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Developing a Process Model for Future-Robust Advancement of Product Portfolios

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Abstract: The advancement of the product portfolio through new innovative products is an essential activity for the long-term success of companies. Simultaneously the advancements due to increasingly networked systems and a volatile environment also represent a major challenge for developers. Two previous interview studies demonstrated that there is a need for action. The overall aim is to support developers in the realization of future-robust advancement. Therefore, an initial process model for the future-robust advancement of product portfolios is developed in this paper. Based on the Design Research Methodology, the descriptive study analyzed theory and practice and derived requirements. Based on these findings, a process model was developed, which was converted into a guideline for execution with companies. The process model was initially evaluated with experts from method development and with experts from companies. This approach is to be further expanded and evaluated in companies in future work.

Keywords: New Product Development, Sustainable Design, Product Families, Future-Robust, Product Portfolio Management

1 Introduction

The advancement of the product portfolio is a key activity for the company's long-term success (Doorasamy, 2015). Further development is characterized by challenges such as shorter product life cycles, complex networked products, adaptable products as well as a volatile business environment (Alfieri et al., 2020). Product portfolio development is a dynamic process and is driven by technological and market-orientated forces (Sadeghi and Zandieh, 2011). These challenges can soon no longer be met with conventional methods (Dumitrescu et al., 2021). An interview study with 7 companies, in which the further development of product portfolios was analyzed, revealed that a description model and a consistent process model for the advancement of product portfolios are required (Meyer et al., 2021). To address these needs, the focus of this work is the process model. The process model is intended to suggest tasks and activities for future-robust further development and to structure the process of further development of product portfolios. Models already exist, such as the "reference model of strategic planning and integrative development of market offerings" according to Gausemeier, which proposes main tasks in the context of strategic product planning to transfer future knowledge into product development (Gausemeier et al., 2019). Approaches from the field of product development are often focused on the development of individual products. They do not address the further advancement of several products in the form of a product portfolio with different levels (Productline, Productfamily and Productvariant), as companies are confronted with daily. However, existing approaches provide a starting point for an extension for product- and cross-generational advancement approaches. For example, the systematic approach for future-oriented product development according to MARTHALER (Marthaler et al., 2019). Approaches from portfolio management, such as the "procedure for sustainable product portfolio planning", take up aspects of scenario management and transfer them to portfolio development, but do not model any further influences on the advancement of product portfolios (Söllner, 2016). DÜLME has developed an approach for the future-oriented consolidation of multi-variant product programs (Dülme, 2018). Andersson outlines basic strategies such as the expansion and reduction of product portfolios (Andersson et al., 2021). Approaches such as productization according to HARKONEN focus on aspects such as the transformation of customer needs into saleable product offerings, but do not yet integrate reference-based development in generations (Harkonen et al., 2017). ECKERT and ALBERS demonstrate that product development in most cases consists of improving and advancing existing products (Eckert et al., 2010) (Albers et al., 2017a). Completely newly developed versions and technologies without design reuse are rare (Schuh et al., 2016). However, many of the existing approaches start without considering an existing product portfolio. The existing elements in the product portfolio represent references that must be explicitly taken up again in the search for innovation potential in the further development of product portfolios in, taking into account various volatile influences. As the two interview studies ((Meyer et al., 2021; Schlegel et al., 2024) show, companies still require methods and processes for the further development of product portfolios. There is currently no suitable process model that enables the reference-based development of products in a portfolio in consistency with a description model and taking into account influences from the environment (Schlegel et al., 2023b). Consequently, we aim to develop a process model for the future-robust advancement of product portfolios in this contribution.

2 Theoretical background

Future-robust advancement of product portfolios addresses three topics as shown in Figure 1. First, most companies do not develop just a single product but have to develop and launch several products at the right intervals and in different cycles (Doorasamy, 2017). The subject area of portfolio management deals with models that address these issues. Strategic product planning as the first cycle of the "reference model of strategic planning and integrative development of market offerings" incorporates elements of foresight, which are necessary for future-robust development, together with aspects of business planning and product discovering e.g technology roadmaps (Gausemeier et al., 2019). The use of references is essential for efficient development (Albers et al., 2019). New developments and successive generations are always developed based on references (Albers et al., 2015). Therefore, the generational concept and the reference-based advancement of the portfolio must also be taken into account.

Figure 1.: The figure shows the relevant fields of investigation that need to be addressed to meet the challenge of the future-robust advancement of product portfolios. (Schlegel et al., 2023b)

The following section takes a look at process models that support the field of the advancement of product portfolios. These are placed in one of the presented investigation fields or already link several investigation fields with each other. The models shown provide a starting point for the development of a process model for the future-robust advancement of product portfolios.

Stage Gate Process according to Cooper is a basic process with the phases: Idea Generation, Scoping, Build Business cases, Development, Testing & Validation and Launch. The so-called gates or milestones are located before each phase. They serve as control and decision points and control the further course of the process. The gates consist of three elements: (1) gate results (2) gate criteria (3) gate output. If the next phase is to be started, an action plan, schedule and deliverables for the following phase are defined. COOPER points out that there is a large focus on pre-development, even before the actual product development begins from phase 3. It also notes that the prescribed, logical and sequential manner of this process can be adapted through iterations and loops between and within the stages The model presented does not provide any recommendations for action, but rather serves to provide orientation and review the current process steps. (Cooper, 2008)

The **process model by Vahs and Burmster** also describes a general procedure in the innovation process. The overarching phases of innovation initiation, idea generation and selection, implementation and market launch can be derived from the approach. Vahs and Burmster thus supplement the approach with the idea impulse as a trigger for development. (Vahs and Burmester, 2013)

The systematic for **future-oriented product development** focuses on the cross-generational derivation and prioritization of product features through systematically integrated strategic foresight in product development. A variant is defined at the beginning and then the current phase, the target phase, the delta phase and finally the implementation phase are run through. The approach combines aspects of strategic product planning with elements of reference-based development in the form of the model of SGE - System Generation Engineering (Marthaler et al., 2019).

The procedure for sustainable product portfolio planning is based on six phases: starting with an analysis of the market and the environment, reference scenarios are created, the design field is characterized and product concepts are developed with the help of design variables. These are then localized and further detailed on a strategic product map. Individual characteristics of the product concepts are then anchored in the strategic planning process with a monitoring concept. (Söllner, 2016)

Cross-generational SGE – System Generation Engineering focuses on the interaction between SGE and foresight and derives a bridge between visions of the future and the technical subsystems. A first explorative study shows potentials between reference-based development in generations and strategic product planning (Albers et al., 2018). As part of the study, a six-step process model was developed, which begins with the evaluation of the current product generation of its customer-experience characteristics and aims to derive product profiles at the subsystem level for several generations via market and environment scenarios. The existing models represent effective approaches for the respective use cases. Individual approaches already combine strategic product planning with generation development or strategic product planning with portfolio analysis. To meet the challenge of the future-robust advancement of product portfolios, however, a combination of the three fields of research is required (Schlegel et al., 2023b). (Albers et al., 2018)

The **correlating descriptive model** for the process model transfers the model of SGE - System Generation Engineering to the field of product portfolios. Descriptive elements are provided which are used as references in the process model for the advancement of product portfolios (Albers et al., 2019). The advancement can be shown with three types of variation according to the Model of SGE: Carryover variation, attribute variation and principle variation. (Albers and Rapp, 2022; Schlegel et al., 2023a)

3 Methodology

Models such as COOPER's Stage-Gate System provide an idealized and highly abstracted approach to product development (Cooper, 2008). Due to their abstract nature, they can merely be used for orientation in the volatile product development processes of the 21st century. Product portfolio management meets growing challenges in an increasingly networked and volatile product development environment (Tolonen et al., 2014). There is a lack of an approach to the holistic and cross-generational further development of product portfolios that addresses the fields of investigation, strategic product planning, portfolio management and reference-based development. (Schlegel et al., 2023).

The overarching aim of this work is to support product developers in their search for innovation potential in the further development of product portfolios, taking into account the various influences. To achieve this aim, a process model for the future-robust advancement of product portfolios will be developed within the present work. This process model should help to systematically identify and evaluate influences on the product portfolio and the resulting need for adaptation of the product portfolio to increase innovation potential (Meyer et al., 2021).

To achieve this aim, the following research questions are to be answered.

RQ1: What requirements have to be fulfilled for the future-robust advancement of product portfolios? (DSI)

RQ2: How can a process model be designed to support the future-robust advancement of product portfolios? (PS)

RQ3: To what extent does the process model support the future-robust advancement of product portfolios? (DSII)

The work is based on the research approach of the Design Research Methodology (DRM) according to (Blessing & Chakrabarti, 2009) as illustrated in Figure 2.

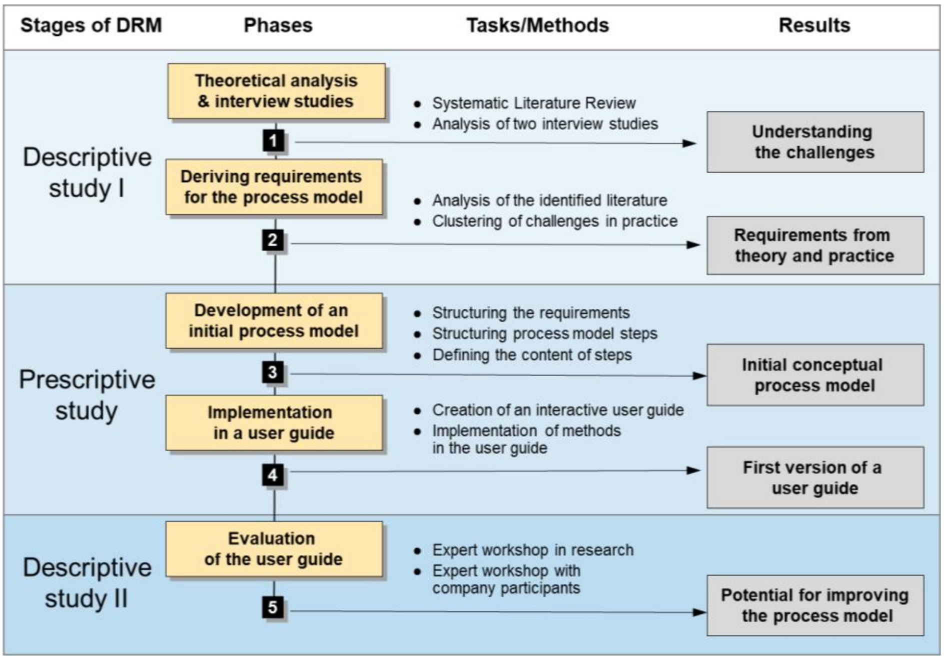

Figure 2.: The figure shows the main milestones, methods used and associated results. The combination of theory and practice at the beginning of the research project is intended to ensure that the approach can be applied in practice.

To understand the underlying relationships, a systematic literature review of current models and systems for the further development of product portfolios is carried out as part of the descriptive study I. The theoretical data collection is supplemented by the practical perspective through the inclusion of interviews with companies in two interview studies with a total of 17 companies that were performed in previous studies (Meyer et al., 2021; Schlegel et al., 2024). Requirements for robust advancement of product portfolios were then derived from theory and practice to answer RQ1.

The findings and requirements for the advancement of product portfolios derived from the analysis are incorporated into the process model in the subsequent prescriptive study (PS). For this purpose, existing models are analyzed and the requirements are localized. Based on the requirements collected from theory and practice, a process model for the future-robust advancement of product portfolios is developed. This process model is then implemented in a guideline to transfer the process model into the application.

This is followed by the second descriptive study (DS II). Within this, the guideline is evaluated in two stages. The two questions to be answered are whether the guideline can be applied and whether it supports the derivation of innovation potentials in the further development of product portfolios.

4 Results

In line with the research methodology and the research questions posed, the results are divided into the following sections: 4.1 Requirements for a process model to advance the product portfolio, 4.2 Process model for the future-robust advancement of product portfolios and 4.3 Evaluation of the guideline developed

4.1 Requirements for a Process Model

The previous systematic literature review has shown that there is no suitable approach for the future-robust advancement of product portfolios by combining the areas of strategic product planning, portfolio management and working with references (Schlegel et al., 2023b). However, requirements and aspects for the further development of product portfolios could be obtained from the approaches. A total of 114 requirements were derived from the literature. In the next step, these 114 requirements were categorized into 14 topic clusters. These clusters were discussed, refined and interactions identified in a three-stage process. This results in 14 requirement clusters as shown in Table 1 with interactions between the individual clusters.

Table 1.: The 14 clusters take up the 114 derived requirements and represent the essential requirement groups for the development of an approach.

Req:	Name of Cluster	Sources of Cluster
T1	Determination of risk	(Albers et al., 2017b), (Albers et al., 2018)
T2	Analysis of the current state	(Albers et al., 2022b), (Gausemeier et al., 2019), (Schlegel et al., 2024), (Graner, 2016), (Herstatt and Verworn, op. 2007)
T3	Planning in generations	(Albers et al., 2019), (Albers et al., 2022b), (Albers et al., 2017b), (Albers et al., 2018), (Gausemeier et al., 2019), (Schlegel et al., 2024), (Krause and Gebhardt, 2023)
T4	Anticipating the future	(Albers et al., 2022b), (Gausemeier, 2013), (Gausemeier et al., 2019), (Herstatt and Verworn, op. 2007)
T5	Determination of the variation ratios	(Meyer et al., 2021), (Albers et al., 2015), (Albers et al., 2017b), (Gausemeier et al., 2019), (Graner, 2016), (Friedrich von den Eichen et al., 2007), (Herstatt and Verworn, op. 2007)
T6	Realization of the identified product profile	(Albers et al., 2017b), (Albers et al., 2018), (Gausemeier et al., 2019), (Herstatt and Verworn, op. 2007)
T7	Observing the triggers	(Meyer et al., 2021), (Gausemeier et al., 2019), (Schlegel et al., 2024), (Herstatt and Verworn, op. 2007)
T8	Development of the product portfolio	(Meyer et al., 2021), (Albers et al., 2022b), (Albers et al., 2018), (Pastewski, 2011), (Krause and Gebhardt, 2023)
T9	Determination of the planning horizon	(Meyer et al., 2021), (Albers et al., 2022b), (Albers et al., 2018), (Gausemeier et al., 2019)

T10	Evaluation of the product profiles	(Albers et al., 2022b), (Albers et al., 2018), (Herstatt and Verworn, op. 2007), (Krause and Gebhardt, 2023)
T11	Consideration of customer requirements	(Albers et al., 2015), (Gausemeier et al., 2019), , (Herstatt and Verworn, op. 2007)
T12	Continuous process control	(Gausemeier et al., 2019), (Pastewski, 2011), (Graner, 2016), (Herstatt and Verworn, op. 2007)
T13	Active compilation of the reference systems	(Albers et al., 2019), (Albers et al., 2015), (Albers et al., 2022b), (Albers et al., 2017b), (Pastewski, 2011), (Krause and Gebhardt, 2023)
T14	Analysis of the future business strategy	(Gausemeier et al., 2019), (Gausemeier, 2013), (Friedrich von den Eichen et al., 2007)

The 14 clusters and the requirements contained therein represent the theoretical view from the perspective of the literature. In the following, the theoretical view is expanded with objectives and requirements from practice. The practical perspective is mapped using two consecutive interview studies. Firstly, the basic principles were developed in an initial interview study with seven companies (Meyer et al., 2021). Building on this, the findings were confirmed and expanded by a further in-depth interview study with 10 companies (Schlegel et al., 2024). The following requirement clusters (table 2) are based on the two interview studies mentioned.

Table 2.: The table shows the main groups of requirements from practice based on the two interview studies.

Req:	**Name of Cluster**
P1	Understanding the portfolio as a complex system
P2	Advancements within the portfolio have an impact on other levels
P3	The search for potential for further advancement should take place across all portfolio levels
P4	The levels of the portfolio are differentiated from each other by various characteristics
P4.1	The levels differ in terms of their respective development periods
P4.2	The levels differ in terms of the triggers for advancement
P4.3	Consideration of the level-specific task focuses on the product portfolio
P5	The portfolio has to be developed holistically and continuously, both vertically (spatially) and horizontally (temporally)
P6	Synchronization of the portfolio levels
P7	Identification of synergy effects within the portfolio

The clusters of requirements form the basis for the development of a process model. RQ1 is answered using Table 1 and Table 2, the 24 clusters from theory (14) and practice (10).

4.2 Process model for the future-robust advancement of product portfolios

At its core, the process model follows the understanding that an undesirable initial state should be transformed into a target state. The structure of the process model is based on existing approaches such as the *future-oriented product development* with the current status, target status and delta analysis phase (Marthaler et al., 2019). However, before the actual status phase begins, the approach provides a further phase at the beginning, the initial phase. In accordance with the derived requirements, it is first necessary to understand the current situation and determine whether an adjustment of the product portfolio is necessary at all or at which points and to what extent. The current products in the portfolio, including their technologies and production system, represent references for advancement and must be analyzed and taken up for efficient advancement in the sense of the model of SGE in the actual state. Based on the actual state, it is now necessary to identify a desirable direction for the advancement of the products in a portfolio. The target state - The aim here is to map a target state of how the products should develop in the future using the results of foresight methods. In the delta analysis, the extent to which the respective products need to be adapted compared to the existing products as a reference is discussed. The results are product profiles, which are broken down over several generations in an initial roadmap. This article focuses on the phases: Initial Phase (4.2.1) and Current- and Target status phase so as the Delta analysis (4.2.2). The sub-steps of the process model are explained in more detail in the following overview in Figure 3:

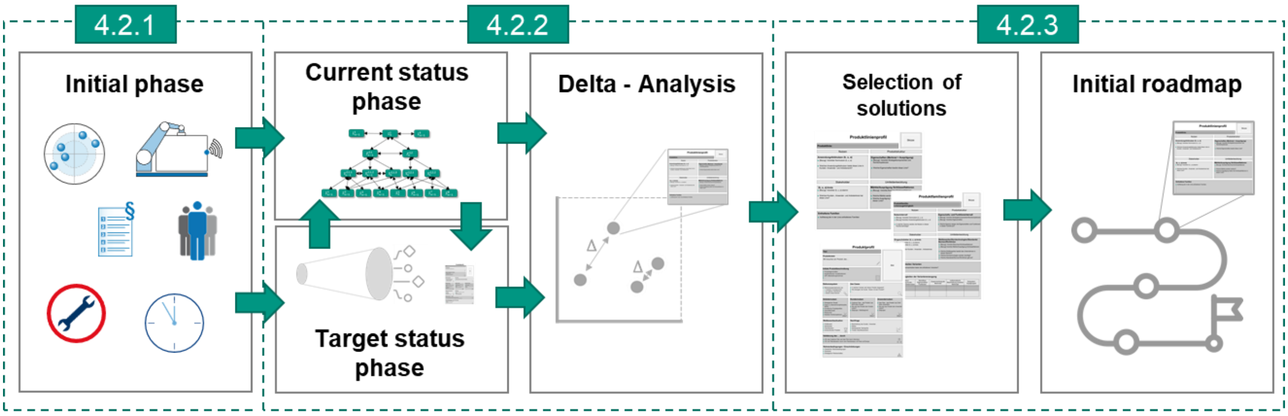

Figure 3.: The initial process model for the future-robust advancement of product portfolios

4.2.1 Initial phase

A company is subject to a variety of environmental changes and influences on the product portfolio. The initial phase aims to identify the influences that affect the product portfolio and trigger action from the various influences on the product portfolio (figure 4), e.g. a shift in technology and production system. These triggers are identified, evaluated and their impact on the portfolio is localized and documented in an influence template. In the **first step**, current influences of triggers on elements of the product portfolio are identified and clustered. These influences can come from various sources; megatrends, customer requirements, new technologies or legal requirements (Meyer et al., 2021; Schlegel et al., 2024). **The second step** involves analyzing whether and where the influence has an impact in the product portfolio. Depending on the location and type of influence, the time horizon can then be further defined and an initial focus and horizon for advancement can be found. For this analysis, part of the product portfolio must be modeled using the descriptive model (Schlegel et al., 2023a). The impact location is relevant for further development, as the main tasks and development periods differ at the levels of the product portfolio (Meyer et al., 2021). Comprehensive forces, such as megatrends, tend to affect the entire portfolio, while limited forces, such as specific customer requirements, affect a specific location or a limited area in the portfolio (Wiederkehr et al., 2023). This categorization can be further refined and triggers can be assigned to individual levels of the product portfolio. Each level has a different focus and different effects.

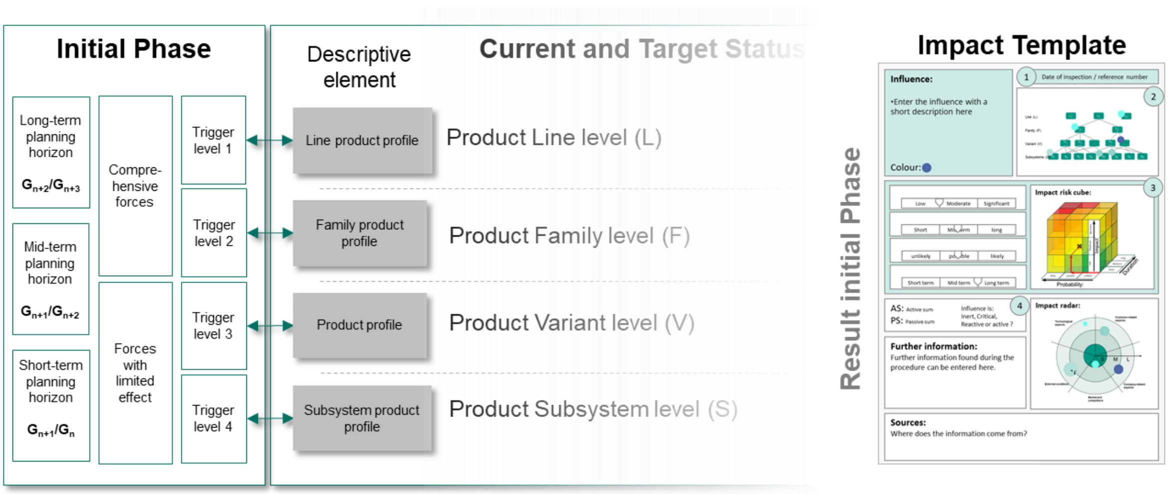

Figure 4.: In the initial phase, triggers are identified and their impact on the product portfolio is localized. A key result of this phase is the impact profile on the right.

Trigger level 1: "Line impact" Comprehensive forces act as triggers at the line level. Trigger level 1 includes all reasons for advancement that are usually planned in long term, they are open-solution and not yet limited to a specific position in the portfolio. Triggers in this category are typically followed by long-term, pre-planned strategic development projects that relate to future product generations.

For trigger level 2 "Family impact": The trigger can be assigned to a specific family within a product line. The trigger affects several variants or even the entire family, so that consideration and advancement activities at family level is necessary. The main task of trigger level 2 relates to finding ideas for realizing potential from the product line's field of application. This is a medium to long-term planning horizon that deals with the planning of at least the next product generation in development.

Trigger level 3 "Variant impact" represent forces with a limited effect. The trigger is already related to a solution in such a way that it can be assigned to individual products at the variant level. For example, specific customer feedback relates to a single variant that the customer has purchased as a product. The main task of trigger level 3 is the solution-orientated adaptation of known and localized requirements. This requires a short to medium-term planning horizon.

Trigger level 4: "Subsystem impact" relates the triggers with a solution-specific character. The triggers already affect a technical subsystem and can be assigned to it. The force acting on the portfolio is therefore often limited to a specific location within the portfolio. It should be noted that the number of times a subsystem is used in other elements of the product portfolio (e.g., a platform element in a modular system) can result in a very high level of interlinking and therefore also have a far-reaching influence on the product portfolio. The main task on this level is to conceptualize and design the subsystems as part of product development. Level 4 triggers require (often) the shortest planning horizon. This can be attributed to the most limited search space for advancement within the portfolio.

The trigger levels represent typical characteristics in the future-robust advancement of product portfolios and always have to take into account other constraints in the company's portfolio. Regarding a modular product platform design, the customization of central sub-system elements can become a long-term project. A shift in production systems and available technologies has an impact as an influence on the subsystems of the product itself, so as a key constraint for the design and realization of the product and therefore the possible advancement of the product portfolio. (Albers et al., 2022a)

In the next step, in addition to the levels of impact, the triggers are assessed regarding their probability and duration. The overall criticality of the trigger can be visualized in an “impact risk cube” (see figure 4). The triggers are also mapped on a “impact radar” (see figure 4), which differentiates the time of occurrence and the area from which the trigger originates. The impact location is shown in an initial section of the portfolio. As a result of the initial phase, an impact template is created for the individual triggers, which takes up and documents the key results from the first phase.

4.2.2 Current status, Target status and Delta analysis

Based on the identification and localization of action-triggering influences, the extent of the impact in the product portfolio has to be further defined.

The **current status phase** describes the current situation and the product portfolio as it currently exists on the market. The description is made with the help of level-specific product profiles. At higher levels, the elements are presented more comprehensively and strategically at lower levels, they are more short-term and operationalized. The analysis of the product portfolio shows the current product profiles and the customers, providers and user benefits addressed by them. The current status can be used a central reference system element for the advancement of the product portfolio (Albers et al., 2019). By understanding the initial situation, variations of the products to be developed can be worked out in the further course and thus possible potentials, ideas and concepts can be described and evaluated.

The **target status phase** deals with the question of how the elements at line, family, variant and subsystem level in the product portfolio should be organized in the future. For example, this involves identifying future relevant customer benefits that are derived using foresight methods. Here too, the focus is on different levels of the product portfolio depending on the trigger level. At higher levels, for example, the process model uses foresight methods with a longer horizon such as scenarios and trends, while lower levels focus on customer and service feedback as well as forecasts and trends with a short time horizon. By proposing level-specific methods that support the main activities, the search for innovation potential within the portfolio, across all levels can be supported.

In the **delta analysis phase**, the effort required to get from the current status to the desired target status is worked out. At first possible references within and outside the company are searched to develop the expected target state. Existing elements from the product portfolio are systematically included in order to find ideas for realization. Based on this, synergy effects in the portfolio are examined to minimize the delta and limit the risk in the second step. Various alternative product profiles are developed in order to realize future products. To estimate the feasibility, the distance to the target state must be estimated using the types of variation and, if necessary, divided into several generations. It is not only the technical change that plays a role here, but also the change in the benefits for the supplier, user and customer.

The interaction of the current phase, target phase and delta analysis phases is shown in the following figure 5. Within the current phase, reference is made to the product generation on the market, which can be recognized in the figure 5 by the indices i=n-1. The future initial product profiles developed in the target phase are divided into product generations in the delta phase. In the figure below, new elements to be developed (i=n) replace existing elements (i=n-1) in the product portfolio.

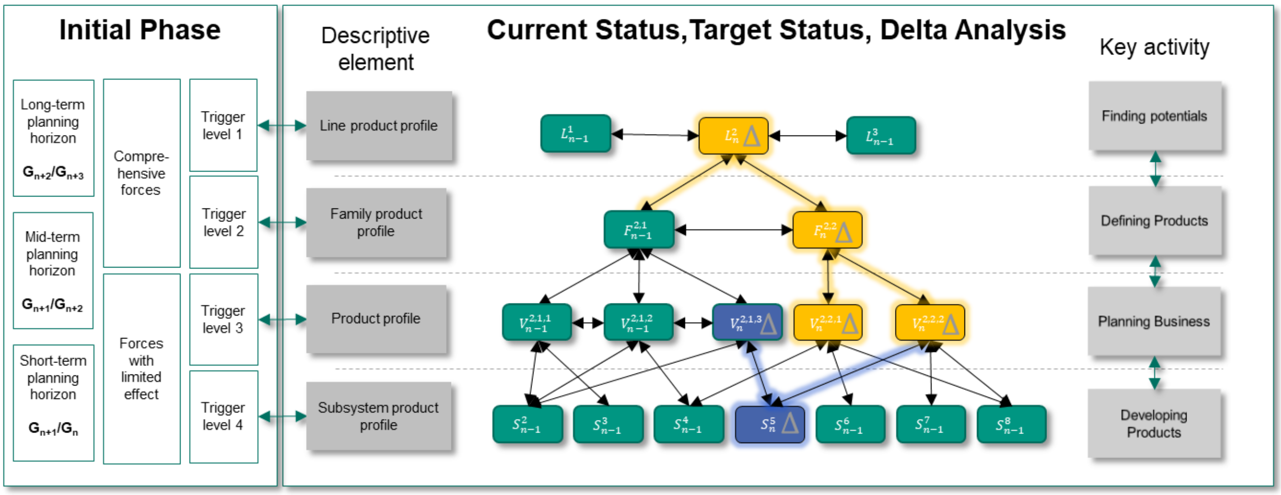

Figure 5: The elements of the portfolio are described as level-specific elements. The center section of the diagram shows the interconnectedness of the elements and the development status via the indication of the model of SGE (orange: elements changed affected of trigger on line level, blue: elements changed by subsystem trigger) (Schlegel et al., 2023a). Level-specific key activities for the advancement of product portfolios are also assigned to the elements (Meyer et al., 2021).

4.2.3 Selection of solution and initial roadmap

Based on the basic description of the development effort in the delta phase, the potentials for possible future products are then evaluated and selected. For the selection and evaluation of innovation potentials, the future viability, the strategy fit, comparison with competition, technical feasibility in terms of technology and production systems and the availability of references are evaluated. The risk can be derived according to the origin of the references and the share of variation (Albers et al., 2017b). Based on the current status, the next steps required to realize the innovation potential according to the target state in the product portfolio are outlined via a cross-generational roadmap.

The process model represents an approach for support answering research question 2. Whether the process model has a supportive effect for advancement must be worked out as part of the evaluation. The process model was implemented in an interactive online guide for use with experts and companies.

4.3 Evaluation of the process model

The guideline was evaluated in two stages and is orientated according to the DRM (Blessing and Chakrabarti, 2009). **Stage I - Expert workshop** with 12 experts from the field of methodological research. **Stage II - Company workshop** with four experts.

Stage I: Expert workshop - After an introduction, the process model implemented in the online guidelines was applied independently by the workshop participants. The introduction includes the objectives of the workshop and the accompanying feedback questions. Feedback was collected in an online survey and throughout the workshop. The following key questions were asked: QI: At what level/with what trigger did you proceed through the guide? QII: Was the guide applicable? Did the guide address the central aspects? QIII: What added value does the guide offer? Did the guideline provide positive support in the further development of product portfolios? QIV: Is the guideline understandable? Are there clear instructions and guiding questions for support? The comments (C) from the expert workshop were reviewed and clustered: C1: Comments on the design of the slides - The cluster shows potential for improvement in the formatting, presentation and arrangement of the slides in the guide. C2: Desire for a more precise description of thematic content - A distinction can be made here between - C2A: More precise description of proposed methods - C2B: More precise description of terms. C3: Inconsistency of terms - A partial inconsistency in the use of terms was noted. C4: Clearer distinction between the target phase and delta analysis - The phases refer to product profiles several times, these should be consistently separated from each other by the actual and target product profiles. C5: German and English versions of the guide - An English version of the guide was suggested to broaden the spectrum of possible users. C6: Input fields for documentation - Input fields for documentation were requested to obtain a summarized individual overview at the end. C7: Structure the key questions as a tree structure - It was also suggested that key questions within the guide could be organized as a tree structure in the sense of a flow chart. Overall, the users confirmed the added value of the guide in the advancement of product portfolios: Expert statement: *"The guide has made an extensive treasure trove of methods accessible and provided a process for orientation via the process model, which I find successful."* As well as *"The guide helps to include important information, including information that is available but might simply not have been considered without the guide."* **Stage II:** The evaluation with the company experts was carried out in the same way as the presentation to the expert panel of method researchers. Added value was also recognized in the further development of the product portfolio. It was positively emphasized that the guideline reproduces existing methods in a *"user-friendly and applicable way and does not remain in the academic world."* It is *"intuitive and logically structured."* The guideline *"creates an idea of how further development can be approached in principle."* However, a clear added value can only be proven once the method has been applied in the company over several months. The answer to RQ3 cannot be clearly proven with the help of the results and is therefore taken up in the discussion.

4 Discussion

As part of the **descriptive study I**, a system of objectives for supporting approaches in the advancement of product portfolios was developed. The requirements from theory and practice must be summarized in clusters due to the large number. Regarding the **prescriptive study** it is important to take a close look at why and which areas of the product portfolio should be advanced. Only when it has been established that there is a need for action should advancements be carried out at the appropriate level, taking the influencing factors into account. The interview studies show that advancement often takes place without a structured process and that methods and processes are needed to structure it. The central aim is therefore to create a framework for advancement by describing central methods for orientation and just refer to sub-process steps in detail. Consistent high granularity would exceed the scope of an overarching process model. The process model is not intended to create new methods in all areas of the advancement process. It is intended to integrate existing methods, such as foresight, into a framework and position them concerning the advancement of product portfolios. The process model thus combines elements of strategic product planning, reference-based engineering according to the model of SGE and the simultaneous consideration of several products in a product portfolio. The process model represents an initial conceptual model that serves to investigate how a supportive approach for the future-robust advancement of product portfolios can be designed. The approach is to be further developed in future work. **Descriptive study II** - The two-stage validation study represents an initial validation. The first study with experts from the field of development methodology shows fundamental potential, so the approach will be pursued further. However, the experts in methodology research represent the viewpoint from a university context, not like the actual target group of the approach in the company. The experts from a company also see potential added value in the methodology. Initial findings indicate that the implementation of the approach in an evaluation study in a company can extend over several months or even years. The statements of both expert groups are based solely on assumptions about the potential support provided by the approach, based on a reduced workshop concept. RQ3 can therefore not be answered unequivocally. For a verifiable answer to RQ3, the approach has to be examined in a company over a longer period. It is currently only possible to express the tendency that a support performance is expected.

5 Conclusion and Outlook

As part of the descriptive study, requirements from theory and practice were identified in order to address the challenges in developing a supportive approach. 117 requirements from theory were transferred into 14 clusters and, based on 2 interview studies with a total of 17 companies, 20 requirements from practice were added. Based on the analysis of the interviews with companies and the consideration of existing models from the relevant research areas, a process model for the further development of product portfolios was developed, which is intended to support the further development of the product portfolio in the form of a guideline and addresses the challenges from practice and theory. In the two-stage validation, initial potentials and added values of the developed approach are recognized. For a comprehensive validation, the approach must be implemented in a company over a longer period of time. This evaluation should therefore only be considered initial. The process model is to be further expanded in future work. Accompanying documentation is to be drawn up and further methods and process elements are to be included to guide the user through the advancement process. In addition, further validation stages are also required. The approach should be improved through validation studies in real laboratories. Live labs combine the challenges of real companies, but can be designed in such a way that the research elements can be applied and monitored. In future work, an assignment of several months in a company is also planned in order to demonstrate a possible supportive effect.

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