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Productization as a link to combining product portfolio management and product family development

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Abstract

In R&D many disciplines focus on different aspects of managing the product life cycle. Generally, the focus can be divided into technical aspects and business aspects. Combining these two views, and research areas can be beneficial in the context of productization. Productization links to the concept of product structure and relates to modelling of the offering according to a consistent product structure, commercially and technically. The goal of this research is to identify how a business-specific product structure can be formed and should be managed to maximize the value of the offering. This study uses a literature review for defining the current state of product portfolio management (PPM) and product family development (PFD) concepts with linkages to productization. As a result, this study presents similarities and differences between PPM and PFD through the productization lens. A suggestion of combining the best practices of both approaches is demonstrated through an illustrative case study. Also, proposals for future research are presented. The main contribution involves indicating that effective PPM requires a business-specific physical product structure and partitioning logic. The benefits of PPM can only be truly captured through applicable product structure. Therefore, PFD is recommended to be used in designing product portfolio related technical aspects. PPM is applied for management purposes with the support of a defined product structure.

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Keywords: productization; product portfolio management; product family development; product structure; partitioning logic

1. Introduction

Successful productization [1] is one of the key processes for achieving the economic sustainability of manufacturing companies. Productization includes both technical and commercial aspects of the offering. It relates to defining the offering to a product-like form that is manageable [2]. Productization links to the concept of product structure and relates to modelling of the offering according to a consistent product structure, commercially and technically. A productized offering is well-defined, articulated, and documented with relevant features and descriptions [3]. It is specifically the gained consistency that can be beneficial for dealing with the products [4,5]. Productization can be applied to offerings of different nature [2], [6].

Traditionally technical aspects are developed in product family development (PFD) and commercial analysis done by product portfolio management (PPM). PFD refers to the development of product platforms including re-usable assets for fulfilling certain needs by providing product variants [7]. Defining which products to develop, sell, deliver, maintain, and remove according to the company´s strategic targets are the main function of PPM [8]. The interlinkages and cooperation of PFD and PPM approaches have been deficiently covered by the reviewed literature. The related understanding and discussion in the industry are also lacking.

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Both, PPM and PFD, approaches are aiming to maximize the benefits of the offering with the help of productization by various means. Generally, PPM uses a management perspective to productization and highlight the product management models and concepts in achieving the benefits. PFD instead relies on the idea that proper product structure is the root of success. The benefits of an excellent product structure can be ruined by poor management, but good results cannot be achieved without a suitable product structure. Therefore, this research aims to identify how a business-specific product structure can be formed and should be managed to maximize the value of the offering.

PPM focuses on the entire offering of a company and links the sales items on the commercial structure to the technical product structure [1,4,5,8]. PPM does not take a position on how the technical structure is formed but aims for consistency in logic [4,5]. Hence, it can be seen that in practice, PPM and PFD are interlinked whether or not it is has been realized.

PFD studies the significance of product structure and presents different means for defining the product structure [9,10]. Assessing the quality of the product structure in the early phase of development has, however, been seen as challenging due to uncertainty and complexity [11]. One example of the importance of considering product structure and potential interlinkages among PPM and PFD involves the observation that the full financial gains of introducing product configurators necessitate consistent product structure to support the activities to succeed, especially related to engineering to order (ETO) products [12].

Therefore, this research aims to clarify the special characteristics of PPM and PFD concepts in the context of productization, as well as their interlinkages and potential cooperation. The following research questions are addressed:

RQ1: What are the similarities and differences between PPM and PFD in the productization context?
RQ2: How to benefit from PPM and PFD in productization?

RQs are answered by using literature as the main source of information (RQ1) and illustrative case example (RQ2) for demonstrating the effects and connections of successful PPM and PFD. The present paper is structured as follows: next, a literature review of the area is provided. Then, the methodology is presented. The analysis and results are followed by a discussion and conclusion.

2. Literature review

A constructive research strategy was selected, and a literature review is used as the main research method for this research. The industrial experience of authors is also applied for the illustrative case study examples to highlight the relevance of findings. The literature review was conducted by using Scopus and the following keywords: “productization” OR “productisation” 2010-2021, “product portfolio management” 2010-2021, “product family development” 2010-2021. References focusing on product structures were selected and their references were also used to complement the literature review. The aim was to introduce a topic discussed in the current literature, not to present a comprehensive literature review.

2.1. Productization

The concept of productization is mostly referred to as a process of transforming customer needs or ideas into a sellable product. It is discussed mainly in four content categories; productization of products, services, software and technology [2]. Currently, the productization discussion is the most developed concerning products [1,2,4,5,8] and services [2,4,5,8,13]. This research focuses on the manufacturing industry sector and is, therefore, most closely related to the productization of physical products. In this context, the productization focus on modeling the commercial and technical product structure of the offering to reach a consistency [4] seems appropriate. In practice, the commercial side of the offering is managed by PPM and technical aspects can be provided with the logic of PFD, both of which are discussed in more detail below.

2.2. Product portfolio management, PPM

Defining which products to develop, sell, deliver, maintain, and remove according to the company´s strategic targets are the main function of PPM [8]. Even though the strategic targets are important, and these relate to performance indicators (KPIs), it is important to notice that in the service context the focus can be more on adding value rather than traditional KPIs [3]. Thus, PPM operates on a management level contributed mainly by the business or industrial management scholars. Strategic targets [8] and corporate goals [14,15] are highlighted in the PPM literature for guiding the decisions. The total offering of a company is usually divided into, for example, product lines or product families for managing aspects in a technical product portfolio, see Figure 1.

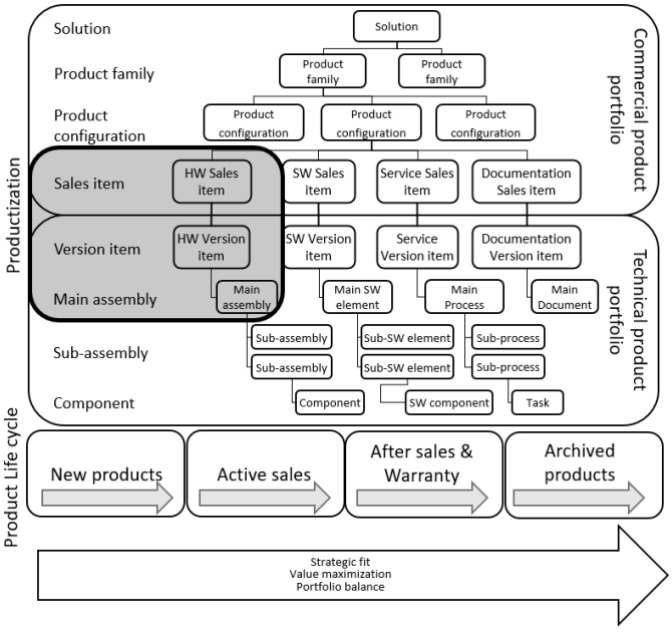

Figure 1. Concept of product portfolio management over the life cycle in productization (adapted from Lahtinen et al. [5]) and foci of this research highlighted (grey).

PPM aims to manage cost, value and strategic fit of product portfolio by conceptualizing clear connection between commercial and technical product portfolios, see Figure 1 [5]. PPM aims to understand the total number of items in the portfolio, in addition to recognizing profitable and/or strategic products. Sales item refers to an entity that can be chosen and purchased by the customer and generates revenue. Each sales item is realized technically by assemblies or components, causing costs. Strategic fit is evaluated against the company strategy [8].

The PPM model also focuses on the product life cycle through the focus on what products to develop, sell, or archive [1]. PPM includes vertical and horizontal product portfolios referring to the product structure and product life cycle. Using this kind of a generic product structure is also discussed for improving the design reuse in engineer-to-order products [16]. Since PPM focuses on the commercial product portfolio and provides a general structure for the technical product portfolio, additional tools for developing product families are needed as discussed below.

2.3. Product family development, PFD

When companies are aiming to increase design reuse and enable product variants the development of product families is often discussed [10]. A product family is based on product platforms including re-usable assets for fulfilling certain needs by providing product variants [7]. PFD focuses on technical aspects of product structure, contributed mainly by the engineering design research discipline. Although, also customer view is seen as vital when developing product families [17]. The customer view forms a clear connection between PPM and PFD by describing the features that are in the customers´ interest. In PFD the engineering and part views are two additional interesting areas that refer to working principles, and the more detailed physical structure of a product family. During the productization process, there are several different product views such as bill of materials (BOM) and engineering bill of materials (EBOM) raising questions on which views are most important in PFD.

PFD methods can be categorized into four groups of being function-oriented, index-based, optimization and, matrix and clustering-based methods [10]. The function-based partitioning logic is discussed, for example, by Erixon [9] who presents the Modular Function Deployment method. Simpson et al. [18] propose an index-based method for defining the common and unique structures of product families. They contribute also to matrix-based methods by providing support tools for studying interactions of components and sub-systems. The optimization approaches focus on multiple aspects such as multi-objective optimization in product variants [19].

Since PFD is seen as a complex task [11], various additional methods, tools and principles have been suggested to support previously mentioned categories. Modularization is often connected to PFD. According to Andreasen [20] modularization “is aiming at creating variety seen from the customer’s viewpoint, whilst at the same time showing kinship or commonality between module variants, and such structural properties, that it reduces the complexity in the company’s operations.” Pakkanen et al. [10] propose the Brownfield Process for rationalizing existing product variety towards modular product families. They conclude that a module system requires knowledge of modules, interfaces, architecture, configuration, and especially the partitioning logic which is seen as a key element for capturing the value of the product families. Partitioning logic “defines viewpoints that affect product structuring decisions from both a business and customer perspective” [7]. Module interfaces and visualization [21] is one approach to communicating the knowledge.

Product life cycle perspective is discussed for example by focusing on supply chain [22] and assembly [23]. More comprehensive evaluations of the life cycle effects of the product family are proposed for example by Andreasen [20] and Pakkanen [7]. The strategic fit of the product family with organizational and process-related aspects are also worthy of consideration [24]. Design maturity and the product structure should support the product lifecycle where productization prepares products for the external markets and internal production [25].

The design of product structure must therefore consider the customer needs causing variety, the company´s internal operational activities and objectives, besides requirements from outside the company. Business-specific product structure enables capturing the value of the product family during the product life cycle.

2.4. Synthesis of literature findings

Summary of findings related to differences and similarities between PPM and PFD in the productization context is synthesized in Table 1. PPM focuses on managerial and commercial level decisions related to product portfolio whereas PFD provides support for defining technical product structure and architecture and thus rationalizing the partitioning logic. The connection of PPM and PFD involves the link between sales items and technical assemblies, which can be formulated in different ways.

Table 1. Summary of literature review: perspectives of PPM and PFD in the productization context.

Perspectives	Product portfolio management, PPM	Product family development, PFD
Main objective	“PPM should define, which products to develop, sell, deliver, maintain, and remove based on company’s strategic targets” [8]	“Increase design reuse and enable product variants” [10]
Concreteness (concept, model, method, etc.)	Higher-level i.e. product structure concept [5]	Aims for practicability i.e. method [23], process [10], or approach [19]
Quantitative - Qualitative	Quantitative approaches are used for revenue [1] but qualitative in product structure [16]	Focus on qualitative [10,17,23] but quantitative tools exists [18,19]

Future - past	Data is based on actual figures (past) and targets are in the near future	Focus on future, targets of PFD are 5+ years away
Vertical portfolios (product structure)	The primary focus is on commercial aspects	The primary focus is on technical aspects
Technical	General product structure is proposed but existing product structure is used as a base [5]	Multiple approaches proposed for defining technical structure[9,17] and the partitioning logic [10]
Commercial	Income, cost and strategic fit is used according to sales items [5] based on the technical structure	Technical structure is based on commercial input such as customer view [17] and main customer questions [10]
Horizontal portfolios (product life cycle)	Discussed in varying depth such as Sales [5], Design [5], Maintenance/Warranty [5]	Discussed in-depth such as Sales [10,24], Design [24], Supply chain [22], Manufacturing [23], Use [24], Maintenance/Warranty [10]
Value creation	Value maximization includes, for example, market attractiveness and turnover [1]	Decisions about product structure are mainly based on potential value instead of actual figures [9,10]
Costs and income	Income from sales items and cost from technical realization [5]	Value creation mechanisms proposed to evaluate business impact [10]
Company strategy	Portfolio aligned with strategy [8,14,15]	Taken into account [10,24]
Knowledge focus	Strategic fit, value maximization and balanced and right-size portfolio [1]	Partitioning logic, architecture, interfaces, modules, and configuration rules [10]
Weaknesses	Visibility behind product costs and value, support for product development	Difficulties to assess the impact of the decisions taken
Strengths	Fact-based evaluation of outcome through money and strategy	Possibility to affect value and cost of sales items at the product level

3. Results and illustrative case

To support PPM, the sales items and the technical product structure are essential to link to each other. However, it is not trivial how this is done in practice; totally software-based linking is not efficient and therefore also physical product structure with design principles is considered. To open this paradigm an illustrative case example is used, see Figure 2. We applied the Brownfield process [10] to redesign the product structure of a load-bearing steel frame of a container crane. From the customer perspective, the main customer questions (MCQ) i.e., sales items were height and width of the frame, type of wheels, and the location of the cable reel. The target of PFD is to isolate the effects of the MCQs on controllable items in the product structure.

Figure 2 shows two different ways to control the product in terms of variation. The left side shows the engineering-to-order approach, familiar from the projecting business, where everything is designed according to the customer's wishes. The right side describes the configure-to-order method, in which reusable sections and delivery-configurable sections are identified in the product. The goal of the PFD was that not everything would have to be redesigned due to changing customer requirements, but the change could be applied to a smaller part of the product. This would support, for example, the benefits of design reuse. Analyzing the typical requirements of the customer's, partitioning logic was found to increase the controllability of the product in terms of changes.

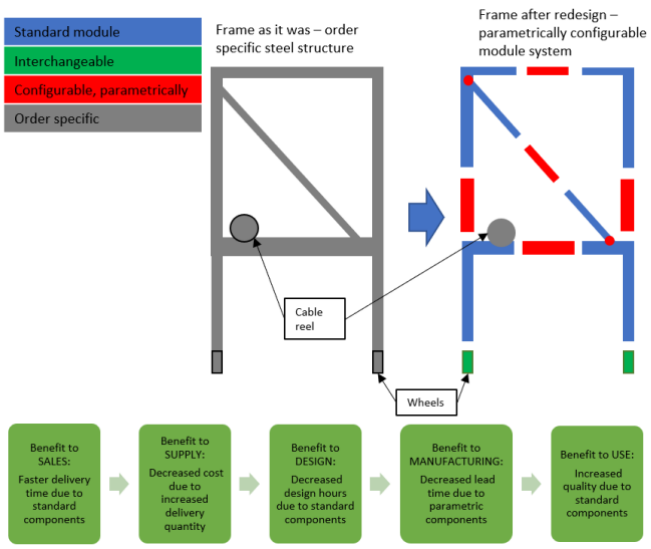

Figure 2. The visual product structure of a container crane before and after redesign with potential benefits during the product life cycle.

Originally the steel frame was an order-specific structure and the connection between the sales items and the physical structure was challenging to formulate. After the redesign, the height and width were realized through vertical and horizontal part elements see Figure 3. Wheels were designed as interchangeable, and the cable reel remained as it was. The connections between the sales items and the container crane product structure are presented in Figure 3 according to the PPM product structure model proposed by Tolonen et al. [1].

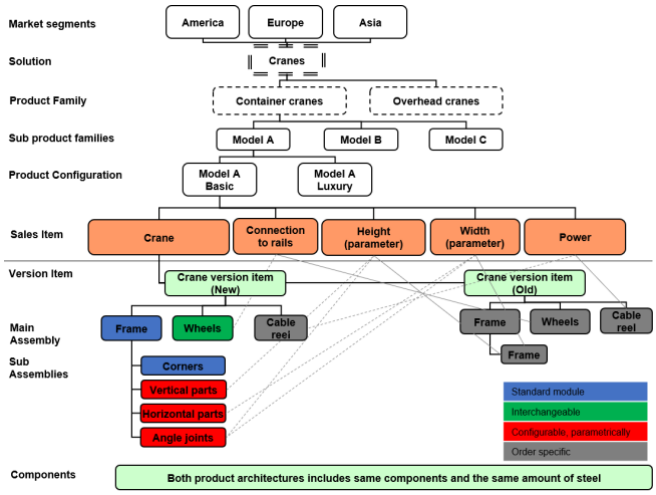

Figure 3. Horizontal and vertical portfolio concept of container crane before and after the redesign. Grey lines describe the configuration rules i.e., the connection between sales items and technical assemblies.

Potential business benefits of the redesigned product structure are presented at the bottom of Figure 2 where the effects are proposed according to product life cycle phases [7]. The sales can be supported by promising shorter delivery times due to storing standard components instead of delivery specific designs. During the supply chain, the costs can be decreased by buying standard components in larger batches. Parametrically configurable straight steel beams have a reducing effect on the required design time. Manufacturing can benefit from larger batch sizes and standard components both in time and money. During the use phase of a container crane, the proposed standard components provide tested quality to the customer and better spare part availability. Thus, redesigned version of the product structure support both PPM and PFD approaches to maximize the value and strategic fit of a product.

4. Discussion

In the productization context, the understanding of the connection between technical and commercial product portfolios is seen as vital. Generally, the technical aspects of a portfolio are developed by responsible PFD, using for example function or value-based methods. Company´s product portfolio is managed by PPM, focusing mainly on commercial aspects but also highlighting the role of technical product structure. Decisions are based on monetary estimations, but strategic portfolio aspects are considered. The main differences and similarities between PPM and PFD are listed in Table 1 as an answer to RQ1.

Generally, in the PPM literature product is seen as a black box referring to the interrelations of product properties, and the structures are not visible or understood in the sense of value creation during the product life cycle. This can lead to non sequitur for example looking at profitable or non-profitable sales items. This was highlighted in the container crane example where the product structure comparison revealed that both versions of structures include the same components and the same amount of steel. The structures also provide the same functionality to a customer. However, the same components in a different physical product structure can affect profitability and the agility of a manufacturing company.

The PPM management tools do not directly support developing a technical product structure from the perspective of value creation. Certain general propositions of the connection between sales items and technical structure are presented, but it should be understood that this can be done in several different ways. Tools from PFD are recommended to be used for developing the technical product structure since business-specific partitioning logic is vital for capturing the benefits in PPM. The product structure cannot be managed efficiently enough if virtual.

In answer to RQ2, the product structure formed in PFD should support the proposed PPM model. The PPM model can be used for all kinds of products. PPM tools can be used for evaluating and validating the outcomes of PFD in real-time i.e., the price and cost of fulfilling customer requirements (sales items). Therefore, close cooperation between PPM and PFD is important for efficient productization.

PPM scholars can benefit from the research related to the definition and effects of technical product portfolio [1,5]. Focusing on partitioning logic and using a product structure as it is designed is seen as beneficial both in ETO products (see Figure 2) but also in fully configurable products since a new generation of products is designed. The effects of product structure on product life cycle phases (horizontal product portfolio) are discussed widely in the PFD literature and can be used in PPM [1]. Purely IT-based linking between sales items and product structure does not necessarily give a true picture of the goodness of the portfolio.

The main challenges of PFD are related to evaluating the effects of decisions done in PFD [11]. PPM can be used for evaluating the product family outcomes by using the sales items as a reference point between the old and new product structures. The research contribution to PFD lies in this improved portfolio-level analysis.

Managers can benefit from the findings by recognizing the importance of the connection between sales items and the technical structure of a product. Also, the effects of product structure on business benefits are worth investigating since the same components in different structures can have a significant impact on the economic sustainability of the manufacturing industry.

5. Conclusion

This research aimed to review PPM and PFD literature and propose how productization can benefit from the current methods. The main contribution involves indicating that effective PPM requires a business-specific physical product structure and partitioning logic. The benefits of PPM can only be truly captured through applicable product structure. Therefore, PFD is recommended to be used in designing product portfolio related technical aspects. PPM is applied for management purposes with the support of a defined product structure.

Limitations of this research consist of limited depth of literature review since the aim was to introduce different perspectives of PPM and PFD related to productization.

Therefore, some of the relevant literature could be left out of the review causing an incomplete comparison between PPM and PFD. Also, research was mainly on a theoretical level besides the illustrative case example where the industrial experience of authors was synthesized for communicating the findings.

Potential areas of future research were recognized in two categories: applying the findings in a different context and further developing of PPM concept. For example, the service business can benefit from modular service portfolios which can be developed through proposed principles. It is also worth exploring whether the PPM model can be supported in practice by PFD tools for example in the management of product life cycle and value maximization.

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