

A FRAMEWORK FOR A PRODUCT-SERVICE-SYSTEM PORTFOLIO: MANAGING THE EARLY PLANNING

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1. Introduction

1.1 Introducing services to an integrated PSS-view

In search of new revenue opportunities, companies have always been trying to improve their products. From the market view, normal activities in the development departments have been either quality enhancements or functional enlargements. From the inner view of a company, the goal was either to reduce the costs at bringing a product to market or to fasten the process to do so. In the last years, the focus has been laid on improving functional elements of a product. Bringing it to perfection, the challenge is to implement them in a way that the customer would even recognize the improvement. As products are not only seen by their material manifestations, but their overall value to the one who purchases it, companies have recognized a whole new approach to their products. Enlarging them to an around-the-clock total package of functional supplies, they had the advantages on their side. In other words, companies have seized the opportunity to implement services to their hardware. Examples are to find in all types of markets. May this be a producer of professional construction tools like the Hilti Corporation from the Principality of Lichtenstein or a provider of IT solutions like the IBM Corporation from the United States. Companies are not handling anymore with products, but solutions. On the one side, the value chain providing the revenue mentioned in the beginning has been extended as companies can provide services after the sole production of their material products. On the other side, companies got the advantage of binding the customer closer to themselves as a total solution implemented in the sphere of influence of a customer is generally more difficult to replace than a product. These product-service-systems (PSS) bring a huge benefit to a company which has broadened its focus of giving the customer the opportunity of a surplus [Baines et al. 2007].

Accompanying the advantages of PSS, the enhancement poses a significant challenge to every domain of a company. From the management over the marketing to the developers, every department has to deal with changed conditions and has to adapt to them. In order to develop an integrated product-service system, designers of the product section are obliged to discuss their proceedings with the one who are responsible for the service section. And this is only the least connection between these two. There are concepts of merging the service and the product development in order to get a real PSS which is coordinated fully with the requirements of both worlds. Also, regarding it from a different point of view, there are changes in requirements through the whole innovation process. Looking upon an integrated life cycle, there are several phases in which products and services cannot be seen separately regarding a PSS. This paper deals with the impact a PSS has on the early planning during the innovation process and discusses the possible approach for how to deal with the changed circumstances. Thereby, a special regard is put on the answers a PSS-portfolio has to provide in this

stage of the innovation process and the way they can be achieved. Introducing this framework entails also the specifications which have to be provided in order to compose a PSS-portfolio.

1.2 Motivation

To synchronize the efforts in product and service development, it is necessary to understand the complex interconnections between these two domains. This work is a contribution to this problem and addresses the various requirements for the early planning of PSS with introducing an approach how to handle the diverse interrelations between the impact factors in this stage of the innovation process.

The problem at hand has been recognized along the preparation for the collaborative research centre ‘Sonderforschungsbereich (SFB) 768 – Managing cycles in innovation processes – Integrated development of product-service-systems based on technical products’ and was therefore, introduced in one of the various subprojects, namely C2, cycle-oriented product-service-portfolios considering the life cycle of future product-service-systems.

Companies are facing a lack of scientifically developed methods to deal with the mentioned constraints. As the service aspect continues to increase its impact on the innovations process formerly known by the company, a satisfying solution to the change of paradigm has to be found. Like in the sole product-focused company where a lot of processes and goals are competition-driven, the PSS-orientated company needs to be already in position at the time when the unique selling point of already implemented hybrid products are copied and adopted by other competitors. A well integrated PSS-portfolio gives the company a method to organize and manage the challenge in the early phase of the innovation process.

This paper addresses the overall approach to a PSS-portfolio. It demonstrates the interconnections between several impact factors for the early planning and gives an outlook what characteristics a portfolio has to deal with. For describing the characteristics, there have to be addressed the following issues:

- Which requirements have to be taken into account?
- What information is needed and where is it derived from?
- Where are the starting points for managing a portfolio?
- Are the interconnections between the life cycle phases taken into account?
- What is the challenge in dealing with portfolios of the future?

With the answer to these questions, a foundation is laid to give the companies the awareness of the obligation to handle their integrated PSS in a methodically approved way. In addition, the framework sums up the current status of research done and designates open fields for future work.

1.3 Preliminary approaches for the early planning

The primary task is to give a structured view of the dependencies, interconnections and relations which are combined in a PSS-portfolio. As the motivation derives from the change in the nature of offered goods, companies with a manufacturing background are confronted with modified conditions. Therefore, it is suggested to start with well-known and already implemented methods, which can provide the techniques and the experience required for the task at hand.

Product flexibility with its different foci offers a good starting point of how to structure the desired image of product-service-systems and allows to match the mentioned requirements with a pool of different approaches in this field. An analysis of several representatives like product families, variant management and the product spectrum offers the needed tools for structuring the portfolio [Tseng 2001, Martin and Ishii 2002].

Several different methods are available to be analyzed for this framework, because of the differential focus of each one on gradational levels in the early planning phase of PSS and their special design structures.

The product spectrum by Baumberger (2007) describes an image of the products, which are established in an enterprise. This means the sum of products in market, product concepts in development and product ideas a company is able to bring to market. With this tool as changed to PSS-requirements in a model in Figure 1, there is a way to illustrate the different PSS varieties. The considered characteristics reflect several specifications. There are the compulsive parts, the mandatory

choice of parts, optional parts, etc. In other words, a PSS-portfolio is a reflection of the potential of a company. A point in this paper is to transfer the product spectrum in an enhanced PSS-portfolio. First promising attempts for improving the results in the early planning phase have already been done by Lindemann and Maurer (2006).

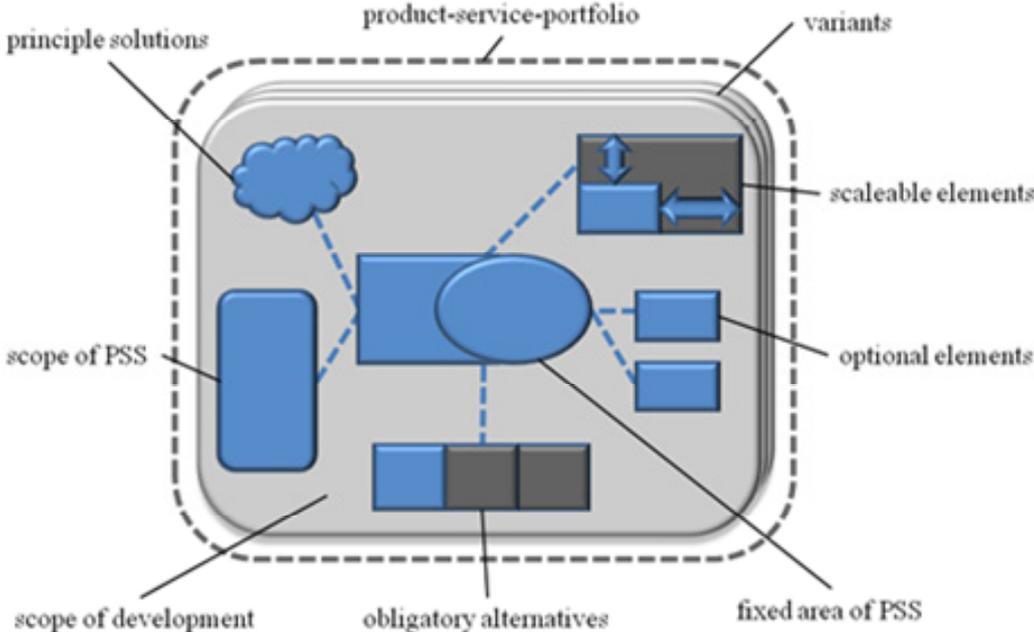


Figure 1. The flexibility structure of a PSS-portfolio according to the product spectrum [Baumberger 2007]

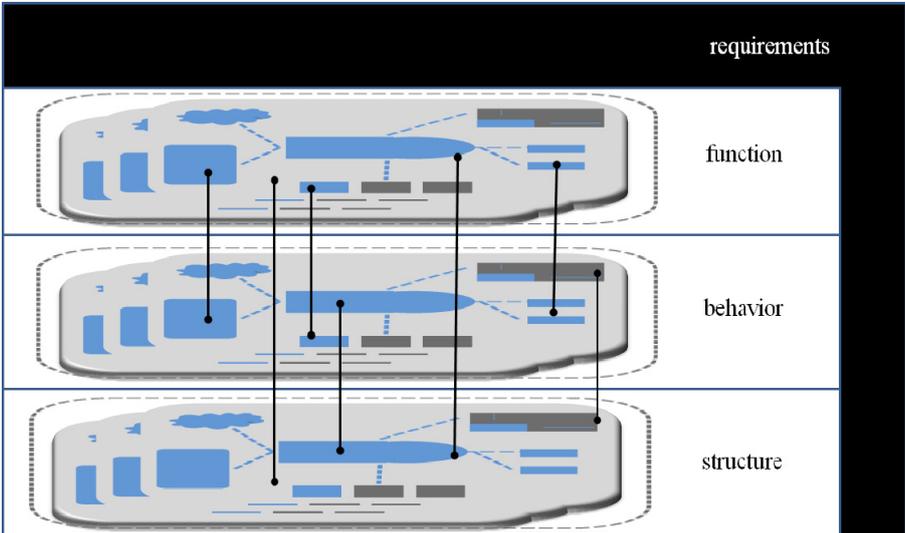


Figure 2. The flexibility structure divided in the three concretization levels according to Ponn and Lindemann (2006)

The gradational levels represent the progress during the planning phase where step by step the concretization degree of a PSS is increased. Umeda and Tomiyama (1995) offer a model which is divided into three independent levels as referred to functions, behavior and structure. Each of the levels is connected to the next one. Ponn and Lindemann (2006) are extending the three levels with a mantle layer which represents the increasing detail of the requirements during the designing process.

Each of the three layers consist of a PSS-portfolio in their own concretization degree and support therefore the flexibility requirement. During the innovations process and its improving concretization level of a PSS, the connections between the three layers can be identified and shown in the concretization structure of the PSS-portfolio as shown in Figure 2. The major outcome of this view is the visualization of stronger connections between the characteristic modules of a PSS. A product part for instance which is already identified as a fixed part in the body part of the whole PSS, will probably be fixed along the whole concretization chain.

The structure of a portfolio represents only the frame for the portfolio. Thus, the context model [Langer and Lindemann 2009] is consulted to analyze the needed information and serves in the same time for the content itself. The context model deals with several layers and origins of information and brings it into relation. The general idea is to match the information about peripheral, market-driven and company-derived information on the life cycle of a PSS. It represents a combination of several different structuring attempts in the field of impact factors for the company and is suited for the special requirements of a cyclic view in the innovation process. Later in this paper, some aspects derived of the context model are discussed in more detail.

Further, the life cycle of a PSS poses challenges on the portfolio. Interconnections and dependencies of different phases have to be taken into account to assure a successful product-service system. As many models of life cycles are focusing on a product or a service only, an integrated point of view leads to a satisfying aspect of the PSS. It can be stated that an integrated model of the PSS-life cycle is missing in literature. The necessary model should deal with a PSS-life cycle derived from several approaches in this field and be able to give information to the aligned coordination of product and service development which suits the problem discussed in this paper.

Completing the overview of the methods required for composing a PSS-portfolio, various resources of information have to be searched for and placed into the context in order to satisfy a further requirement of the portfolio. The information needed to answer the important and difficult question which PSS has to be prepared and how a company has to be aligned to the chosen PSS, is enormous and hard to gather. Resulting from research done in other subprojects of the collaborative research center, there are approaches on how to deal with the white fields of some domains. For example, technology roadmapping [Phaal et al. 2006] depicts information on possible solutions for desired functions and is therefore a potent approach for dealing with technological development and its implementation in the context of a PSS-portfolio.

Having build up a portfolio and filled it with the related information, the relations in time come to interest. For reducing fixed costs, it is obligatory to match the resources of a company to the desired offered product-service-systems. Relating to the portfolio, this means to analyze the given structure and comparing it to a possible structure in the future. Methods to change a structure from one to another are well documented in systems engineering [Blanchard 2004]. The aim is to minimize the effort to achieve the best suited portfolio in each period.

Subsuming the approaches, each of the mentioned method contributes to compose a PSS-portfolio. Thus, the specialization of each one helps to support the demand of the requested characteristics of the portfolio. The interest of this paper is posed on the overall view and the connections between these methods and how they form a portfolio.

2. The aspects of a time-related PSS-portfolio

Companies are facing fast changing market demands which have to be satisfied by a limited amount of resources available to a company. A claim arises requiring an approach to maximize the congruence of the potential of a company with the demands of the customer. The PSS-portfolio offers to the early planning in a company the opportunity to gather all the information needed, structure it, and receive an image of the tasks at hand. Though, doing so, several requirements of the PSS-portfolio have to be identified, addressed and aggregated. This chapter represents the analysis done during the work in the collaborative research center. The first subchapter describes the development process towards the PSS-portfolio. The second subchapter deals with the obligatory connection along the innovation process. The third one comprises the dependencies within the PSS. Finally, the fourth subchapter evaluates the impact on the following phases of the life cycle.

2.1 Development process of the results at hand

The described PSS-portfolio is the further development of the product spectrum, enhancing it with the capability to deal with services and their requirements. Interviews with 18 experts from companies with different backgrounds and sizes revealed the challenges which have to be faced. All of the interviewed experts were involved in the early planning of new products and services within their companies. Having analyzed the mentioned problematic of each of the interview partners, there was developed, during a workshop, a list of characteristics which are related to these points. After a classification of the list of characteristics, the following specifics of a PSS-portfolio were identified.

2.2 Becoming acquainted to the PSS-portfolio

As the portfolio represents an image of the complex situation a company is facing in the business world, there is to be kept in mind its influences and interactions. Reminding the aim of synchronizing the outer-company world with the one in the company, it is of interest to analyze the specifics of a PSS-portfolio and how they are connected. Figure 3 demonstrates the various dimensions of dependencies and how they affect the portfolio. Though, the overview lacks the details and shall be described more precisely as follows.

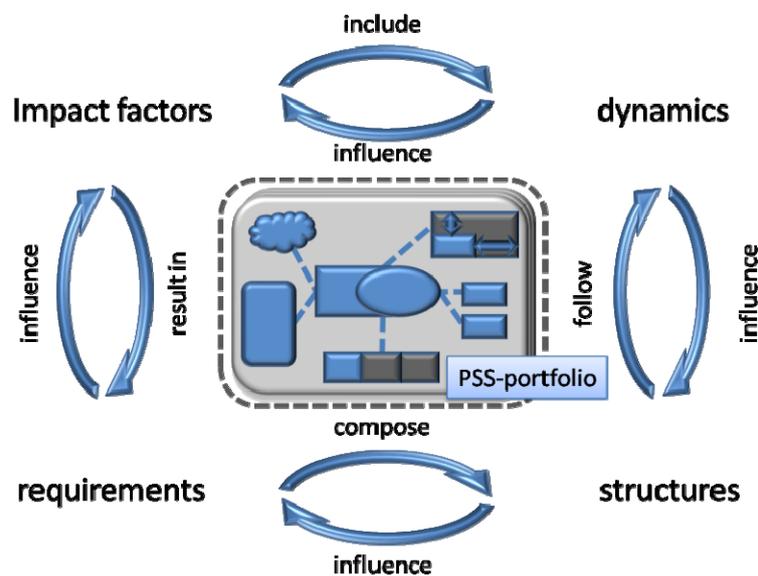


Figure 3. Dependencies and their interconnections in a PSS-portfolio

The product spectrum suits the view of a company which is specialized in the manufacturing branch. However, it lacks the growing importance of services which occurs in this branch. Stating an equivalent importance of products and services to the revenue, the two areas are connected and influencing each other. This crucial change of paradigm has to reach companies which are trying to expand their customer benefit. Nevertheless, the planned and defined PSS-portfolio is to be understood generically, which means there are situations in which focusing on services might bring more benefit to the company and the other way around [Tan and McAloone 2006]. Comparing a producer for washing machines and a telecommunication company reveals the obvious difference of importance between these two areas.

Turning to the dependencies, this paper addresses four of its kind - Impact factors, dynamics, requirements and structures. The four of them are important to be kept in mind for a successful generation of a portfolio and shall be described as follows:

Impact factors represent the parameters which are affecting a company in its whole. According to Langer (2009) they can be categorized in two dimensions. On the one side, one has to distinguish context factors as they are called in five foci. Initiating a broad analysis, there is the environment which affects the scope of action of a company. Examples might be changes in demographics or the overall economic development. Narrowing the view, the market appears in which the company is

active. Going further, there has to be an analysis of the direct interfaces of a company like the stakeholder integration or the customer services. Turning to the inside view of a company, the company focus is followed by a narrow angle of view in the development.

On the other side, there are different kinds of impact factors which affect the potential of a company. They can be either restrictive or supporting. Knowledge and technology experience represent the category in which it is hard to achieve unique advantages but easy to lose them. The socio-economic factors are difficult to control but might have a profound influence. Legislation and politics are defining the playground by which a company is constrained. Finally, there is the category of resources which are limited and therefore carefully utilized.

It is shown, that there are manifold impact factors which have to be brought into consideration. Designing a PSS-portfolio requires a consistent observation of all the levels and the active parts within. This way, it is possible to assure being prepared to start the right development projects which fit into the complex context a company is acting.

Dynamics are a dimension which was neglected a long time and are only considered since a few years. With the spreading of systems engineering and its identification of complex interactions within the system analyzed, dynamics achieved the attention which is necessary to handle a system successfully in a complex environment.

Dynamics like cycles, jumps or drops in the characteristics of impact factors constitute a challenge in managing a PSS-portfolio and shall therefore be taken into consideration. Thus, dynamics have two different occurrences. There are dynamics which have to be taken as they are because they are impossible or at least very hard to influence. Examples of this group are the changes in culture or ethics of a society. The other one is the group of manageable dynamics like the strategy of a company or the inspiration of demands through marketing activities.

The challenge is now, to align these two kinds of dynamics in order to achieve the best success possible. Along others, this is the goal of the collaborative research center. Expensive failure in developing the wrong product-service-systems or the wrong introduction time to market could be avoided with the understanding of the interconnections among all kinds of dynamics. For instance, the decision how specifications of the new generation of accumulators for cell phones have to look like, can be decided after the publication of a new law regarding stricter environment regulations.

Requirements describe the specifications which a PSS has to meet. These requirements are the constraints for the development and the values a customer can expect from a PSS. Along the development, there exists a solution space in which the developers are free to design a product, a service or a mix of both. Requirements mainly derive from impact factors like market demands or production feasibility as they are a translation of each of the factors according to the management strategy. The resulting PSS is the interpretation of these requirements along which it was developed. Early determined requirements might be an advantage for lean development because along the innovation process, all the departments can focus on one outcome. In contrast, there is a risk that the decided requirements have to be changed and thereby, iterations are necessary which increase development costs.

Structures exist in various ways within a PSS. The manifold dimensions range from knowledge interconnections over how production facilities are assembled to the PSS itself. Additionally, the various dimensions or domains how they are called in complexity management are connected among each other. This results in difficult decision processes, because there are no obvious outcomes. Laying down a group of workers might have the effect that certain knowledge is lost to the company and thereby, a certain function within the PSS-portfolio has to be abolished. The challenge is given in the creation of a system understanding and the consciousness of managing it. A special issue poses the structure of a life cycle. Beside of building up an integrated life cycle which seeks to satisfy the requirements of cycle-focused interconnections, it is essential for the early planning to understand the interconnections between the individual phases. Hereby, it will be possible to react rapidly and with the right decisions on changed circumstances. To illustrate this matter, the example of changed environment regulations is taken. Having an effect on the recycling phase like the obligation to change a special production process in order to reuse a material more easily, there are consequences during the development and the production of new PSS. The development has to seek other solutions to

handle the material and the production department is in need of new machines to adapt to the changed material.

Having introduced the four kinds of dependencies, there has to be discussed a further issue. The four kinds like to see in Figure 3 are connected and influence each other.

Impact factors correlate strongly with dynamics as the impact factor describes the character a criterion having influence on the PSS-portfolio and the dynamics describe the behavior. Impact factors include a special dynamic as the dynamics influence the impact factors. A technology leap of accumulators for instance include the technology as impact factor and the leap as a foreseeable dynamic influence the development of new generations of combustion engines as there is an opportunity of introducing an electrical engine in personal vehicles.

Impact factors when identified and understood are translated into requirements of new PSS development projects. It happens to be a common process in the development. However, there is the other way round in which the requirements influence the impact factors. Knowledge requirements in the development process may tie resources in a way that other projects may not be started in their best timeframes.

Requirements compose the structures in a company, i.e. how a development process is structured or how production lines are assembled. Structures themselves are influencing requirements as well. Given process flows may be restricting the solution space of new PSS-developments and therefore, have to be taken into account.

Dynamics influence the structures as well. Considering a PSS-lifecycle like the one by a car model, the development teams, their knowledge and their experience are bound to market introductions of new models. The optimum would be adapting structures to orders of a cycle management. In reality structures are too inactive and inflexible for adjusting to dynamics, especially when they obey a high frequency.

Subsuming the dependencies of a PSS-portfolio, there has been shown a vast amount of entities which has to be considered in the compilation of it. To get the best results regarding the fast and competitive development of product-service-systems, there has to be found an optimum in adjusting the four dimensions to each other. A problem is to be found in the conflicts of objectives and goals. The further work within the subproject C2 of the collaborative research center will be to focus on the interconnections of the introduced dimensions and to develop a method how to align them.

2.3 A structure leading to transparency

After having identified the essential information to compose a PSS-portfolio, it has to be structured and adjusted to the requirements of the innovation process. Methods of product flexibility seem to have the right approaches for this kind of problem. Having the objective to satisfy the goals of mass customization, possibilities of communalization and modularization have been developed and tested intensively. The general idea of product flexibility is to provide solutions to structure future offered products along the development process with a special focus on cost reducing and individualization. Taking the already introduced FBS-approach along which the degrees of product maturity increases, there are several methods which can provide the tools for handling a product structure. As the methods originally come from the product-focused spectrum, there is further analysis necessary which characterize the transferability into the field of product-service-systems. An interesting point is the character and the amount of information going in and out the three different levels of PSS-maturity. The structure level in the FBS-approach for instance does not suit the necessary focus on services as services do not provide such a level because of their immaterial nature. Service design may stop at the behavior level, but that has to be analyzed in detail yet. Additionally, methods of product flexibility deal with products only. Methods suitable for a PSS-portfolio have to be capable to structure various kinds of different elements. i.e. storing data about technology knowledge is as important as the information about production resources or the detailed interactions of market demands. Further, it is of interest, how changed impact factors and thus, the decisions made by the management of a PSS-portfolio, can be implemented into an already existing portfolio.

2.4 Connection between future PSS-portfolios

An existing PSS-portfolio is capable of providing detailed information about the chances and constraints of new development projects. Transforming the given information into a portfolio is a challenge by itself, but the result helps a company stay competitive and up to date. Nevertheless, this would remain only a short-term view and would pose unnecessary difficulties for the fixed capital of a company, because future changes would be implemented too late in the existing portfolio. The suggestion is to maintain several portfolios at one time. Today's portfolio will be composed out of information which will unlikely change and therefore, will be robust for transfer of projects to the development departments. In order to focus on a middle- term and a long-term view, two portfolios more are the solution to take trends of the future into account. This is just exemplary, since there is the opportunity of composing far more portfolios if this suits the company. It depends on how the market activities demand for flexible and fast answers on changes. A cell phone producer acts in a market far more agile than the one in the heavy metal industry. As the three-divided view represents the common fragmentation in industry, this one should be discussed further on.

Figure 4 shows the mentioned three portfolios and introduces the main benefit of the anticipatory work. As a portfolio represents a reflection of a company and the offered PSS with its structures and resources, the question arises how to align these three. Changing installed structures causes sunk costs and new fixed capital.

The interconnections between the three periods have to be analyzed in order to obtain feedback about the degree of change between two adjacent portfolios. As the portfolios represent the future plan of a company how it wants to position itself, the delta between two portfolios relate to the effort that has to be made for attaining the strategic goals. Finally, it is essential to identify methods, how the changes can be kept to a minimum. As the change of a PSS-portfolio is highly connected with investments, write-downs and simply the costs for reorganization, the different portfolios in the future have to be designed in a way in which not only the actual influences of the period are lodged but the influences of different periods are coordinated. This way, the company positions itself perfectly according to the market demands and ensures sustainable development.

Further, there has to be put a focus on the structures within a portfolio. The interconnections between the planned portfolios result in an additional structure. Highly effective tools can be found in systems engineering which helps to optimize the future development process of a company.

In reality, keeping changes to a minimum will have an effect on the strategic positioning of a company. For instance, the decision if to provide certain functions like an extra equipment in the automobile branch by the company itself or to purchase it by a supplier is depending on the classical outsourcing strategies. This effort has to concur with the long-term goals of the company. There could be a clear positive answer to that regarding the short- and middle-term view but a strict rejection for the far future. Providing an interface for some audio equipment is a good example for it. Fashionable equipment might last long on the market but can be replaced very quickly by another technology leap. Having gained a huge income with providing this interface by the company itself, leaves it to massive fixed and sunk costs afterwards.

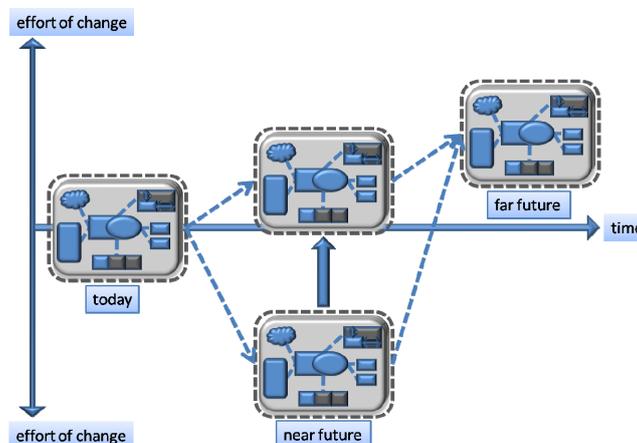


Figure 4. Synchronizing PSS-portfolios over time

However, the problem with future portfolios is the risk in data. Future information can change and therefore, has to be monitored in periodic intervals. The same principle which is important for the current portfolio to be up-to-date is to be considered during the composing of future ones. Specifying this statement, adjustments of the future portfolio do not have to occur in the same intervals as for the present one, but refreshing future portfolios with essential data could have consequences for the present.

3. Conclusion

The introduced characterization of a Product-Service-System-Portfolio shows how a method can look like in a holistic view that gathers important information. Impact factors from the outside and the inside view of a company can be identified. Dynamics and especially cycles are taken into account which pose a threat to the successful introduction of a PSS to market. The requirements of new projects are put into the overall context of the company. Finally, the importance of structures is accentuated in the proposed concept of a PSS-portfolio. Being able to adapt existing methods of different areas of design and utilize them to form a powerful tool the PSS-portfolio gives a company the chance to identify essential information about itself and the provided systems. Specific instructions are given for gathering information about dependencies and interconnections in order to compose a portfolio within the ongoing circumstances and the future ones in order to synchronize them.

The steady change towards integrated PSS in the product portfolio of companies poses a demand for research in this area. Subsuming, the paper at hand addresses various aspects which are essential for preserving the success of product-service-systems.

3.1 Outlook

Future work will concentrate on the open questions addressed in this paper. As connected to the collaborative research center, it will be the goal to contribute to the overall research question of how to manage cycles in the innovation process.

An integrated life cycle is required to specify the dependencies between the phases. In understanding the degree of changes along the life cycle, it will be possible to react faster and more precise to changed impact factors.

Along this, exploring the behavior and accordingly giving advices for the management of the four dimensions introduced in this paper are an essential goal of research.

The mentioned discrepancy between methods of product flexibility and their matching on service specifications is crucial for the further work in the collaborative research center.

In order to use time-relevant portfolios, there has to be analyzed how different structures can be measured regarding change efforts in order to be able to evaluate them against each other.

Further work is as well necessary in the expanded view of this paper. Concentrating on the own company may be putting effort in something blinkered. Possible expansions of the work at hand may be considering the composing of portfolios of competitors and comparing them to one's own version. This opens the opportunity to find white fields in the satisfaction of market demands and therefore, developing a unique selling point. The comparison of different structures provides opportunities to improve structures within the company by adapting the ones from the best performing competitor. Additionally to this aspect, there is the opportunity of obtaining information not only for the decision if a solution is outsourced or not but also at what time. Being able to understand the dynamics of a technology and its impact on the company provides the information, if it is of advantage first to provide the solution by oneself and then to offload it.

Enhancing the understanding of the structures might even result in advancing certain structures with cost functions in order to compare them more precisely and thus, give the management the opportunity to decide on quantitative reasons.

Nevertheless, it is to be said that there is still a long way to provide a detailed proceeding model. This work states the milestones which have to be processed in order to achieve the intended outcome.

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