovation process on a continuous and long-term basis. The connection and integration of innovation management and corporate strategy planning, the increase of process transparency and the establishment of an innovation strategy were further mentioned by participants. The structure of the process model was found to provide high potential for practitioners. Participants stated that they would use the process model for staff training and team development as well as for implementing a structured information and task flow at the FEI. Independent of industry or size of organisation, the process model was found to be highly relevant, be it for establishing, restructuring and addressing internal process steps or activities or for supporting external projects and interfaces to customers and partners. Only one participant neither agreed nor disagreed with statement 12 regarding the relevance of the process model for his or her job. This participant explained his or her answer option in the textual comment stating that the process model is relevant for strategic and long-term innovation and strategy planning, but may not be relevant for ideas that arise within discussions e.g. with customers or suppliers. However, such types of signals are not only included in the activities of formal external and internal scanning (cf. sections 5.2.1.2 and 5.2.1.3) but also in informal scanning (cf. section 5.2.1.1). Furthermore, the actual idea generation process, i.e. the identification and capturing of ideas, is not part of the process model's focus.

Regarding the item of PU results demonstrability respectively statement 18 ("I would have difficulty explaining why using the process model may or may not be beneficial"; mode: strongly disagree) some participants stated that they would have problems with explaining process model usage benefits. The reasons for that include e.g. the amount of effort that would be required to implement the process model, that uncertainties are always difficult to handle, that the model is quite complex and not easy to communicate and explain to non-domain experts and that more information would be required to fully understand the process model. These statements are understandable and it can be agreed that for non-domain experts the process model may not be easy to understand. The need to further discuss, present and explain the process model to practitioners, who would be interested in its implementation, is seen.

Figure 51 summarises average results and standard deviations of the statements evaluated as part of PSQ of the process model (cf. Figure 51).

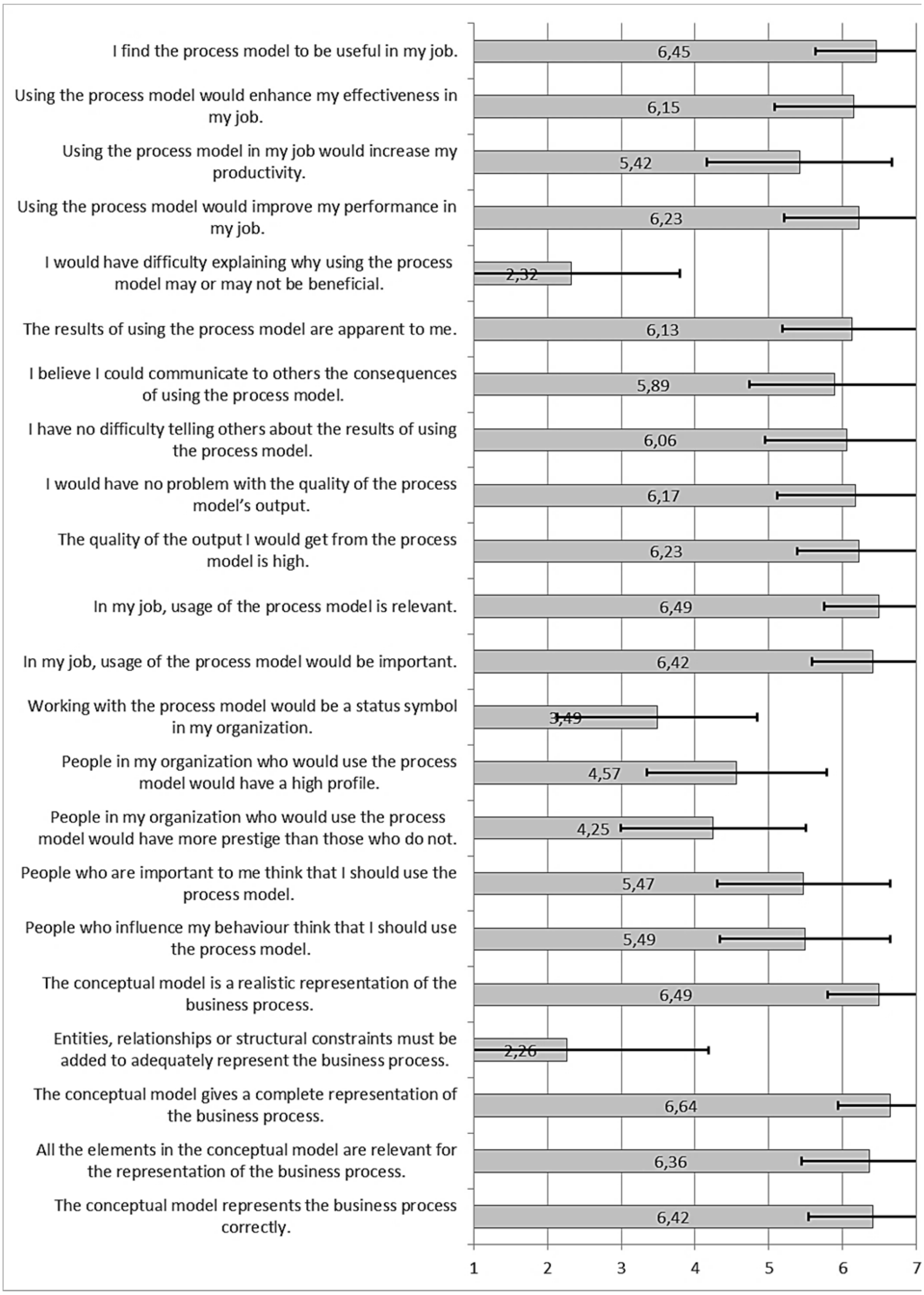


Figure 51: Average and standard deviation of PU statements results

In summary, perceived usefulness of process model was found to be of high approval ratings and the model can hence be considered of high pragmatic quality from practitioners' point of view.

7.4 Discussion of Ex-Post Evaluation Results

The design hypothesis, that the strategic FEI can be structured by the provision of a comprehensive process model, could not only be confirmed by literature (cf. section 1.3) but also by the survey results. Examining composition and background of survey participants, most of them are from large sized organisations concerned with product innovations. Semantic and pragmatic process model quality is given for this type of organisations. This corresponds well with the focus of process model development, which is on product innovation and which is well covered by participating organisations. In total, 47 out of 53 participants were from organisations merely concerned with product innovation. The six remaining participants were from organisations concerned with both product and service innovation from an ICT, a consulting or a research background. For this group, results also confirm high approval ratings of process model quality (normalised average of PSQ: 6,57 and of PU: 5,94). The results for this group are also included in the final analysis. Due to the limited size of this group and due to the fact that they are concerned with both service and product innovation, results cannot be considered as reliable proof that the process model is equally applicable for product and service innovation. Same applies for medium or small sized organisations (17 out of 53): for this group of participants, results indicate a high level of perceived semantic and pragmatic quality of the process model (normalised average of PSQ: 6,42 and of PU: 5,56). But again this sample is not reliable enough to state that the process model is applicable independent of size of the respective organisation. In view of the above, the sample confirms that for large sized organisations concerned with product innovation the process model clearly is of high quality, both from a semantic and a pragmatic point of view.

The relevance and also the complexity of the FEI, its "fuzziness" and especially the non-existence of structured and continuous approaches to this part of the innovation process in organisational practice is not only confirmed by means of literature review. It is also reflected in survey results and textual comments. Practitioners participating in the survey state that the process model provides 1) a clear structure for projects and decisions at the FEI, 2) has high potential for organisational practice, 3) can establish not yet existing interfaces between innovation management and corporate strategy planning and 4) would definitely be applied and implemented in practice, provided the required resources are available. However, it is also stated in textual comments that the process model may be difficult to communicate and present to non-domain experts. Several comments indicate that it may be difficult to justify the high amount of time and resources necessary to implement the process model towards other departments and areas than innovation management or strategic planning.

An interesting finding of the survey is that the item of “image” received by far the lowest average score. Contrasting this finding to the other items of PU, and especially to the item of “job relevance”, it is found that although the process model was of high perceived usefulness, the image of using it is only evaluated as “neutral”. Especially statement 10 (“Working with the process model would be a status symbol in my organisation”) and statement 8 (“People in my organisation who would use the process model would have more prestige than those who do not”) scores low and shows an average of 3,49 respectively of 4,25 and a mode of “neutral”. Although the process model is of high perceived semantic and pragmatic quality, using it would not lead to increased prestige and would not be considered a status symbol by practitioners. One of the reasons for this could be a low level of emotional involvement of individuals, the lack of organisational support and respective structure at the strategic FEI, a low esteem of activities and measures at this stage of the innovation process or missing acceptance of the amount of effort required to succeed at this specific process stage.

In regards to a potential future process model implementation project in an organisational context, this entails several implications. Firstly, establishing an organisation wide awareness of the relevance of structured approaches to the strategic FEI is a prerequisite for a successful implementation project. Secondly, top management support has to be ensured. Thirdly, organisational culture and communication structure have to allow for the openness and inquisitiveness required to successfully gather and analyse signals and to identify sparks and strategic issues. Examining these prerequisites for successfully implementing the process model, it can be found that each of these requirements is reflected in and represented by those FEI principles, which have been classified as non-process factors in the thesis (cf. 3.2.3): top-management support, the establishment of a common view of strategic FEI relevance as well as the provision of the required structures, which allow for interdisciplinarity and openness and an appropriate supporting organisational culture, are incorporated in FEI principle 2 “Composition and management of roles and teams” and FEI principle 3 “Creation and fostering of an innovation-friendly, motivating culture”. Hence, as explicitly stated in section 1 based on literature, the importance of addressing and taking into consideration the non-process factors at the strategic FEI can also be stated based on survey results.

Regarding the general innovation process requirements (I-PR 1-5, cf. section 1.1.2) and the FEI process requirements (FEI-PR 1-6, cf. section 3.1.3) the final process model addresses all of these: its structure allows for parallel activities and tasks (I-PR1), the integration of external as well as of internal sources is explicitly foreseen (I-PR2, FEI-PR6), feedback-loops are an essential part of it (I-PR3), methods are integrated and explained to support its activities (I-PR4, FEI-PR 5) and market as well as technological developments may trigger new innovation projects (I-PR5). Furthermore, the process model is iterative rather than strictly sequential (FEI-PR1), clearly states the relevance of the non-process factors (FEI-PR2), is clearly solution oriented towards solving problematic parts at FEI (FEI-PR3) and can be considered of high practitioner relevance due to its positive evaluation results (FEI-PR4).

8 Summary and Conclusion

This chapter outlines the conclusions of the research thesis and provides a critical review. The research questions are briefly revisited. Subsequently, the contributions of the thesis are positioned and the artefact's implications to the field of knowledge and to practice are presented, followed by a critical review of the limitations of the thesis. The section concludes with a summary and an outlook on future research needs.

8.1 Revisiting the research questions

As outlined in section 1.4, the objective of the thesis is to identify principles at the FEI, to derive process model design requirements based on these and to develop and evaluate a formal process model specifically supporting process key activities at the strategic FEI. The research questions defined to meet these objectives are presented in section 1.5. Subsequently these RQs are revisited and their final results are discussed.

Research question one addresses the identification of FEI principles. The final list of FEI principles includes theoretical as well as practical sources. One of the main findings of research question one was that practitioners and academia have a similar understanding of what is crucial at the strategic FEI. Each principle collected based on literature is also considered relevant from the participating practitioners' point of view. Vice versa, each principle at the strategic FEI derived based on the results collected in the course of focus group study is reflected in relevant literature. This is an important finding, considering the fact that there are still few empirical studies clarifying FEI practices (cf. 1.6). The focus group study conducted in this thesis is the first to collect, contrast and match theoretical and practical principles specifically for the strategic FEI.

Another finding of research question one is the shared agreement of practitioners and literature regarding the importance of the strategic FEI. For each of the three organisations participating in the focus group study the high relevance of this stage of the innovation process could be confirmed. Further examining the research gaps identified in section 1.2, additional findings can be derived based on the results of RQ1. Regarding the operative parts of the FEI, i.e. idea generation and selection, organisations show a high level of maturity and already have established structured and method based process support at these stages. In line with the defined research gaps and the practitioner and expert meetings held over the initial months of the research project (cf. section 1.3), focus group results indicate that organisations are aware of the potential of process based support at the strategic FEI. Results also show that organisations have problems in identifying which activities can be structured and depicted in formal processes. Focus group study results indicate that organisations struggle to define appropriate method based and process like support for the strategic FEI.

Research question two includes the analysis of FEI principles in regard to their relevance for the focus of the thesis, i.e. the strategic FEI and the transition to idea generation (cf. section 3.1.4). Against the background of the ongoing discussion in literature, whether the FEI can or cannot be structured, a pivotal contribution of research question two is the identification of process and non-process principles for the strategic FEI (cf. section 8.2.1). This has not been done in prior research. The discussion of these strategic FEI principles provides the basis for deriving concrete process model design requirements, which provide the basis for process model development. Considering the theoretical background and the results of these discussions, Corporate Foresight (CF) and Strategic Issue Management (SIM) could be identified as appropriate concepts to address these process model design requirements. The potential of CF at the FEI has already been stated in previous research. However, the constructs underlying this concept have not yet been applied to the strategic FEI in the form of a comprehensive process model (cf. section 8.2.1). Finally, the main output of research question 2 is the process model for the strategic FEI.

The ex-post evaluation of this process model is addressed in the third research question. Defining an appropriate evaluation approach allowing for evaluating process model quality before actually implementing it, is found to be a complex task. Evaluation approaches for conceptual models in a DSR context are scarce and a suitable and reliable approach fitting to the specific research context has to be developed. Pragmatic, syntactic and semantic quality are selected as the basic quality dimensions for ex-post evaluation. The defined evaluation approach proves to be applicable and produces valuable results. It does not only allow for evaluating PSQ and PU related statements but also for collecting additional textual input in the form of comments. These comments provide an important basis for additional discussion of evaluation results. The basic structure, the methods applied and the design chosen for this evaluation approach represent interesting findings for other researchers concerned with the evaluation of similar types of artefacts.

8.2 Contributions and Position of the Research

The contributions of the thesis are manifold. In the subsequent sections, the main contributions (section 8.2.1), the theoretical impact (section 8.2.2) and the impact for practice (section 8.2.3) are discussed.

8.2.1 Main Contributions

The process model developed is the main output of the thesis, is based on acknowledged concepts, theories and approaches and extends them to solve new problems. Following this, the thesis' main contributions fall into the category of "exaptation" as defined by Gregor (Gregor, Hevner 2013). Exaptation refers to contributions where design knowledge that already exists in one particular field is further refined or extended and applied to new application domains. This type of contribution is common in IS research, where new technology or changing systems and processes often require new applications and approaches and where a consequent need to test and refine prior ideas exists (Gregor, Hevner 2013). In the context of IS research, the process model represents the domain in which potential future information systems will operate. The current research is hence partially settled within the IS domain and the domain of innovation management.

The concepts of business process modelling, CF and SIM have already been applied in other research settings as e.g. in process management, change management, in general product development, corporate strategy planning or in the area of business development. Thus, the process model is developed by synthesising multiple sources of existing knowledge and solutions and by applying it to fulfil the principles and design requirements describing the research problem area. The specific requirements at the strategic FEI on the other hand have not yet been analysed in literature in the level of detail which is required for deriving process model design requirements for the thesis. Hence, the process model is a synthesis of research best practice, identifies requirements at the strategic FEI in practice and applies known solutions and approaches from other domains to this under-researched part of the innovation process.

The first pivotal contribution of the thesis is the identification of process and non-process principles at the strategic FEI. Following the underlying design hypothesis the thesis deals with the important and controversial issue of structuring the strategic parts of the FEI. Approaches to and recommendations for this part of the innovation process range from "no structure at all as structure kills creativity" to "the FEI can be treated like any other business process" (cf. section 1.3). Against this background, the thesis is concerned with a highly significant subject. The author positions his work between these two contradicting groups of scholars and follows a third group, who postulates a positive impact of formalising and structuring selected key activities at the strategic FEI. At the same time, the importance of considering and addressing non-process factors as well is stated. This point of view on the strategic FEI has several implications on research design. Firstly, the focus on key activities is reflected in the structure of the thesis (cf. sections 1.5 and 1.7): FEI principles are collected, process model design requirements are derived and process model key activities are defined based on these design requirements and the concepts of CF and SIM. Secondly, the thesis follows the idea that certain, process related parts of the strategic FEI can be structured without having harmful effects on e.g. creativity and information flow, as one group of scholars proposes. This enables and allows for the current research, its objectives and its research questions in the first place. Thirdly, the awareness of the importance of non-process factors influences the design of the conducted focus group study and specifically of the developed analysis scheme. This directly affects final focus group study results and thus the final list of FEI principles.

This point of view on the strategic FEI led to the final process model and enabled the distinction between process and non-process factors. The main process related elements of the process model are concerned with strategically oriented uncertainty reduction and with definition and implementation of an innovation strategy. These elements are addressed in the developed process model in the form of its six key activity groups. Ex-post evaluation confirms that these can be structured and depicted using a formal process modelling notation from a practitioner's point of view. The identified non-process factors "Composition and Management of Roles and Teams" and "Creation of an innovation-friendly, motivating culture" represent essential non-process factors that infuse and shape the way work is conducted by influencing how individuals and groups behave. In contrast to the process factors, these cannot be modelled and depicted using formal and structured process models. The importance of these factors and the difficulty of formally modelling, structuring and depicting them can also be established in ex-post survey results. The textual comments collected in the course of the survey confirm this issue (cf. section 7.2).

The second main contribution of this thesis is the application of CF and SIM to the strategic FEI by combining these two concepts and by depicting relevant aspects of these in one process model. The introduction of the terms “signal”, “spark”, “strategic issue”, “scanning”, “monitoring” and “innovation opportunity” and their theoretical background provide the common ontology required to do so. Besides this ontology, an appropriate structure has to be defined as well. Existing FEI process models do not integrate the structural requirements of CF and SIM and lack a more detailed description and process based depiction of the formal connection between the strategic FEI, the innovation strategy and corporate strategy planning. In the thesis, the basic structure of the process model derives from 1) the FEI processes existing in organisational practice and the ideal typical process structure in practice (cf. Figure 25), 2) the six process model design requirement blocks (“key activities”, cf. section 4.6), and 3) the general structure of CF frameworks (Input-Analysis-Output-Strategy, cf. section 5.1.1.1) as well as the concept of strategic issues (cf. section 5.1.1.2). The combination of the results of these building blocks leads to a four-step structure: inputs have to be collected, information gathered has to be analysed and findings respectively output has to be forwarded to the subsequent stages at the FEI or to innovation strategy and corporate strategy definition. This specific structure 1) allows for benefiting from the synergetic effects of both SIM and CF, 2) increases the chance to identify, analyse and process relevant signals, opportunities and issues at the strategic FEI and 3) establishes a formal connection between strategic FEI activities, corporate strategy planning and the operative FEI.

8.2.2 Theoretical Impact and Position

The significance of the identified research problems and gaps as well as of the underlying design hypothesis is discussed in detail in section 1. Due to the gaps in theory and the weaknesses and requirements in practice (cf. section 3.2.2), it can be concluded that the thesis addresses a highly relevant research area.

The main theoretical foundations are represented in the form of 1) general innovation process model requirements (I-PR1-4), 2) the FEI process model specific process requirements (FEI-PR1-6), 3) the FEI principles derived in the course of systematic literature review (cf. Table 10) and 4) the concepts of CF and SIM (cf. section 5.1). Regarding the impact on theory and the provision of new or improved evidence, the thesis contributes in several ways. As discussed in sections 1.2 and 1.6, the amount of empirical studies clarifying Front End practices and specifically dealing with the strategic FEI is low. To identify principles at the strategic FEI and to gain an understanding of FEI processes and activities in practice, a comprehensive focus group study was conducted. The results of this study are summarised in section 3.2.2.5 and deliver new insights on and empirically constructed knowledge about the FEI. The results of artefact evaluation constitute new empirical knowledge about the strategic FEI and provide additional contributions to knowledge base in the form of new evidence regarding FEI process model quality. The conducted survey is the first to provide detailed and scientifically collected quality results for a strategic FEI process model. The textual comments collected during the web based survey allow for deriving specific practitioner and expert feedback regarding selected items of process model quality. This allows, for example, identifying potential future research starting points.

In terms of employing new or improved methodology to do analysis or interpretation, the thesis contributes in several ways. Firstly, the research methodology of the thesis is adapted based on the acknowledged DSR framework by Peffers (cf. section 2.2). It proves to be suitable for the research and enables a transparent, comprehensible and replicable way of developing a process model for the strategic FEI. The transparent research methodology provides insights on artefact construction and contributes e.g. to the DSR domain. This and the research framework applied and presented in section 1.5 support other researchers concerned with similar research problems in conceptual modelling in developing and applying appropriate research approaches and methodologies. Secondly, the combination of findings from theory and practice in the form of the derived FEI principles, of process model design requirements and of process model structure and elements represents a transparent, coherent and applicable methodology to do analysis, interpretation and collation of theoretical and empirical knowledge.

New or improved concepts or theories are provided in the form of (1) principles at the strategic FEI derived from theory and practice, (2) design requirements for process and non-process based support of the strategic FEI, (3) process key activities at the strategic FEI and (4) the process model specifically addressing these key activities by applying the concept of CF and SIM. The research thesis contributes to the domain of Innovation Management by identifying key FEI principles based on scientific literature (literature review), on the results of an extensive focus group study and on continuous practitioner involvement. By identifying both process and non-process principles for the strategic FEI, future research on this issue is provided with extensive information and knowledge about this early stage of the innovation process. Furthermore, the division of FEI principles into process and non-process principle groups provides potential starting points for future research on e.g. the non-process design requirements and FEI principles at the FEI. It provides research and practitioners with insights into the formally depictable activities at the strategic FEI. The research contributes to the IS domain in the form of describing and depicting the area respectively the specific process in which potential future information systems for the strategic FEI will operate. In this context, the developed process model is a prerequisite for planning and designing complex systems of this sort.

8.2.3 Impact for Practice

At the operational level of organisational innovation management practice, the ultimate result of the thesis, i.e. the process model, guides organisations in structuring and specifically addressing the key activities at the strategic FEI. Existing FEI process models either do not cover the stages preceding idea generation or fail to deliver practicable and concrete sets of guidelines and measures for practitioners. The process model specifically focusses on the stages of opportunity identification and analysis and provides in-depth details, formally described activities and a clear structured process for the under-researched strategic parts of the FEI. Against the background of the focus group study results gained in this thesis, the current process model hence provides valuable benefits to organisational practice. Each of the process related challenges identified in current practice is incorporated in the process model. Same applies for critical success factors observable in practice (cf. section 3.2.2.5). The results of ex-post evaluation confirm the correctness, completeness and usefulness of the process model. Practitioners state that they would apply and implement it in practice, provided the required resources are available (cf. section 7.4). The actual implementation of the process model would enable organisations to 1) add structure and continuity to the complex strategic FEI, to 2) establish strategically oriented and on-going scanning and monitoring functions, 3) to clearly allocate responsibilities and define communication and decision making paths, to 4) link strategic and operative level FEI activities and ultimately to 5) establish a formal connection between innovation management and corporate strategy planning.

8.3 Critical Review and Limitations

From a critical perspective, the author is aware that a universally usable process model cannot be designed in this thesis. Although survey results prove the usefulness of the model, results that may be true for large sized organisations concerned with product innovation may not apply to small sized enterprises in for example the service industry. In correspondence with the focus of the thesis, the FEI principles, which provide the basis for deriving process model design requirements and hence for process model development, are rigorously and thoroughly derived based on literature and on the results of a comprehensive focus group study with three selected large sized organisations from Austria concerned with product innovation. To elaborate practitioner FEI principles for service innovation or for a specific company size, additional studies should be conducted. Such studies could e.g. include organisations from further industries, of different size, from different countries or concerned with different types innovation.

An important success factor for this design was to conduct the ex-post evaluation independent from process model design. This means that evaluation was done with different organisations than those which were involved in process model design. In accordance with the thesis' focus on product innovation, ex-post evaluation results confirm process model quality for this type of innovation. Further studies in other domains (e.g. in service industry or the public sector, cf. section 8.4) should analyse its applicability in these domains.

A challenging undertaking in the thesis is the step from FEI principles to process model design requirements and finally to process model elements and activities. This issue is addressed by not only conducting an ex-post but also an ex-ante evaluation regarding the process model design process. Ex-ante evaluation allows for evaluating the design process before actually finishing process model development. This allows for identifying potential shortcomings and inconsistencies at an early stage of work. Evaluation of process model quality is done based on the three dimensions of syntactic, semantic and pragmatic model quality; the developed ex-post evaluation approach covers various criteria from these three areas. An important success factor of the evaluation approach is reflected in the collection of additional textual feedback regarding irrelevant and unneeded as well as lacking process model elements. Thereby, additional input is collected for identifying elements which have to be dismissed and for determining missing elements, which have to be included into a relevant and complete FEI process model. In the present case, the final evaluation results confirm the completeness and relevance of process model elements and activities, and hence of process model design requirements. Consequently, it is unlikely that significant FEI principles were ignored respectively overlooked in the course of deriving process model design requirements and of subsequent process model development.

In terms of evaluating the process model, particular attention is devoted to the ex-ante and ex-post evaluation approach. Reliability and validity related issues of the thesis are discussed in section 2.3 and the measures proposed and presented there are followed thoroughly throughout the thesis. Ex-ante evaluation confirms and enriched the FEI principles identified in the course of the literature review. The process model proves to be of high quality from a syntactic, semantic and pragmatic point of view. The ex-post evaluation approach focusses on perceived semantic and pragmatic quality. The use of perception-based measurements has been justified in section 6.1. Furthermore, it has been observed in various businesses and management disciplines and perceptions of senior executives and middle managers are found to be a good proxy for organisational performance of process models (cf. section 6.1.3). Although this may be a potential weakness of the thesis, this evaluation approach is most reasonable and suitable for this specific research context, as evaluation results confirm. However, further research is necessary to evaluate the actual performance and quality of the process model after its implementation in organisational practice. As mentioned, this would require a long-term, diverse evaluation approach and is subject to future research.

Of crucial importance for the thesis is the involvement of a number of approaches to design, develop and evaluate the process model (i.e. literature review, focus group studies, qualitative content analysis, business process modelling and surveys). This use of multiple, qualitative and quantitative research methods enabled testing the design hypothesis both based on design principles in the course of ex-ante and by practical application in the course of ex-post evaluation. Another success critical aspect of the thesis is the use of methods and measurement instruments which have already been tested for rigour and validation (cf. section 2.3).

8.4 Summary and Future Work

Examining the results, contributions and limitations of the thesis, several future research opportunities and the need for further empirical studies arise. As the thesis is focussed on product innovation, such research could for example focus on the elaboration of process based support for public and service sector. The need for investigating the strategic FEI in other sectors is still high and findings could contribute to knowledge base. Furthermore, future research projects could extend or alter the scope of the process model, by for example extending it to include or cover corporate strategy planning or the actual NPD process as well. Future work could also lay a specific focus on evaluating the process model with experts from medium and small sized enterprises. This would not only be interesting, but would also contribute to the understanding of differences and similarities between large sized and small respectively medium sized enterprises.

The strategically oriented parts of the FEI are highly complex and dynamic; process models for this part of the innovation process should rather visualise and address specific key activities than just provide an all-inclusive and only-true formal process for all aspects of the FEI. The author does not want to postulate such an only true solution for this part of the innovation process. Further research could focus on evaluating the actual performance and quality of the process model after its implementation in organisational practice. In addition to the ex-post evaluation results gained in the thesis, this could provide valuable contributions to continually develop and adapt the process model.

Future work could also support strengthening understanding of FEI principles by conducting a quantitative study specifically focussing on this subject. Depending on the respective subject of the study and depending on its sample size, several contributions to knowledge base could be gained. For example, it would be interesting to analyse the level of coherence of FEI principles in organisations of different sizes, of different industries, from different countries and of different stages of the organisational lifecycle.

Against the background of the thesis' focus on process FEI factors, the need for in-depth analysis and empirically grounded studies regarding principles of and approaches to the non-process FEI factors is high. Considering the nature of the non-process FEI factors identified in the thesis, several research domains could contribute to this issue. For example, research in the organisational culture domain could investigate exactly which attributes and patterns of organisational culture are required at the strategic FEI. Likewise, research in the organisational learning domain or in the area of knowledge management could also contribute significantly to the body of knowledge on the strategic FEI. By for example focussing on intra and interpersonal, on intra and intergroup or on intra and inter organisational aspects at the strategic FEI, valuable insights could be gained. Based on the results and findings of this thesis, other areas (like for example research on entrepreneurship, human behaviour, network management or corporate development and corporate venturing) could produce relevant knowledge too.

Additional future research challenges at the strategic FEI could also be found at a more micro level: future studies could analyse the influence of factors like project size, technology type and degree of innovation, level of uncertainty or interrelations between different projects on strategic level FEI activities.

Other efforts could be made to develop and implement ICT based support for the activities of the process model. In this context, the process model developed in the thesis can serve as theoretical and conceptual background. Furthermore, it represents the framework for integrating and combining single tools into one coherent software platform covering the key process activities at the strategic FEI.

The findings gained in this thesis address an interesting domain and focus on a still under-researched part of the innovation process. The design hypotheses defined at the beginning of the thesis could be confirmed: Key activities and tasks at the strategic FEI can be structured and systematically addressed and supported by a formal process model. The findings of ex-post evaluation confirm the semantic and pragmatic quality of the developed artefact and practitioners deem the process model to be useful and relevant in organisational practice.

Appendices

Appendix A - Selected literature sources for SLR “FEI principles”

Table 49: Selected literature sources for SLR “FEI principles”

No.	*Source*
1	Aagaard 2012
2	Aagaard, Gertsen 2011
3	Akbar, Tzokas 2013
4	Alam 2006
5	Andersen, Andersen 2014
6	Andriopoulos, Gotsi 2006
7	Appio et al. 2013
8	Attar 2010
9	Backman et al. 2007
10	Bate 2010
11	Bers, Dismukes 2012
12	Bessant, Phillips 2013
13	Bocken et al. 2014
14	Boeddrich 2004
15	Bothos et al. 2012
16	Brem, Voigt 2009
17	Brentani, Reid 2012
18	Bröring, Leker 2007
19	Bröring et al. 2006
20	Brunswicker, Hutschek 2010
21	Chang et al. 2007
22	Cooper 1999
23	Cuhls 2003
24	D'Aujourd'hui 2015
25	Daheim, Uerz 2008
26	Filieri 2013
27	Florén, Frishammar 2012
28	Frishammar et al. 2011
29	Gaubinger, Rabl 2014
30	Globocnik 2011
31	Gordon et al. 2008
32	Güemes Castorena et al. 2013
33	Günzel, Holm 2013
34	Hannola et al. 2009
35	Hannola, Ovaska 2011
36	Herstatt, Verworn 2003

37	Herstatt 2007
38	Herstatt et al. 2006
39	Hideg 2007
40	Ho, Tsai 2011
41	Holtorf 2011
42	Ilevbare et al. 2014
43	Jetter 2005
44	Jörgensen et al. 2011
45	Khurana, Rosenthal 1997
46	Khurana, Rosenthal 1998
47	Kim, Wilemon 2002
48	Koen et al. 2001
49	Koen et al. 2014a
50	Koen et al. 2014b
51	Kurkkio 2011
52	Lauto et al. 2013
53	Leon 2009
54	Liebl, Schwarz 2010
55	MacKay, McKiernan 2010
56	Markham 2013
57	Markham, Lee 2013
58	Markham et al. 2010
59	Martini et al. 2014
60	Martinsuo 2009
61	Martinsuo, Poskela 2011
62	Mathews 2010
63	Montoya-Weiss, O'Driscoll 2000
64	Oliveira, Rozenfeld 2010
65	Piirainen et al. 2010
66	Poskela 2007
67	Poskela, Martinsuo 2009
68	Postma et al. 2012
69	Reid, Brentani 2004
70	Reid, Brentani 2012
71	Rejeb et al. 2011
72	Rice et al. 2001
73	Riel et al. 2013
74	Rohrbeck 2011
75	Rohrbeck, Gemünden 2011
76	Rohrbeck 2014
77	Russell 2008
78	Saetre, Brun 2012
79	Sánchez et al. 2011

80	Sawhney et al. 2005
81	Scheiner et al. 2014
82	Schoonmaker et al. 2013
83	Schweitzer, Gabriel 2012
84	Smith, Herbein 1999
85	Spanjol et al. 2011
86	Stevens 2014
87	Stockstrom, Herstatt 2008
88	Trotter 2011
89	van der Duin, Patrick, den Hartigh 2009
90	van der Duin, Patrick A. et al. 2014
91	Vantrijp, Vankleef 2008
92	von der Gracht, Heiko A. et al. 2010
93	Verworn 2009
94	Verworn et al. 2008
95	West, Sacramento 2006
96	Whitney 2007
97	Wießmeier, Georg F. L. et al. 2012
98	Zien, Buckler 1997
99	Zirger, Maidique 1990

Appendix B - Selected definitions of the term Front End of Innovation

Table 50: Selected definitions of the term Front End of Innovation

Author	***Definition***
Brentani, Reid 2012, p. 70	*"The fuzzy front-end (FFE) of the new product development (NPD) process—that is, the time and activity prior to an organization's first screen of a new product idea […]"*
Brem, Voigt 2009, p. 353	*"In this sense, the phase is partly analog to the introduced idea generation stage, but the focus on the front end is mainly one of opportunity identification and analysis [...]."*
Khurana, Rosenthal 1998, p. 59	*"[…] we define the front end to include product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition, project planning, and executive reviews."*
Hannola et al. 2009, p. 900	*"The FEI is defined as those activities that take place before an actual, well-structured new product development process."*

Koen et al. 2014a, p. 34	"*The front end is often envisioned as a linear process of three stages separated by management decision gates. In the first stage, pre-work is done to discover new opportunities. In the second, scoping stage, quick and inexpensive assessments of the marketing and technical merits of the project are carried out. A detailed business case is constructed in the final stage.*"
Verworn 2009, p. 1571	"*The fuzzy front end [...] is considered to be the first stage of the new product development process and roughly covers the period from the generation of an idea to its approval for development or termination.*"
Aagaard 2012, p. 457	*"The Front end innovation (FEI) represents the first building blocks of product development, but is often regarded as a weak link in innovation literature*."
Ho, Tsai 2011, p. 48	*"We define the FEI as a systematic planning and controlling process during the period between when an opportunity is first considered and when an idea is judged ready for innovative product development."*
Postma et al. 2012, p. 642	*"The front-end of new product development involves the identification and analysis of product or service opportunities, idea generation, and the selection of new product and service concepts."*

Appendix C - Overview of FEI Principles derived from literature

Table 51: Overview of FEI Principles derived from literature

Source	***Derived principle***	***Nr.***
Alam 2006	Frequent contact to selected customers at the FEI	LP1
Bothos et al. 2012	Systematic sharing of ideas across organisations	LP2
	Fostering of cognitive diversity in teams	LP3
	Low complexity of idea input mechanism	LP4
	Motivation of people	LP5
	Application of the concept of play	LP6
	Proper feedback provision	LP7
Brunswicker, Hutschek 2010	Alignment of internal and external innovation processes	LP8
	Clear innovation search strategy	LP9

Gordon et al. 2008	Early, sharp product definition	LP10
	IT-Support at the Front End of Innovation	LP11
Hannola et al. 2009	Preliminary market assessment	LP12
	Preliminary technology assessment	LP13
	Detailed customer need analysis	LP14
	Priorities for product features	LP15
	Recognise need to change product definition	LP16
	Frequent customer contact during idea generation and evaluation	LP17
Herstatt et al. 2006	Frequent contact between marketing and customers	LP18
	Frequent integration of customers during concept definition	LP19
	Systematic translation of customer requirements into technical specifications	LP20
	Systematic project planning prior to its start	LP21
	Reduction of market uncertainty	LP22
	Reduction of technical uncertainty	LP23
	Team selection	LP24
Ho, Tsai 2011	Strategic goal	LP25
	Innovative Culture	LP26
	Proficient procedure	LP27
	Strategic alignment between NPD and strategy	LP28
Khurana, Rosenthal 1998	Product positioning	LP29
	NPD portfolio planning	LP30
	Early, sharp product definition	LP31
	Preliminary market & technology assessment	LP32
	Priorities for product features	LP33
	Recognise need to change product definition	LP34
	Project priorities	LP35

	Resource allocation planning	LP36
	Planning for technical / market contingencies	LP37
	Project Manager's role	LP38
	Team organisation	LP39
	Organisational communications	LP40
	IT Support	LP41
Kim, Wilemon 2002	Well-defined target markets	LP42
	Clear product specifications and concepts	LP43
	Extensive preliminary market assessment	LP44
Koen et al. 2014b	Effective teams	LP45
	Team Leadership	LP46
	Communities of Practice	LP47
	Front End Performance	LP48
	Systematic Opportunity Identification and Analysis	LP49
	Systematic Idea Generation	LP50
	Systematic Idea Enrichment	LP51
	Systematic Idea Selection	LP52
	Systematic Concept Definition	LP53
Poskela 2007	Common strategy awareness	LP54
	Integration of strategic and operative level FEI activities	LP55
	Systematic FEI approach / process	LP56
Poskela, Martinsuo 2009	Innovation Input Control	LP57
	Management Involvement	LP58
	Intrinsic task motivation and individual self-control	LP59
Rejeb et al. 2011	Social and economic context of industrial environment	LP60
	Customer involvement and interaction	LP61
	Selection of successful concepts	LP62
Riel et al. 2013	Top management integration	LP63

	Clearly defined focus	LP64
	Innovation networks	LP65
	Creativity support	LP66
	Entrepreneurial thinking	LP67
	Organisational orientation	LP68
Russell 2008	Clear documentation of required resources	LP69
	Clear documentation of the project's ability to meet customer needs	LP70
	Trained personnel	LP71
	Appropriate starter personnel	LP72
	Management enforced company values	LP73
	Management support	LP74
	Idea Hub	LP75
	Early assigned project leader	LP76
	Efficiency and Effectiveness	LP77
	Cross-functional teams	LP78
	Ability to flexibly support alternative development methods	LP79
	Fair evaluation of radical ideas	LP80
	Flexible and adaptable process support	LP81
	Definition of review points	LP82
	Rapid idea screening process	LP83
	Internal and external idea collection system	LP84
	Team's ability to get external ideas	LP85
	Integration of partners, suppliers and vendors	LP86
	Clear and well-structured new product strategy	LP87
	Active business strategy and financial objectives	LP88
	Identification of project's competitive advantage	LP89
Scheiner et al. 2014	Strategic approach to environmental scanning	LP90

	Technological Gatekeepers / Individuals	LP91
Schoonmaker et al. 2013	Innovation Community / Networks	LP92
Schweitzer, Gabriel 2012	Efficiency	LP93
	Creativity	LP94
	Uncertainty reduction & agreement on further actions	LP95
	Cross-functional interaction	LP96
	Gathering knowledge on customer needs	LP97
	Fostering of commitment	LP98
	Systematic application of methods and analyses	LP99
	Project formalisation	LP100
Smith, Herbein 1999	Robust strategic technology planning process	LP101
	Fast evaluation of ideas	LP102
	Exceptional inventors	LP103
	Linkage to strategy	LP104
	Well-defined process	LP105
	Executive-level leadership and participation	LP106
	Cross-functional Teamwork	LP107
	External interactions	LP108
	Clear assessment of competencies and skills required	LP109
	Definition of technology options	LP110
Trotter 2011	Strategic orientation	LP111
	Market orientation	LP112
	Customer orientation	LP113
	Technology orientation	LP114
	Project champion	LP115
	Executive champion	LP116
	Cultural freedom to innovate	LP117

	Full time multi-skilled teams	LP118
	Definition of communication and strategy	LP119
	Vision	LP120
	Reward of innovative ideas	LP121
	Culture that allows failures	LP122
	Flexible funding	LP123
Vantrijp, Vankleef 2008	Market orientation	LP124
	Interdepartmental connectedness	LP125
	Top management emphasis	LP126
	Reward systems	LP127
Verworn 2009	Initial planning prior to development	LP128
	Early involvement of all departments	LP129
	Fostering of informal, cross-departmental face-to-face meet-ings	LP130
	Teamwork quality	LP131
	Interdisciplinary idea-generation and selection	LP132
	Reduction of market uncertainty	LP133
	Reduction of technical uncertainty	LP134
	Intensity of initial planning prior to development	LP135
Verworn et al. 2008	Reduction of market uncertainty	LP136
	Reduction of technical uncertainty	LP137
	Intensity of initial planning prior to development	LP138
Zien, Buckler 1997	Faith and treasure identity as an innovative company	LP139
	Experimentalism	LP140
	Relationship between marketing and technology	LP141
	Customer intimacy	LP142
	Engagement of the whole organisation	LP143
	The Individual	LP144

	Powerful and purposeful stories	LP145
	Total interconnectivity	LP146
	Permeable boundaries across all systems and groups	LP147

Appendix D - Selected definitions of innovation strategy

Table 52: Selected definitions of innovation strategy

Source	***Definition***
Tidd, Bessant 2009	"*An innovation strategy must cope with an external environment that is complex and ever-changing, with considerable uncertainties about present and future developments in technology, competitive threats and market (and non-market) demands.*" (Tidd, Bessant 2009, p. 164)
Afuah 2002; Afuah 1998	An innovation strategy comprises "*patterns of activities about when and how to use new knowledge to offer products of services.*" (Afuah 2002, p. 369) "*An innovation strategy tells us what actions a firm will take, when, and how it allocates its innovation resource*" (Afuah 1998, p. 99)
Sánchez et al. 2011	An innovation strategy "*means the highest level of innovative practices, and includes the creation of an innovative vision, the alignment of same with business strategy, communication and dissemination of the strategy at all organizational levels, the existence of mechanisms for competitive analysis (market trends, technologies, and competitors' moves), and objectives' measurement.*" (Sánchez et al. 2011, p. 17)
Cooper, Edgett 2010	"*A comprehensive product innovation strategy must include, among other elements, clearly defined objectives and defined strategic areas of focus; it must have a widely understood role in broader business goal.*" (Cooper, Edgett 2010, p. 34)
Gaubinger, Rabl 2014	"*An innovation strategy expresses a company's long-term innovation goals and primarily comprises all strategic statements on development and marketing of new products, technologies and procedures as well as on the opening of new markets. Innovation strategy is always part of a set of strategies. Its objectives are derived from the overall corporate strategy […] A clearly defined innovation strategy*

	determines where a company wants to focus its R&D efforts and therefore where it wants to search for ideas." (Gaubinger, Rabl 2014, pp. 23-24
Strecker 2009	"*Innovation strategy is defined as the sum of strategic choices a firm makes regarding its innovation activity. Innovation goals (ends) are not included - only means. Innovation strategy is considered a firm-wide, cross-functional meta-strategy.*" (Strecker 2009, p. 18)

Appendix E - Definition approaches of the term "business process"

Table 53: Definition approaches of the term "business process"

Source	***Definition***
Davenport 1993, p. 5	"*A process is […] a structured, measured set of activities designed to produce a specified output for a particular customer or market. It implies a strong emphasis on how work is done within an organization, in contrast to a product focus's emphasis on what. A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action.*"
Palmberg 2009, p. 207	A business "*process definition can be condensed to: a horizontal sequence of activities that transform an input (need) to an output (result) to meet the needs of a customer or stakeholder.*"
Zairi 1997, p. 64	A business process is a "*related series of actions, directed to the achievement of a goal, that transforms a set of inputs into desired outputs, by adding value.*"
Bititci et al. 2011, p. 853)	"*A business process is a series of continuous or intermittent cross-functional activities that are naturally connected together with work flowing through these activities for a particular outcome / purpose.*"

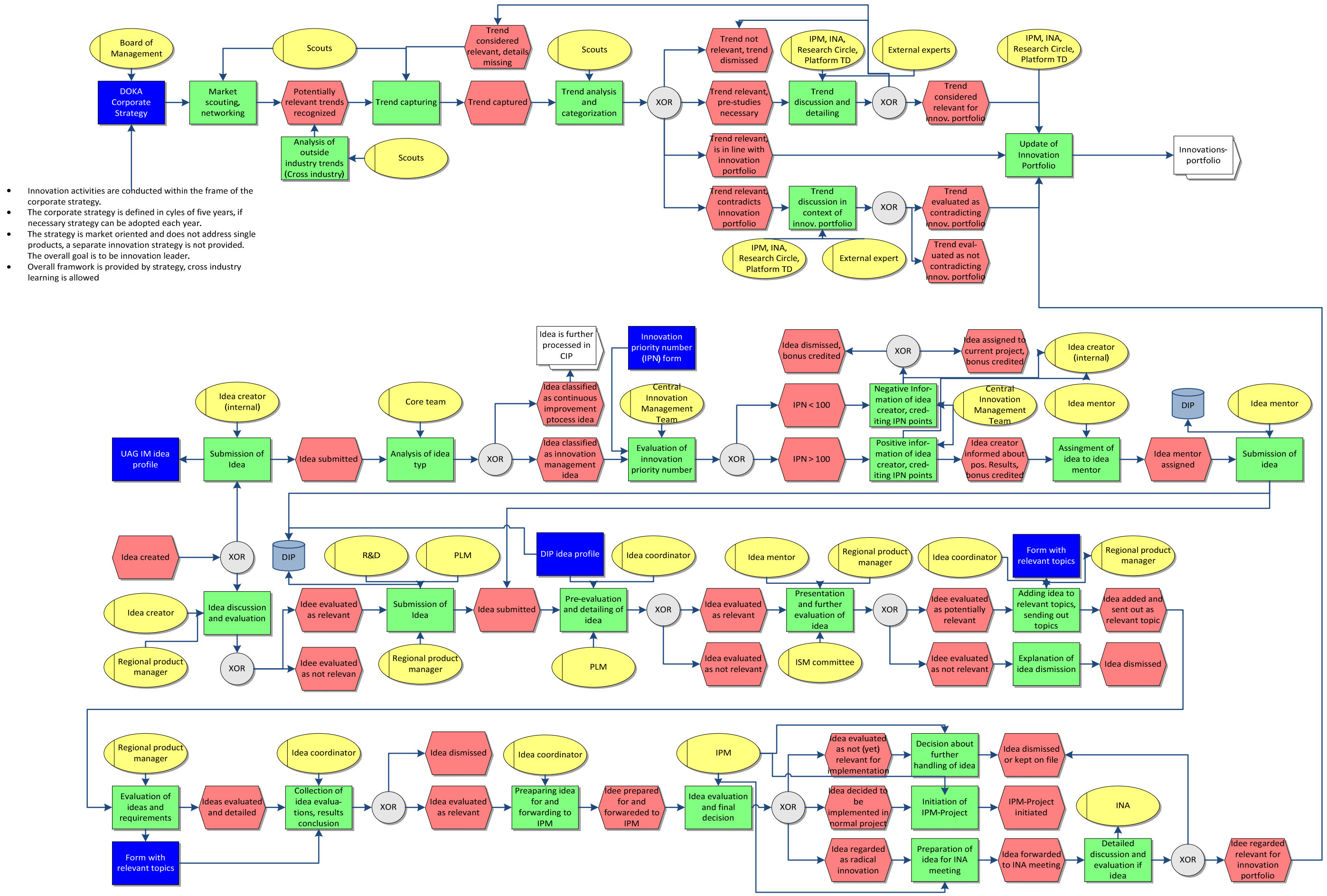
Appendix F - Selected definitions of Corporate Foresight

Table 54: Selected definitions of Corporate Foresight

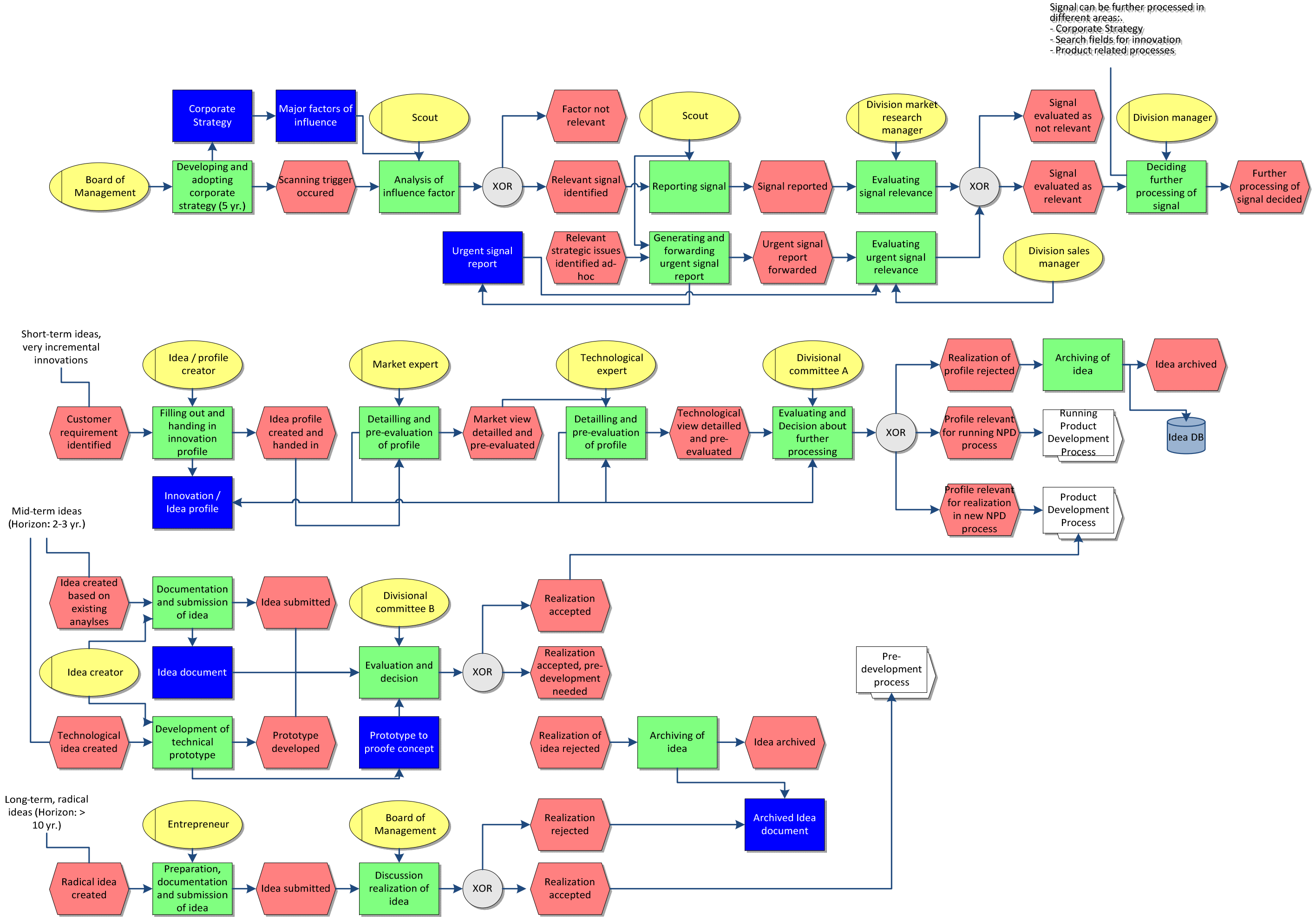
Source	***Definition***
Ruff 2006, p. 282	"*Futures research (corporate foresight) in the enterprise supports the early identification and evaluation of opportunities and risks and thus*

	contributes to innovation management, business and investment strategy.”
Daheim, Uerz 2008, p. 322	“*CF is regarded by a growing number of corporations as the tool of choice for preparing business for the future, whether in terms of producing a long-term strategic vision, ideas for product innovations or a scenario for communication purposes*.”
Rohrbeck 2011, p. 11	*“Corporate foresight is an ability that includes any structural or cultural element that enables the company to detect discontinuous change early, interpret the consequences for the company, and formulate effective responses to ensure the long-term survival and success of the company”.*
Horton 1999, p. 5	*“Foresight is the process of developing a range of views of possible ways in which the future could develop, and understanding these sufficiently well to be able to decide what decisions can be taken today to create the best possible tomorrow”.*
Battistella 2014, p.60	*“Corporate Foresight (CF) is the process used by companies to identify weak signals and information from the periphery, anticipate emerging markets and trends and formulate corporate strategies and innovation policies to prepare for an uncertain future”.*
Darkow 2015, p 10	*“Corporate foresight is seen as a method of reflecting critically on potential future developments and the impact they may have […]. It is important to perceive developments that may become trends, their interrelations, and emerging patterns that may have an impact on corporate settings”.*
von der Gracht et al. 2010, p 381	*“Corporate foresight [...] stands for the analysis of long-term prospects in business environments, markets and new technologies, and their implications for corporate strategies and innovation […] and is, therefore, considered a part of strategic (innovation) management”.*

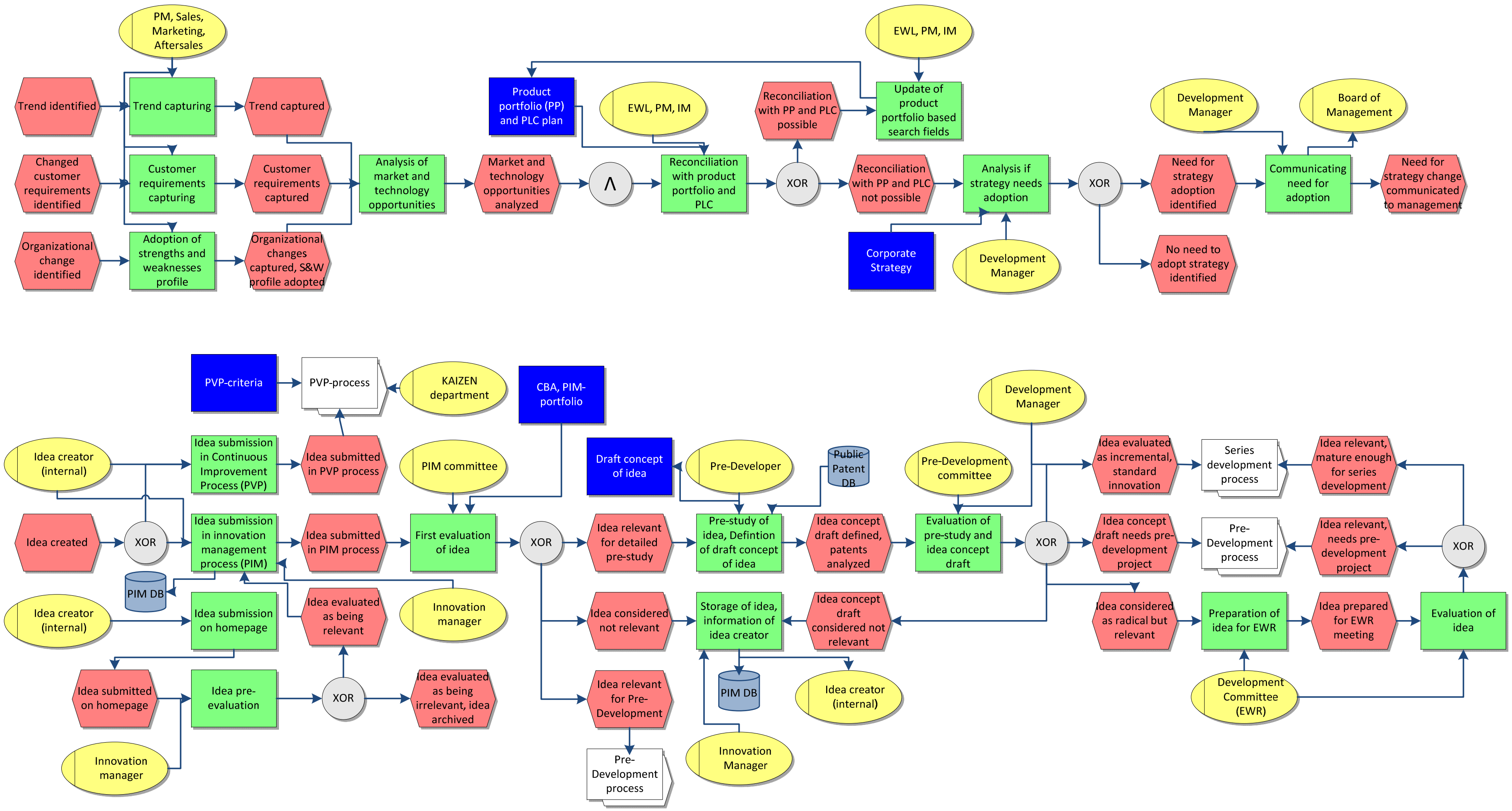
Appendix G - FEI Process in Organisation 1



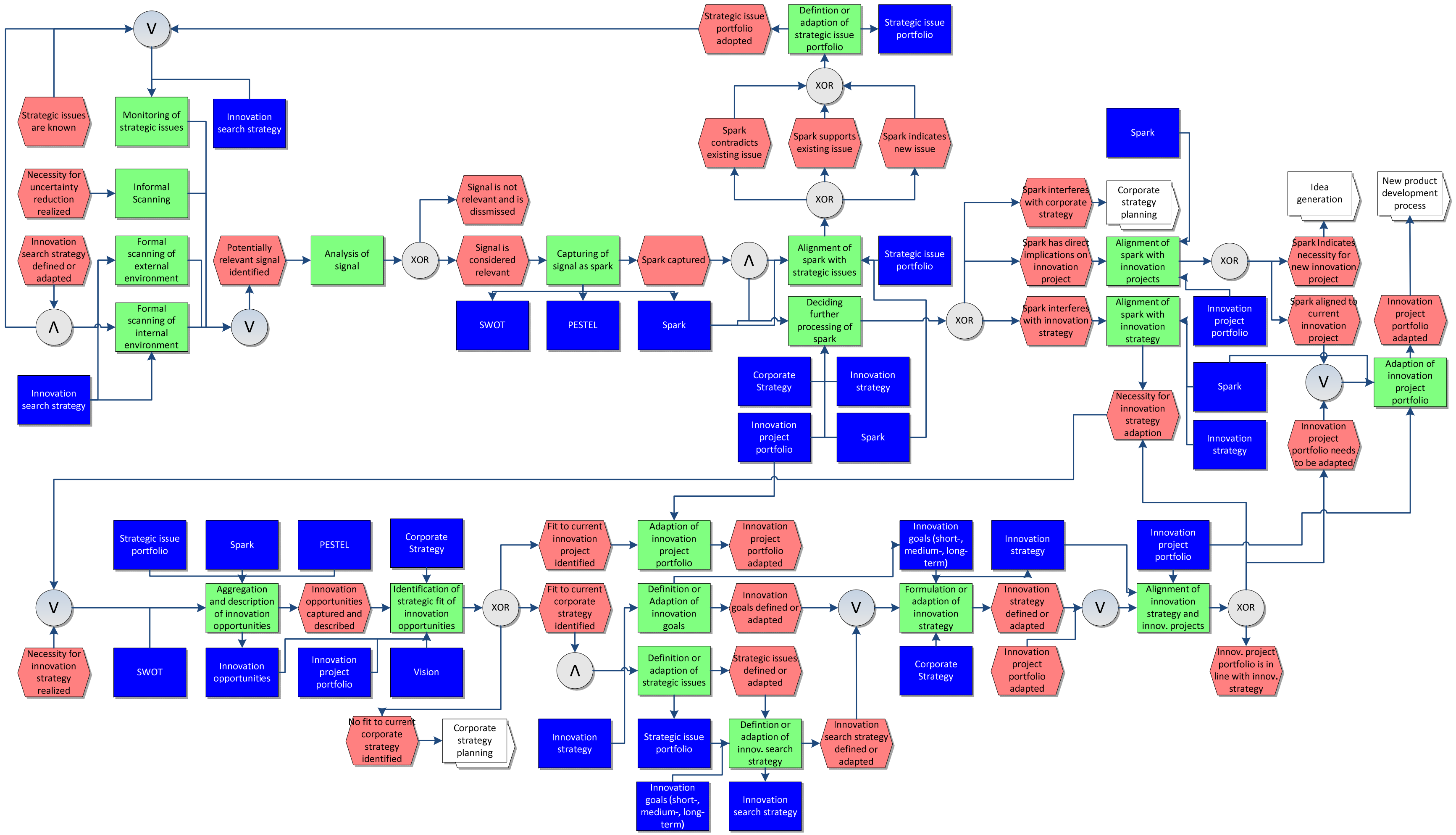
Appendix H - FEI Process in Organisation 2



Appendix I - FEI Process in Organisation 3



Appendix J - Strategic FEI Process Model of the Thesis



Appendix K - Theoretical and practical basis for FEI principle P1

Table 55: Theoretical and practical basis for FEI principle P1

FEI-principle 1:		***Systematic uncertainty reduction***
Matched derived source principle(s):		
ID	*Source*	*Derived Description*
PP1	Focus group FG2	Monitoring and reporting of selected factors of influence
PP2	Focus group FG2	Identification of relevant influencing factors
PP3	Focus group FG2	A traceable evaluation of qualitative influencing factors
PP4	Focus group FG2	Identification of future developments on the end user market
PP5	Focus group FG2	Cross-industry technology transfer
PP6	Focus group FG2	Technology, commercialisation and customer benefits are key aspects.
PP8	Focus group FG2	Identification of substitute products despite a strong product focus
PP9	Focus group FG2	Evaluation of influencing factors and identification of trends
PP16	Focus group FG2	Identification and integration of customer problems
PP18	Focus group FG1	Identification of country specific requirements on a global market
PP19	Focus group FG1	Monitoring of developments and trends in the organisational environment
PP20	Focus group FG1	Integration of external experts
PP22	Focus group FG1	Identification of long-term future developments
PP24	Focus group FG1	Communication and Integration of market research data
PP25	Focus group FG1	Objective identification and evaluation of trends
PP26	Focus group FG1	Strategically oriented opportunity analysis
PP27	Focus group FG1	Grouping of trends and combination of knowledge

PP35	Focus group FG3	Our employees, their intrinsic motivation and their networks
PP36	Focus group FG3	Integration of external experts and establishing networks
PP40	Focus group FG3	Structured and strategically oriented opportunity analysis
PP41	Focus group FG3	Criteria-based opportunity analysis
PP50	Focus group FG3	Technology monitoring based idea generation
LP1	Alam 2006	Frequent contact to selected customers at the FEI
LP11	Gordon et al. 2008	IT-Support at the Front End of Innovation
LP12	Hannola et al. 2009	Preliminary market assessment
LP13	Hannola et al. 2009	Preliminary technology assessment
LP14	Hannola et al. 2009	Detailed customer need analysis
LP17	Hannola et al. 2009	Frequent customer contact during idea generation and evaluation
LP18	Herstatt et al. 2006	Frequent contact between marketing and customers
LP19	Herstatt et al. 2006	Frequent integration of customers during concept definition
LP20	Herstatt et al. 2006	Systematic translation of customer requirements into technical specifications
LP22	Herstatt et al. 2006	Reduction of market uncertainty
LP23	Herstatt et al. 2006	Reduction of technical uncertainty
LP32	Khurana, Rosenthal 1998	Preliminary market & technology assessment
LP37	Khurana, Rosenthal 1998	Planning for technical / market contingencies
LP41	Khurana, Rosenthal 1998	IT Support
LP44	Kim, Wilemon 2002	Extensive preliminary market assessment
LP48	Koen et al. 2014b	Front End Performance
LP49	Koen et al. 2014b	Systematic Opportunity Identification and Analysis
LP56	Poskela 2007	Systematic FEI approach / process

LP60	Rejeb et al. 2011	Social and economic context of industrial environment
LP61	Rejeb et al. 2011	Customer involvement and interaction
LP68	Riel et al. 2013	Organisational orientation
LP70	Russell 2008	Clear documentation of the project's ability to meet customer needs
LP81	Russell 2008	Flexible and adaptable process support
LP85	Russell 2008	Team's ability to get external ideas
LP86	Russell 2008	Integration of partners, suppliers and vendors
LP90	Scheiner et al. 2014	Strategic approach to environmental scanning
LP91	Scheiner et al. 2014	Technological Gatekeepers / Individuals
LP95	Schweitzer, Gabriel 2012	Uncertainty reduction & agreement on further actions
LP97	Schweitzer, Gabriel 2012	Gathering knowledge on customer needs
LP99	Schweitzer, Gabriel 2012	Systematic application of methods and analyses
LP101	Smith, Herbein 1999	Robust strategic technology planning process
LP105	Smith, Herbein 1999	Well-defined process
LP108	Smith, Herbein 1999	External interactions
LP110	Smith, Herbein 1999	Definition of technology options
LP112	Trotter 2011	Market orientation
LP113	Trotter 2011	Customer orientation
LP114	Trotter 2011	Technology orientation
LP124	Vantrijp, Vankleef 2008	Market orientation
LP128	Verworn et al. 2008	Reduction of market uncertainty
LP129	Verworn et al. 2008	Reduction of technical uncertainty
LP136	Verworn 2009	Reduction of market uncertainty
LP137	Verworn 2009	Reduction of technical uncertainty
LP142	Zien, Buckler 1997	Customer intimacy

Appendix L - Theoretical and practical basis for FEI principle P4

Table 56: Theoretical and practical basis for FEI principle P4

FEI-principle 4:		***Definition of an innovation strategy***
Matched derived source principle(s):		
No	*Source*	*Derived Description*
PP7	Focus group FG2	Balance between short-, mid- and long-term innovation projects
PP21	Focus group FG1	Integration of strategical knowledge in the innovation activities
PP23	Focus group FG1	Resource allocation planning
PP26	Focus group FG1	Strategically oriented opportunity analysis
PP37	Focus group FG3	Long-term oriented resource allocation
PP38	Focus group FG3	Definition of consistent and stable innovation goals
PP39	Focus group FG3	Strategically oriented innovation processes
PP40	Focus group FG3	Structured and strategically oriented opportunity analysis
PP47	Focus group FG3	Integration of different structures and systems
LP8	Brunswicker, Hutschek 2010	Alignment of internal and external innovation processes
LP9	Brunswicker, Hutschek 2010	Clear innovation search strategy
LP21	Herstatt et al. 2006	Systematic project planning prior to its start
LP25	Ho, Tsai 2011	Strategic goal
LP27	Ho, Tsai 2011	Proficient procedure
LP28	Ho, Tsai 2011	Strategic alignment between NPD and strategy
LP29	Khurana, Rosenthal 1998	Product positioning
LP30	Khurana, Rosenthal 1998	NPD portfolio planning
LP35	Khurana, Rosenthal 1998	Project priorities
LP36	Khurana, Rosenthal 1998	Resource allocation planning

LP42	Kim, Wilemon 2002	Well-defined target markets
LP48	Koen et al. 2014b	Front End Performance
LP54	Poskela 2007	Common strategy awareness
LP55	Poskela 2007	Integration of strategic & operative level FEI activities
LP57	Poskela, Martinsuo 2009	Innovation Input Control
LP64	Riel et al. 2013	Clearly defined focus
LP69	Russell 2008	Clear documentation of required resources
LP87	Russell 2008	Clear and well-structured new product strategy
LP88	Russell 2008	Active business strategy and financial objectives
LP90	Scheiner et al. 2014	Strategic approach to environmental scanning
LP93	Schweitzer, Gabriel 2012	Efficiency
LP101	Smith, Herbein 1999	Robust strategic technology planning process
LP104	Smith, Herbein 1999	Linkage to strategy
LP111	Trotter 2011	Strategic orientation
LP119	Trotter 2011	Definition of communication and strategy
LP120	Trotter 2011	Vision
LP123	Trotter 2011	Flexible funding
LP128	Verworn 2009	Initial planning prior to development
LP135	Verworn et al. 2008	Intensity of initial planning prior to development
LP138	Verworn 2009	Intensity of initial planning prior to development

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