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# Interacting Forces for a Resilient, Future-robust Evolution of Product Portfolios

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**Abstract**

The further evolution of product portfolios is driven by changes in the company's global and local environment. On the one hand, megatrends have a high and long-lasting influence on the evolution of product portfolios. For example, digitalization enables the networking of products. On the other hand, drastic market changes have an impact on the portfolio. These tend to occur suddenly and require a resilient attitude from manufacturing companies. These two forces affect each element of the product portfolio in the form of new customer needs, new technologies, legal requirements, and competitive pressures. As a result, product portfolios need to evolve constantly. Manufacturing companies already engage in this behavior, resulting in the establishment of heuristics from their experience. But there is no structured way to help manufacturing companies evolve their product portfolios. This paper deals with the characterization and structuring of interacting forces for a resilient, future-robust evolution of the product portfolio. First, the relevance of the problem is presented, then the knowledge base is identified, and finally, a model representation of reality is developed.



*Keywords:* Interacting Forces; Future-robust Evolution of Product Portfolio; Product Portfolio Evolution; Further Development of Product Portfolios

## 1. Introduction

The development of products is becoming increasingly complex [1, 2]. According to Barczak et al., 58% of all development projects fail [3]. Cooper et al. mentioned the lack of understanding of customer needs as one of the reasons for the failure of development projects [4]. Although, there are a variety of methods for customer orientation, which should help to identify the current needs of the customer and to implement them into products [5, 6]. A traditional method is the Kano model [32]. It categorizes the product's features into delighters, performance attributes, and must-haves [32]: **Delighters** are characterized by high customer satisfaction. This includes, for example, new technologies that are not offered by the competition at the beginning of the product releases. Certainly, the competition quickly follows, so this attribute quickly loses its power [6, 7]. **Performance attributes** describe target functionalities. Competitors offer similar forms of these functionalities, but an increase in the performance attribute leads to higher customer satisfaction [6, 7]. **Must-haves** must be present, otherwise, the customer is dissatisfied. Often the functionality is seen as self-evident. Therefore, it does not increase customer satisfaction, but also the elimination of the attribute seems inconceivable [6, 7]. Over time, delighters and performance attributes will evolve into must-haves, making continuous redevelopment of product portfolios inevitable [6]. This justifies the need to develop new products, and consequently, to evolve complete product portfolios. New products are usually not developed completely from scratch. Only 7% of development orders are new developments while


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93% are based on reference systems. These so-called reference systems form the basis for the development of new product features and characteristics [12]. In addition to changing customer needs, there are other impulses that drive the need to develop products and product portfolios. For example, competitive pressure has a decisive impact on the development of new products and product portfolios [10]. In this context, Meyer et al. refer to forces acting on the product portfolio. However, companies lack a common understanding of the opportunities and challenges associated with these forces [9]. Against this background, this paper addresses the following research questions:

*How can the forces be characterized and structured to enable the resilient, future-robust evolution of the product portfolio? How do the forces interact?*

The paper is structured as follows: Section two presents the theoretical background. The research design is presented in section three. Section four presents the results. Finally, section five summarises the contribution and gives an outlook on future research needs.

## 2. Theoretical Background

Product portfolio management enables companies to derive the maximum benefit from the product portfolio [10]. According to Cooper et al., effective portfolio management leads to high-quality products. Moreover, the interaction between development projects and resource management is balanced [11]. The resilient, future-robust evolution of product portfolios requires a strategic viewpoint as well as a model to describe the dynamic nature of product portfolios. The basic theories product planning and system generation engineering – SGE prove to be valuable tools for that. Each of these is briefly described below. Then impulses for the evolution of product portfolios are given. Finally, existing approaches to future-robust evolution are described.

### *2.1. Basic Theories of Product Planning and System Generation Engineering*

Gausemeier's reference model for strategic planning and integrative development of market offerings can be used to describe product planning: The reference model describes the process of creating new complex market offerings (products and services) from the initial idea to the start of production or market entry [13]. It consists of four main tasks: strategic product planning, product development, service development, and production system development [13]. Within the strategic product planning domain, three tasks are considered: identifying future success potentials, creating product ideas, and business planning [13]. The results of these main tasks are the product plan, which describes the products to be developed as well as the schedule [42], and the requirements list [14]. The results are summarized in the development order [15]. The SGE model is based on two hypotheses [16]. The first is that the development of a product is based on a reference system. This reference system consists of elements of existing or planned socio-technical systems. It forms the basis for a new product generation [17]. The second hypothesis is that a new system generation is developed based on the reference system through a combination of three types of variation: principal variation, attribute variation, and carry-over variation. Principal variation describes which aspects are adopted by the reference system. In an attribute variation, the characteristic changes, and in a principal variation, the solution principle is different [16, 18].

### *2.2. Impulses for the Evolution of Product Portfolios*

The following is an example of which impulses or forces for the evolution of product portfolios can be analyzed: The PESTEL analysis is a strategic and qualitative analysis technique used in business and government to analyze different perspectives. PESTEL is composed of the factors **p**olitical, **e**conomic, **s**ocial, **t**echnological, **e**nvironmental, and **l**egal. All relevant information in these six areas is analyzed for future potential and challenges, as well as opportunities and risks [43].

Porter postulates five central forces for describing competitive effects on the whole company. These are the rivalry of existing competitors, the threat of new entrants, the power of suppliers, the power of buyers, and substitute products and services [8]. The basic idea of the framework is that these forces have an external effect on the entire company [8].

In addition to these approaches, there are also the results of an interview study by Meyer et al.: The authors condense six generic forces that affect a company's existing product portfolio. The six forces identified are megatrends, drastic market changes, new customer requirements, new technologies, legal requirements, and competitive pressure [9]. The authors do not define them in detail. However, they state that these forces provide the most holistic view of the triggers for product portfolio evolution [9].

### *2.3. Future-robust Evolution of Product Portfolios*

There are a variety of approaches to dealing with future-robust evolution in a particular way. For this paper, the starting point or trigger for evolution is particularly important. Only these parts will be examined below. Söllner, for example, considers the planning and monitoring of a future-robust product portfolio. The method disposes of a generic analysis of the market and environment [7]. Dülme has developed an approach for the future-oriented consolidation of variant-rich product programs: The system focuses on the preparation of information to identify product groups to be analyzed [19]. Peitz develops a product lifecycle-oriented business model roadmap; the initial focus is on examining the company, the strategy, and the business model [20, 21]. Marthaler's system for future-oriented product development is analogous. It is a systematic approach to derive cross-generational goal systems for future product generations through strategic foresight [22]. Fahl considers the product portfolio in the context of the specification of product functions; this includes the analysis of the product [23, 31]. Meyer et al. proposed an initial structure of the product portfolio [9]. It is based on the definition of a product portfolio provided by Krause et al. According to the authors, a product portfolio is the collection of all a company's market offerings, both self-produced and purchased [33]. The focus is on in-house products, which can be divided into product lines, product families, product variants, and subsystems [33]. The product line describes the top level of a company's product portfolio. They aggregate product families based on their areas of application. Product families group similar products, while product variants represent products that differ in value or complexity. The bottom level considers subsystems, which are individual components of the product. Latinen et al. support this. The authors refer to a product portfolio consisting of entities [40]. Viewing a portfolio as a single entity to be managed, rather than a multitude of separate products to be managed, brings huge efficiencies in production and maintenance [41]. Figure 1 shows the structure of a product portfolio according to Meyer et al.

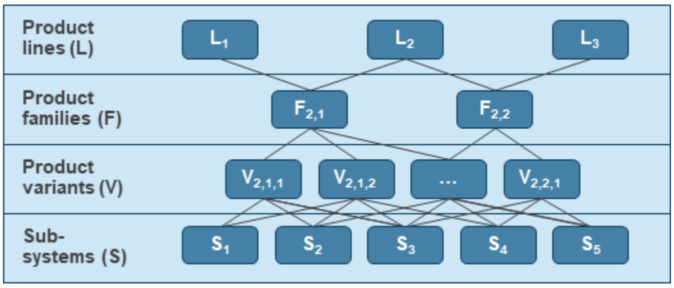


Fig. 1. Structuring a Product Portfolio according to Meyer et al.

## 3. Research Design

The research design is based on the guidelines of Design Science Research (DSR) according to Hevner et al [24, 25]. Hevner divides DSR into three cycles that complement or enhance each other: The first cycle is the relevance cycle. It serves to illuminate the problem in its context, i.e., in its environment [24, 25]. The rigor cycle considers and summarises existing knowledge. It thus constitutes the knowledge base [24, 25]. The third cycle is the design part, where the model that answers the research question is designed. In this paper, the problem was highlighted in the first chapter in the form of a research question. The second chapter presents the knowledge base. Finally, the fourth chapter covers the design cycle, where instead of a design artifact that solves a problem, a model representation of reality is developed. A critical discussion takes place in the last chapter, where a contribution and an outlook for future research content are given. To answer the research questions "*How can the forces be characterized and structured to enable the resilient, future-robust evolution of product portfolio? How do the forces interact?*", the description of the forces by Meyer et al. is analyzed with individual statements from the interview study. These statements are evaluated for interactions. Finally, the interactions between these forces and the product portfolio are examined.

## 4. Results

**Megatrends** include digitalization and sustainability, for example. Following Meyer et al. megatrends lead to **new customer needs** [9]. In addition to megatrends, **new technologies** displace already mature technologies thus leading to the evolution of product portfolios as well. Especially in times of **drastic market changes**, new technologies are often required and lead to the evolution of product portfolios. Furthermore, there is competitive pressure resulting from market differentiation. Moreover, the authors identify legal requirements that play a crucial role in the evolution of product portfolios [9].

The author's description of the forces shows that there is potential for interaction between the forces. In addition, megatrends and drastic market segments are mentioned explicitly as forces, which turn in trigger other forces. The interaction based on these two forces is described below. Figure 2 shows the interactions (I). They are analyzed in more detail below.

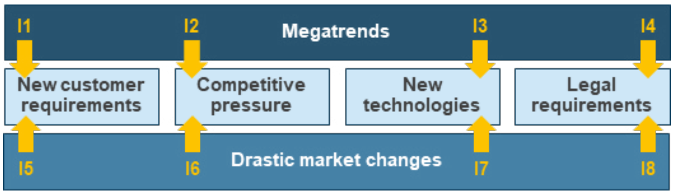


Fig. 2. Possible interactions between the six forces

**Megatrends** describe global changes in social, technological, economic, and political conditions with a half-life of more than ten years [26]. Their gradual development can be explained by the gradual emergence of several micro-trends that together form a megatrend [27].

**I1:** Megatrends can be divided into micro and market trends, which are short or medium-term [27]. Looking at a micro trend, it is often possible to derive direct customer requirements [27]. This means that megatrends break down into customer requirements over time. For example, the megatrend sustainability leads to customers wanting a product that is made from recycled materials or that can be recycled after use.

**Findings:** Megatrends are long-lasting. They are composed of several trends from which new customer requirements arise.

**I2:** Using the example above, the interaction between megatrends and competitive pressures can be described as follows: If competitors can anticipate trends such as sustainability more quickly, they will gain a competitive advantage by meeting customer needs earlier: Competitive pressure only arises when companies compete with each other for resources, market share, or information [28]. It is an ongoing task for a company to hold its own against its competitors under changing conditions [35].

**Findings:** Competitive advantage comes from anticipating trends or megatrends. New customer demands go hand in hand, so there is also an interaction between competitive pressure and new customer demands.

**I3:** Technologies are used to achieve goals in a reproducible and specific way [35]. For example, the Internet allows documents to be distributed easily and efficiently. Technological progress makes it possible to use new and sometimes better methods to solve problems. To illustrate the interaction between megatrends and new technologies, we take digitalization as an example. Digitalization can be divided into three phases. The first and second phases are about automating processes. The third phase enables cyber-physical systems by integrating sensors, microprocessors, data storage, and software into conventional products. A literature review by Kersten et al. shows that "new technologies" is one of 30 identified megatrends, including other trends such as RFID, cloud computing, simulation, etc. Megatrends can therefore be broken down into macro- or micro-trends, which then represent new technologies [34].

**Findings:** Megatrends are enabled by new technologies. Moreover, new technologies may be trends in themselves.

**I4:** Companies' actions are influenced by the constantly changing politics and legislation of the respective country, which in turn is often dependent on megatrends [36]. An example of this is the General Data Protection Regulation (EU-DSGVO), which can be traced back to the trend of digital transformation or the megatrend of digitalization.

**Findings:** Megatrends and legal requirements depend on each other.

In contrast to megatrends, **drastic market changes** occur unexpectedly. Their probability of occurrence is low, but their impact – especially on the resilience of product portfolios – is high [37]. The term wildcards is often used when referring to drastic market changes. Wildcards are difficult to predict and companies are often unprepared and have to react to changes on an ad hoc basis.

**I5:** The interaction between drastic market changes and new customer needs depends on a company's ability to respond [37]. For example, during the COVID-19 pandemic, textile manufacturers were able to switch production to medical masks – which were in incredible demand – to minimize lost sales from store sales [37].

**Findings:** The abruptness of drastic market changes also affects customer needs.

**I6:** Drastic market changes and competitive pressure can interact in a variety of ways, as changes in the market can affect the competitive landscape. In general, market shifts can create new opportunities and challenges for firms, which can increase competitive pressure and require firms to adapt to remain successful [38]. For example, political events. New competitors can also lead to drastic market changes [29, 30].

**Findings:** Drastic market changes have both positive and negative effects on competition.

**I7:** Drastic market changes can lead to new innovative technologies [39]. The pandemic has led to the development of faster and more accurate testing methods and applications for tracking infected people. For example, Corona Warn or TraceTogether.

**Findings:** Wild cards require rapid solutions. New technologies make them possible.

**I8:** Drastic market shifts have led to regulatory requirements. An indirect consequence of these regulations is that companies have to adapt their product portfolios to them. On the one hand, this means that products have to be removed from the portfolio because they do not comply with certain regulations. On the other hand, companies may expand their product portfolio.

**Findings:** The effect of drastic market changes on regulatory requirements is always indirect.

The consideration of interactions 1-8 confirms the basic premise made at the beginning that the dominant forces are megatrends and drastic market changes. In particular, the predictability of the probability of occurrence shows a large difference between the forces: While megatrends develop over the years and appear in several gradations (macrotrends, microtrends), drastic market changes are of a sudden character. However, the results show that no matter which force is involved, there are interactions with customer needs, competitive pressures, new technologies, and regulatory requirements. Interactions between the forces themselves were also identified.

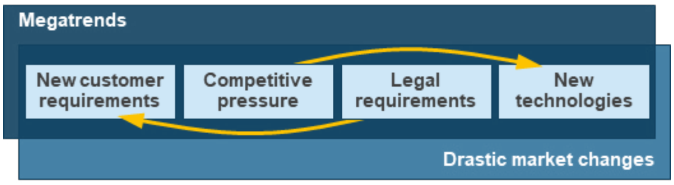


Fig. 3. Interactions of megatrends and drastic market changes

The identified interactions of the six forces are related to the product portfolio as follows. For this purpose, the structure by Meyer et al. is used. It consists of a product line, product family, product variant, and subsystems (see section 2).

As soon as one entity is changed, this leads to overlapping changes in other entities. For example, if an entity in the product family changes, then a higher-level entity that belongs to the product line also changes. Similarly, a lower-level entity in the product variant changes. The following fictional use case illustrates how a change affects an entity in the product portfolio and then affects the entities at lower levels of the product portfolio.

Use Case: The megatrend of sustainability results in the trend of *emission-free mobility*, which results in a new technology that enables the electric drive of motors of engines. The product portfolio refers to vehicles. The product line describes the type of vehicle (Is it a car or a van?). The product family describes the type of passenger car (Is it a saloon car or an estate car?) The product variant refers to the performance of the passenger car (Does the passenger car have standard equipment or high-performance equipment?). The subsystems refer to the type of drive (How is the engine driven?). Figure 4 shows the evolution of the product portfolio, taking three different cases into account:

**Case 1 (blue)** describes the strategic decision of a company to offer emission-free means of transport on the market in the future. The starting point of the development is the product line.

**Case 2 (red)** refers to the new technology that makes it possible to use electric drives for cars. The starting point of evolution is hence the subsystem.

**Case 3 (yellow)** is driven by synergy effects within the company, where evolution takes place based on another entity. In Figure 4, the starting point is the product variant, but this case can also be applied to the product family.

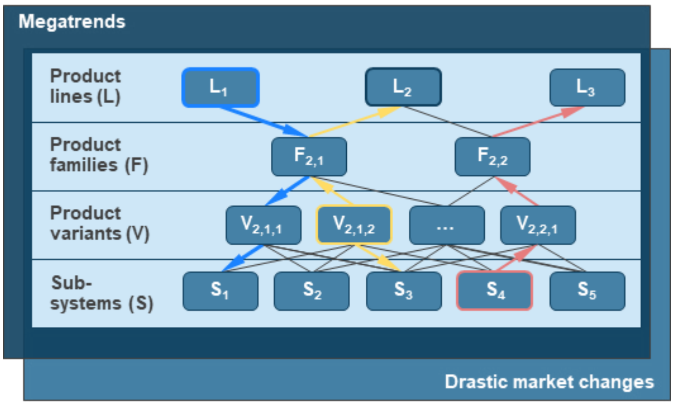


Fig. 4. Product Portfolio Evolution driven by the force New Technology

Different cases lead to the evolution of the product portfolio and, as shown in the fictitious use case, interactions between each level could also be identified. The interactions between the different levels can be traced back to the structure of the product portfolio: As already described, the product portfolio is an interconnected system consisting of several entities. On the one hand, the forces of megatrends and drastic market changes affect the entities of the product portfolio and thus force the evolution of the product portfolio. This is referred to as the indirect action of the forces. The indirect forces in turn give rise to further micro forces - these have a direct effect on the individual entities of the product portfolio. This is referred to as a direct mode of action. The second identified interaction between the levels of a product portfolio is due to the structure of the product portfolio. This means that the product portfolio must be viewed as a system.

## 5. Conclusion

### *5.1. Key Insights*

The paper at hand shows why products or entire product portfolios need to be further developed. Overall, three main key findings were identified in answering the research question: The six forces of megatrends, new customer requirements, competitive pressure, new technologies, legal requirements, and drastic market changes are analyzed in more detail: **The result shows that especially the force of megatrends and the force of drastic market changes have an overarching effect on the product portfolio.** These forces have an indirect effect, as they result in new customer requirements, competitive pressure, new technologies, and legal requirements. There are interactions between the forces as well.

However, since **the product portfolio represents a system, interactions between each level of the product portfolio can also be found here.** The various cases show that regardless of the starting point of evolution, all levels will evolve. Furthermore, the individual levels of the product portfolio need to be looked at more closely.

**There are two different perspectives within the product portfolio: the model-based and the tangible view.** The product line and product family are mental model-based constructs. Changes at this level are more likely to be driven by strategic decisions. The actual development work, on the other hand, takes place at the two lower levels of the product portfolio: Both the product variant and subsystem levels represent more tangible artifacts.

### *5.2. Implications for future research*

Future research should also investigate product portfolio effects in addition to the forces analyzed, e.g. resulting from error correction of individual components. The model-based view and the tangible view are particularly important here since failure analysis and correction are likely to take place at the subsystem level. Research will also focus on how to develop the entire product portfolio. For example, whether further development is technically feasible: does the company have the necessary skills? A calculation of the profitability of further development should also be carried out, i.e., a comparison of income or revenues and expenses or costs. Another factor is time. New products must be developed in such a way that they reach the market in time. On the other hand, they should not cannibalize the previous generations. Once the technical, economic, and temporal feasibility has been established, further development can be planned. For example, by creating a master action plan that serves as a central communication tool for implementation and transformation planning at all management levels and contains all the necessary information.

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