

Future-robust product portfolio development: insights into the advancement of product portfolios in companies - an interview study

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Abstract

A volatile environment and an increasing number of products along with a growing range of functions pose a challenge for companies when it comes to further development. Existing methods are no longer sufficient to cope with these challenges. In order to develop new methods, the process and challenges in the advancement of product portfolios must be understood. In this paper we conduct an interview study with ten experts to gain a better understanding of the advancement of product portfolios. Triggers, changes and actions are examined and goals and requirements for new methods are derived.

Keywords: new product development, portfolio management, product improvement, future robust, system generation engineering (SGE)

1. Introduction

Shorter product life cycles, increasingly complex networked products and a volatile business environment are increasing the challenge of the future robust development of products (Alfieri *et al.*, 2020). Future-robust development is a key activity for companies to be successful in the long term (Cooper and Edgett, 1999). The challenges in the further development of product portfolios can soon no longer be met with conventional methods and approaches (Dumitrescu *et al.*, 2021). An examination of existing models with the help of a systematic literature review confirms this statement and shows that existing models are not sufficient to precisely describe the further development of product portfolios (Schlegel *et al.*, 2023b; Meyer *et al.*, 2021). New methods must therefore be developed for the advancement of the product portfolio in companies. As part of the preliminary work for the present paper, ten company websites were analyzed. Based on the external information, the basic structure of the product portfolio can be recognized, but it is not possible to draw conclusions about the process and challenges in the advancement of the portfolio. To gain a fundamental understanding of the process of further developing product portfolios, an initial interview study was conducted to investigate the process of further development (Meyer *et al.*, 2021). The first interview study identified initial needs such as a descriptive and a process model from practice that need to be addressed to support developers in the advancement of product portfolios (Meyer *et al.*, 2021). However, the understanding of the process of further development is not yet sufficient to allow developing supportive approaches. To expand the comprehension of the advancement process of product portfolios, the previous findings will be extended in a second interview study as part of this paper. The aim is to gain a better understanding of the advancement of multiple products seen as a product portfolio in more detail. This study is therefore

intended to enable the design of supportive approaches in future work by specifying and understanding the challenges to be faced in the advancement of product portfolios.

2. Research framework

This chapter provides an overview of the supporting theories for the presented study. Based on the first interview study (Meyer *et al.*, 2021) a literature review of existing approaches was conducted and three relevant fields of investigation were identified: Portfolio management, strategic product planning and reference-based product development. No approach was found in the literature search that combines these research fields in a uniform model. The systematic literature analysis, together with the interview study, has revealed initial models as starting points for the development of approaches supporting the advancement of product portfolios. (Schlegel *et al.*, 2023b).

The first interview study in the area of product portfolio management as well as the model of SGE and the strategic product planning as references for the development of new methods and processes are introduced below.

2.1. Portfolio management: Need for action - first interview study

The interview study deals with the fundamental further development of product portfolios. It was conducted with seven experts from different areas. Based on the interviews, a framework for the future-robust further development of product portfolios was developed, taking into account existing approaches for structuring product portfolios. Krause and Gebhardt structure the product portfolio according to the following levels: product program, production program, product line, product family and product (Krause and Gebhardt, 2018). Fahl *et al.* define three levels: Product portfolio, product line and product variant (Fahl *et al.*, 2019). Lahtinen *et al.* further distinguish between a commercial and a technical product portfolio (Lahtinen *et al.*, 2021). There are approaches e.g., for product planning at family level with focus to the modularization of subsystems, which initially link the description of product portfolios with process models (Jonas and Krause, 2011). As part of the first interview study according to Meyer *et al.* it was worked out that the further development of product portfolios can be structured on four levels: Product line, product family, product variant and subsystem (Meyer *et al.*, 2021). This structure of the product portfolio was transferred to the Model of SGE - System Generation Engineering as part of an initial descriptive model as shown in Figure 1 (Schlegel *et al.*, 2023a). A reference-based description of the advancement of product portfolios over several product generations is not yet addressed by the initial model.

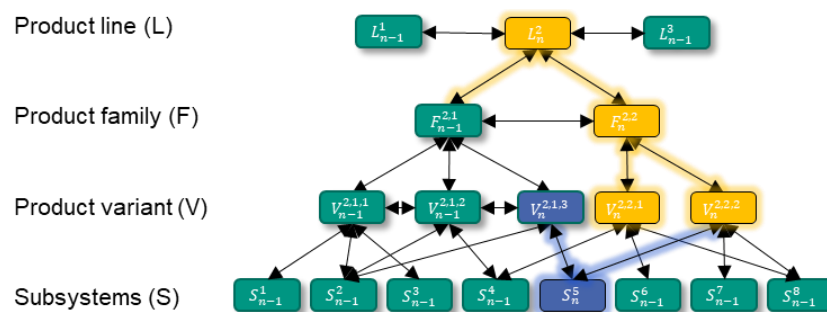


Figure 1. Levels of the product portfolio in the model of SGE, descriptive approaches top-down (yellow) and bottom-up (blue) (Schlegel *et al.*, 2023a)

The findings of the first interview study show that product portfolios at the various levels have different focal points. Overarching potential for new products is identified at the product line level. Information on the design and embodiment of the system is not available on this level. At the family level, the focus is on deriving the individual products. The similarities and differentiating features of individual variants must be planned within the framework of the family. Business planning focuses on the product variant level. The final specification of the products in terms of product development takes place primarily at subsystem level. (Meyer *et al.*, 2021)

To implement new technologies and customer expectations in the product portfolio or to make adjustments due to new or changed legal regulations, a new product generation is developed. A longer planning horizon provides greater scope for solutions for a new product generation, but at the same time increases uncertainty with regard to performance and feasibility. (Meyer *et al.*, 2021)

In summary, the first interview study shows the basic principles in the further development of product portfolios as well as the initial need for action pursuant to a description and procedure model. (Meyer *et al.*, 2021). To develop a support the process of further development in companies must be understood more precisely, therefore a second interview study is carried out in this paper based on the findings of the previous work.

2.2. Descriptive model: Model of SGE - System Generation Engineering

As a starting point for the development of a descriptive model, the model of SGE - System Generation Engineering (formerly known as the Model of PGE - Product Generation Engineering) with its descriptive character is used. The model of SGE is based on two assumptions. (1) Every product development is based on a reference system. Elements of the reference system can be existing products or concepts, which can originate from the previous generation of the product, from products of competitors, different industries or even from research. (2) A new system generation is going to be developed based on the reference system (figure 2) through a combination of three types of variation: carryover variation (CV), attribute variation (AV) and principle variation (PV). The two assumptions of the SGE apply not only to physical systems and products, but also to business models or services (Albers *et al.*, 2019).

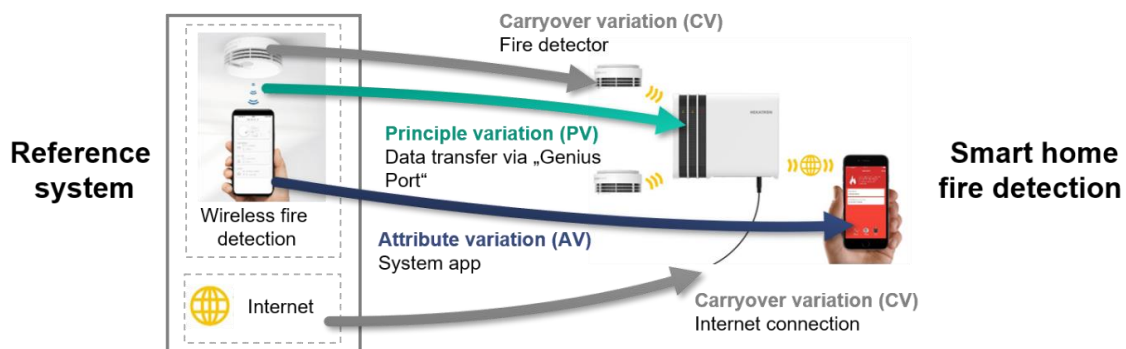


Figure 2. Model of SGE - System Generation Engineering according to Albers and Rapp (2022)

2.3. Process model: SPP - Strategic product planning

The reference model of strategic planning and integrative development of market offerings includes the cycles strategic product planning, product development, service development, and production system development. The first cycle, the strategic product planning (SPP) shows the main activities in the initial stage in product engineering process. The SPP is divided into the activities of foresight, product discovering and business planning. (Gausemeier *et al.*, 2019)

3. Aim of research and research approach

The aim of this paper is to understand the procedure for the further development of several products in the form of a product portfolio in more detail. Based on the fundamental mechanisms of the first interview study, the specific problems and challenges in the individual sub-steps of further development are to be identified and put into context in a second interview study as part of this paper. Based on the findings, the aim is to derive how a supporting method should be designed.

The following research questions are defined to examine the advancement of product portfolios in companies in more detail:

- What challenges and problems do companies face in the advancement of product portfolios?
- What specified needs for a supportive approach can be derived from the extended understanding?

The research questions are to be answered using semi-structured interviews as part of an expert interview study with ten experts from different sectors. The evaluation of the interviews is based on a qualitative content analysis according to Mayring in accordance with the sub-steps in Figure 3 (Mayring, 2015).

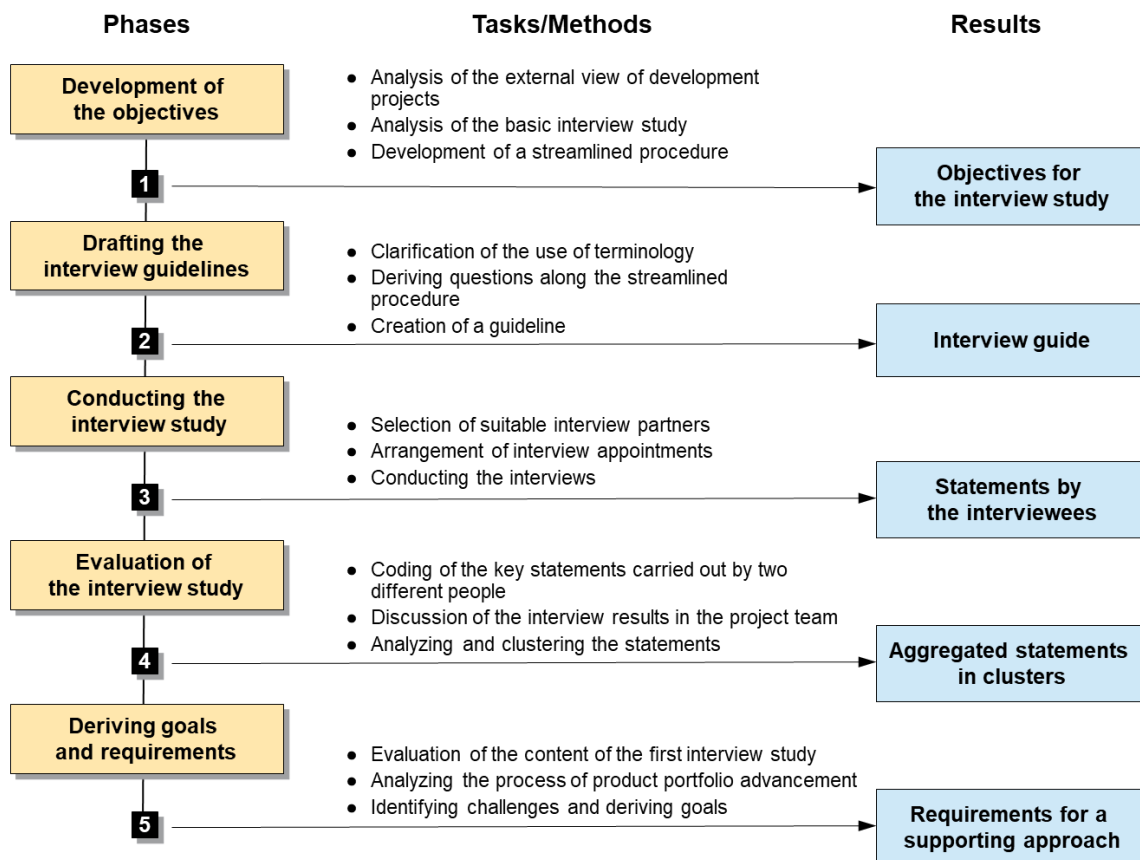


Figure 3. Phases including related activities and correlating results

In the first step, the objectives for the extended interviews is derived on the basis of the basic principles of further development from the first interview study (step 1). The objectives are transferred into an interview-guideline which is based on the simplified model for the advancement of product portfolios (step 2). The semi-structured expert interviews are conducted using the guidelines and statements on the further development of the product portfolio are recorded (step 3). The statements are then clustered across the various interviews and structured thematically based on the streamlined development process for product portfolios (step 4). Based on the clusters and the links, the next step is to derive objectives and requirements for support for the future-robust advancement of product portfolios from a practical perspective (step 5). Based on the extended understanding of the process, following studies will synthesize an approach that meets the identified requirements.

4. Conducting the interview study

4.1. Development of the objectives

The first step is to develop the objectives for the interview study. For this purpose, a streamlined process for advancement of product portfolios was developed on the basis of the first interview study. Further development always begins with one or more triggers that require a change in the product portfolio. This change can take place at different points and at different levels in the product portfolio due to a trigger (Meyer *et al.*, 2021). The change of elements in the product portfolio represents a challenge that can be met with various actions. The simplified process in figure 4 does not represent an optimum process for further development, but merely outlines a typical pattern in further development, which makes it possible to discuss the further development of the product portfolio with different companies in a comparable way.

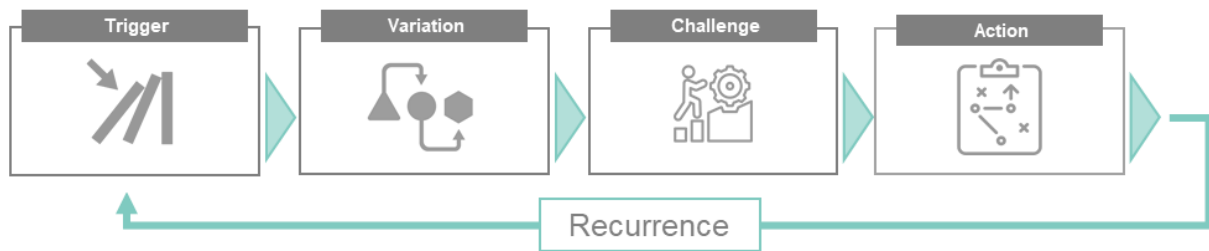
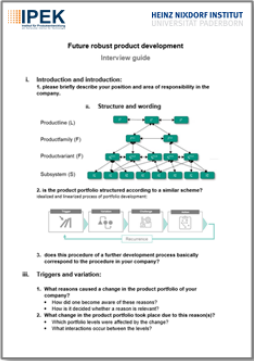


Figure 4. Streamlined process of the evolution of product portfolios

4.2. Preparation of the interview guide

Based on the streamlined process of further development in the product portfolio, a guideline was developed. By running through the steps of the simplified evolutionary process, an attempt is made to gain a retrospective view of the process of further developing product portfolios. The guideline is divided into 5 sections: (i) introduction and presentation, (ii) structure and wording, (iii) reasons and change, (iv) challenges and options for action, and (v) external view. The interviewees were provided with a short version of the interview guide in advance, as shown in Figure 5 on the left. An internal version with additional questions was kept internally to support the conduct of the interviews.



- i. Introduction**
- ii. Structure and wording**
- iii. Triggers and variation**
 1. What triggers caused a change in the product portfolio of your company?
 2. What change in the product portfolio took place due to this trigger(s)?
 3. How does this change interact with strategic goals that were planned?
- iv. Challenges and actions**
 1. What challenges emerged from this change in the product portfolio?
 2. How were these challenges countered?
- v. Perspectives on the product portfolio**
 1. When and how was the change perceived internally and externally?
 2. How do these two perspectives diverge?










Figure 5. Interview guide - phases and main questions

4.3. Participants in the interview study

As part of this research project, ten interviews were conducted between February 2023 and August 2023. With the help of a guideline, managers from various areas were interviewed to understand the further development of product portfolios in companies. The interviews were recorded with the consent of the interviewees and then analyzed in several stages. The duration of the interviews was 45 to 60 minutes per interview. An overview of the interview participants is given below:

Table 1. Participants in the interview study - background information

Nr.	Position of the interviewees	Products	Industry sectors	Employees
I1	Product manager	Timing belt Rubber timing belt	Sealing & Damper Printing & Paper	> 1.000
I2	Project manager freight elevators	Elevator solutions Production logistics	Conveying technology	> 1.000
I3	Senior project manager	Warehouse-Automation	Warehouse and logistics systems	< 1.000

I4	Division manager strategy and marketing	Seating, Interiors Lifecycle solutions	Automotive	> 100.000
I5	Director engineering & technology portfolio management	Rotor blades for wind turbines	Wind turbines	> 10.000
I6	Product manager	Fire detection systems	Fire detection systems	> 1.000
I7	Division manager new development of assemblies	Packaging machines	Packaging technology	> 1.000
I8	Division manager product management	Printing machines Stamping machines	Printing technology Stamping technology	> 1.000
I9	Area manager work preparation assembly			
I10	Head of brand owner management			

5. Results of the interview study

To preserve the anonymity of the interviewees, the introduction and presentation (i) of the interviewees is limited to the information listed in Table 1. Therefore, the results chapter starts with statements on structure and wording (ii).

ii. Structure and wording

At the beginning of the interview, the wording used is explained using examples to prevent misunderstandings or inconsistent use of language during the interview. The basic structuring of the product portfolio into product lines, product families, product variants and subsystems could be transferred to the respective companies by the interviewees in all 10 cases. A product line was formed e.g., by a business group (I4) and by fields of application (I1,2,6,8,10). A family can be structured via a platform (I5) which comprises variants and subsystems. The families differ e.g., according to the operating modes of the system and the variants represent configurations with different functional scopes (I5). Depending on the perspective on the product portfolio, a different sorting is possible (I4). The products that the customers of the respective companies perceive are at the variant level for all interviewed companies (I1-10). The interviewees stated that the highly simplified process shown corresponds to the process in their company. (I1-10) In some places the process in practice is not strictly sequential. Interviewee 4 stated that the innovation process is often initiated by management experience and that there is no formal process. The steps are assessed through experience and expertise. There is a lack of an analytical step that brings together changes and reasons (I4).

iii. Triggers and variation

The triggers for the further development of product portfolios were grouped into six clusters based on the first interview study (Meyer *et al.*, 2021). (1) Megatrends, (2) Customer requirements, (3) New technologies, (4) Market/industry change, (5) Competitive pressure and (6) Legal requirements.

Megatrends are mentioned as fundamental triggers (I3,4,8,10). Examples include e-commerce and sustainability (I8,10). **Customer requirements** are a central trigger for further developments (I1,2,3,5,6,7,8). To understand the trigger, it is crucial to understand how customer requirements are determined. In contrast to the reactive approach of reacting to customer requirements (I6), there is also the proactive approach of using industry analyses to identify new areas for solutions without a customer making a direct request (I5,6,8). Interviewee 2 integrates, for example, lead users, fitters and service as well as votes from the public. Discussions are also sought with customers' customers to anticipate the development of customer needs (I8,9). **New technologies**, such as changes in materials, are also driving the further development of the product portfolio (I5,6). Technological change is primarily taking place at subsystem level (I6). The **market/industry change** cluster addresses regional and temporal changes in market requirements (I2,5) as well as changes in raw material prices or their availability (I1). **Competitive pressure** is a key driver for the further development of the product portfolio and requires the active further development of the product portfolio to keep pace with the performance and costs of

the competition (I1,4,6,8). **Legal requirements** place tough and regionally different demands on the development of products (I1,2,4,6,8). Legislation and standardization in some cases slow down technical inventions (I6). It can not only be seen as a passive limitation for innovation, but also as an enabler for innovation through participation in standardization committees (I2,6).

The large variance in triggers can result in an equally large range of variations. The change can range from the fitting of a screw to the redesign of systems (I7). In the evolution of products, an attempt is made to keep the adaptation as small as possible to have a lower risk during development (I2,3,4,7). The company tries to not completely shift the portfolio, but merely to set a focus (I3,8).

According to the interviewees, a distinction is made between different scopes of further development. An **optimization** that can be clearly operationalized e.g., the optimization of a thread on subsystem level is not discussed extensively, but implemented immediately without major processes (I3,4,7). Extensive adjustments are referred to as the **advancement** of existing elements (I4,7). In principle, the products are not redeveloped even when advancing products in the portfolio (I3,4). The extent of change is kept rather conservative e.g., adapted design, individual optimized functions. The adaptation of products is controlled in fixed cycles by a defined committee for individual projects (I7).

New products in the portfolio are also developments based on existing products (I3,4). These major enhancements have an impact on the production system (I1). The new development is accompanied by longer development times and a process chain via management, product management and sales (I7). It is important that the strategy fit is checked during new development (I10). The strategy is superordinate to the product portfolio and the change to the portfolio is only tackled insofar as this change is fundamentally compatible with the strategy (I5). Feasibility must also be assessed in the direction of the subsystems, as technology development takes place at subsystem level (I5). In consultation with the development department, the technical feasibility must be weighed up, for example via prototypes (I2).

iv. Challenges and actions

Challenges: The companies cite a large number of interlinked challenges in the further development of the product portfolio. The **central challenge** is the **volatile environment** e.g., a forecast used to be valid for approx. 6 years, today it is only valid for approx. 2 years, as more and faster changes are taking place (I8). Regulations change every six months (I1), raw materials and suppliers also change significantly (I1). Implementing your own adapted processes is a challenge and takes a lot of time (I2,4). The volatility is offset by a significantly longer development time. It is necessary to differentiate which changes in the environment are a trigger and which are not (I8).

The creation of adapted processes represents an **organizational challenge**. Newly coordinated processes, competencies and resources are required (I5). In addition, **normative challenges** can slow down the speed of innovation. For example, if applications that are required for marketing have to be processed via approval bodies (I6). In some cases, a transition phase is then planned until the normative side catches up (I6). Another key challenge is the **volatile market**. Changes to the product portfolio must be coordinated with customers and suppliers. (I6) Another challenge is addressing customer benefits via an adapted technical solution and a suitable marketing concept in a volatile environment. (I6) **Technical challenges** in the realization of products include, for example, keeping costs down and suitable production systems (I5). Systems are not developed from scratch, but rather developed so that new technologies have to be integrated into existing systems (I6). In the case of major adaptations, a lot of development work is required with high risk and further adaptations as a consequence (I7). New specifications lead to new calculation, design, new assembly, new marketing and certification (I2). There is a risk of developing products the customer does not want (I9). It may occur that new products are not successful if the change was not noticed by customers or mistakes were made (I7).

Actions: The actions could not be assigned to individual triggers, which is why the actions are clustered below into before, during and after the implementation of the change.

Before: In general, an attempt is made to think the strategy far ahead, to take small steps during implementation and to keep the goal in mind (I9). Solutions for customers can already be thought of in advance (I8). Developing a solution can also be approached with the customer (I5,8). The central option for action is to actively anticipate measures and not wait for triggers (I1,8,9). The aim is not to react individually to individual triggers, but to react uniformly as a company (I8,9). A stage-gate process is

run through: 1. needs assessment 2. specification sheet 3. comparison of product portfolio 4. feasibility 5. decision and review of strategy and portfolio fit (I9). Major adjustments, such as a technological leap, are often strategically planned as a further development of a product in a generational change communicated to the external stakeholders. (I2,3,4,7) To better control fluctuating conditions and supplier availability, insourcing instead of outsourcing is proposed to achieve greater independence from suppliers (I9). Economies of scale can be used to achieve cost advantages in the face of competitive pressure. Similar design reduces costs and increases system understanding during repair or service (I8). Modularization is an option for products with high sales volumes. Upgrades can also be considered in advance so that the product remains inexpensive to purchase but functionality can be guaranteed in the future (I8,9). In the case of very complex systems with lower quantities, the interfaces represent a potential source of errors, so that it does not make sense to modularize (I10).

During: According to the interviewees, if a lot of development work is required for an adaptation, this is associated with a high risk (I7). An attempt is being made to mitigate this through a transition phase, i.e. a gradual change over a period of 4-6 years with a transition period (I4,6,7). Other options for action are to take a two-pronged approach and establish a new technology in the direction of the standard (I6) or new products in pilot groups or pre-series (I1,7). Standard components should be classified as particularly critical, as these are used in many products in the product portfolio and therefore have a major impact in the event of errors (I7). The introduction must be accompanied and monitored with checklists, milestones and a validation plan (I4).

After: The implementation of challenges does not end with the launch of the product. It is important to discuss with service and purchasing where current problems are or which other solutions exist (I7).

v. Perspectives on the product portfolio

A company's customers are open to adapting new developments to varying extents (I7). Major changes are actively offered to adaptation-friendly customers and marketed as a new generation (I4). New products are communicated to customers in the early phase of development to persuade them to make a purchase (I2,4). The disclosure of information from the initial phase is in conflict with the confidentiality of information and possible patents (I5). However, it may also be desired by the company that external parties do not communicate an adjustment to the product portfolio e.g., in case of cost reduction in production (I4) or because a change at subsystem level is simply not relevant for the customer (I6). Adjustments do not represent a new generation in the perception of customers until new functionalities are added (I2). Depending on the premise of whether the change should be made transparent to the outside world, appropriate measures are introduced (I4). If the change is to be perceived externally as a new generation, this change is accompanied by new branding, a new name and realigned marketing (I1,2). A distinction is made between the external and internal perspective e.g., if a development goes into pre-series production, it is seen internally as a new generation (I1,4). Especially in the B2B sector, the perception of a change is often not received by the end customer and user (I4,5).

6. Discussion and conclusion

In the following, the results are discussed in the context of the research and a summary conclusion is drawn.

Structure and wording: The basic principle of structuring product portfolios into levels is transferable to the respective companies in the case of all ten interviews. It should be noted that each company has its own individual use of language for the elements in the portfolio and therefore a transfer support must be provided. When developing cross-company methods and approaches, care must be taken to ensure that this translation work is carried out. All companies interviewed also agreed with the simplified process of further development. This process should not be seen as a benchmark, but rather provides a framework for the cross-company analysis and localization of methods and processes to support the further development of product portfolios. A structure is required that enables the integration of empirical knowledge and at the same time reflects the interaction with the company's strategy. A consistent link between strategic product planning and product development is required.

Trigger: The companies surveyed identified a wide range of triggers for advancement. Megatrends represent a change in the environment that affects every company. Megatrends represent guard rails for

advancement, but do not promise a knowledge advantage over the competition. Customer requirements represent a direction for advancement based on products currently on the market, but only in the near future. New technologies are the enabler for the implementation of identified potentials in new products with high innovation potential. To successfully launch new products on the market, new technologies must be successfully evaluated and integrated in terms of advancement. Support is needed to transfer dynamic requirements into a system that can be perceived as a product in a volatile environment. Competitive pressure requires active foresight and advancement of the product portfolio not to fall behind competition. Legal requirements were identified by the interviewees as an opportunity for innovation but also as a hindrance to the placement of new products with high innovation potential and must therefore also be considered in one approach.

Variation: All interviewees stated that the advancement of the product portfolio is in most cases based on a variation of existing elements of the product portfolio. According to the interview study, small optimizations can often be operationalized immediately and no comprehensive methodological support is required. Like new developments, advancements are based on existing elements of the product portfolio. In all cases, a new product generation is developed on the basis of references, even if these are not always perceived as such by the customer. The ways of adapting the product portfolio mentioned by the interviewees are all based on references, but cannot be clearly distinguished from one another. There is no uniform and formally correct description of changes in the product portfolio within the interviewed companies. To develop a general approach across companies, a neutral and formalized description option has to be provided. With the reference system and corresponding variation types, the model of SGE provides elements to describe the development process formally. The model is suitable as a starting point, but must be adapted to the advancement of product portfolios.

Challenges: The volatility of the environment emerged as a key challenge across all interviews. The requirements and boundary conditions change faster than the development times of the systems. The challenges can also be divided into organizational, normative, market and technological. An overarching corporate strategy is needed to show the direction in the long term, but the product development process must react to various disruptive factors and influences on the strategic product plan. An approach is required that can be implemented continuously and can reflect various influences from the short to the long term. To achieve the strategy but keep the development risk of individual activities low, a cross-generational product roadmap is proposed (Ulrich and Eppinger, 2016). Here, distant goals are to be broken down into manageable generations on the development side.

Strategy: The majority of strategies focus on analyzing and identifying triggers before making adjustments to the product portfolio. Support is needed in assessing whether environmental changes have an impact on the product portfolio or are not relevant for further development. A company's strategy must be more closely linked to product development via portfolio management to counter volatility.

Perspectives on the product portfolio: When developing methods for a product portfolio, a distinction must be made between the engineering and the customer perspective. From an internal perspective, every adaptation can be described as a new product generation, even in the case of a carryover variation. Whether this product generation should be communicated externally must be strategically assessed.

6.1. Conclusion

The interview study in this paper extends the initial findings from the external observation of companies and the first fundamental interview study. The structuring of product portfolios and a streamlined process were confirmed by the interviewees in a semi-structured interview study. The statements of the ten interview participants were coded and analyzed to gain a better understanding of the process of advancing product portfolios. Six clusters of triggers in the further development of product portfolios were identified: (1) Megatrends, (2) Customer requirements, (3) New technologies, (4) Market/industry change, (5) Competitive pressure and (6) Legal requirements. The individual assignment of triggers and strategies was not possible in binary terms. However, it was possible to work out that the further development of product portfolios is carried out in all cases on the basis of references and that a uniform formalized model is required for the description. The central challenge is the volatility of the development environment. A company's strategy must be coordinated with product development via

product portfolio management, taking into account various dynamic influences. To this end, strategic product planning must be more closely linked with product development.

6.2. Limitation and Outlook

Further research needs arise from the limitations of the study. With a sample size of 10 participants, this is a qualitative study and the influence of subjectivity of individual interview participants can be assumed to be significant. Quantitative surveys with a broader sample base should be conducted in future work. Furthermore, the study and its results can only be applied to large companies due to the companies surveyed, which in 7/8 cases have more than 1000 employees. The dominant market shares of all interviewed companies are also located in B2B. The findings of the interview study will be supplemented with objectives based on theoretical considerations. The long-term goal is to develop a holistic approach that supports developers in the robust future advancement of product portfolios.

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