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INNOVATION CYCLES CONCERNING STRATEGIC PLANNING OF PRODUCT-SERVICE-SYSTEMS

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1. Introduction: Managing cycles in innovation processes

This paper proposes a research program for identifying, understanding and describing innovation cycles concerning strategic planning of product-service-systems. A general overview about the background of cycle management in innovation processes, which the proposed research program is part of, is given before focusing cycles concerning strategic planning.

As companies offer more and more complex products in order to satisfy market needs, the innovation process of such products becomes also more complex to manage. Sharing an integrated perspective on the innovation process, it can be detailed in the subprocesses described as follows. Identifying market needs is the subprocess that starts innovation processes. Continuing with various subprocesses that prepare and perform the design and the production, the subprocesses of launching the product and accompanying the time of use of the product conclude the innovation process. These subprocesses are not carried out in strict sequence, as iterations in-between the subprocesses are often necessary in order to achieve satisfying results.

Sharing this integrated perspective on the innovation process of complex products one notices that managing the innovation process and according subprocesses can become difficult. Characteristics as higher product and process complexity, increasing dynamics within and in-between the subprocesses and consequently a higher degree of uncertainty can be perceived. Furthermore, considering services beside the product itself, the mentioned characteristics of innovation processes become even more relevant. In the past years, first interesting results were carried out in research about managing the innovation process of complex product-service-systems having an integrated perspective on both provided products and associated services. Müller and Blessing [2007] for example compared product and service development models and shed light on properties relevant for the development of product-service-systems based on existing design process models. They state that "product-service-systems are capable to deliver more value to the customer, they afford more opportunities to the designer but they complicate the design process". Tan and McAloone [2006] also argue that product-service-systems continuously provide value to the customer. In order to support the innovation process of product-service-systems in companies, they determined strategic characteristics of product-service-systems based on student projects.

Notwithstanding these results in researching product-service-systems, opportunities researching interactions along the innovation process of product-service-systems remain. For example companies offering complex product-service-systems face the challenge that singular components and services of the product-service-system are characterized by different life times. Some functions of the product-service-system and associated components and services last from the first day of use until the technical system is completely sorted out; some original functions remain in the product-service-system but

components and services fulfilling that function are replaced. Other functions are implemented for the first time while the system is already in use; and some functions become obsolete and therefore, components and services are disposed while the system as a whole is still in use for some more time. These examples show that a company must be flexible in launching singular parts of the product-service-system in order to fulfil market needs. Consequently, companies face the challenge of varying development and production times for the different components and services. Also the product and process knowledge of employees – whether they belong to the design, production or service department – has to adapt according to the changes in the product-service-systems.
The above mentioned examples describe recurrent processes in and in-between the subprocesses of the innovation process and therefore, they can be denominated as 'innovation cycles'. In order to research the management of such innovations cycles intensely, a Collaborative Research Centre (SFB 768) at the TU München was recently established. Scientists from engineering, social and business sciences take part to shed light on innovation cycles from various perspectives. In long term perspective, the identified innovation cycles throughout the disciplines will be collectively coordinated in order to develop methods and tools to support the management of cycles in innovation processes. Against that background the proposed research program describes an approach of identifying and describing innovation cycles concerning the strategic planning of product-service-systems. Furthermore, subsequent processing of structuring data gained from strategic planning in the form of a product-service-spectrum is focused. Thereby, both the process of generating and adapting the product-service-spectrum as well as the content of the spectrum, i.e. different types of components, are looked at in detail.

2. Strategic planning as a basis for product-service-spectrums

2.1 Strategic planning sharing an integrated lifecycle-perspective

Systematic strategic planning plays an important role for recognizing complexity and dynamics of product-service-systems early, and in order to reduce uncertainty in innovation processes. Considering present and future trends and tendencies by strategic planning preserves the company's competitive capability and also discloses possible success potentials [Gausemeier 1998]. Bea and Haas [2005] provide a detailed overview about the development of approaches in strategic management. Thus, in particular recent approaches are characterized by increasing integrated system thinking, taking both aspects about the company and the respective company's environment into consideration. Numerous methods and tools supporting strategic product planning were developed in the past. One powerful method to mention in this context is Scenario-Management [Gausemeier 1998], which allows complex product planning by building possible future scenarios. Integrated system thinking as well as multiple futures are main principles in using this method.
Against that background, an integrated perspective on the lifecycle of product-service-systems is fundamental for strategic planning. While an integrated perspective on the lifecycle of products can be deduced from various literature about product-lifecycle-management [e.g. Saaksvouri and Immonen 2005, Stark 2005], an integrated model of the lifecycle of product-service-systems including services is not yet researched as far. On the one hand, talking about an integrated perspective on the lifecycle of product-service-systems means that aspects from all stages from the development of a product-service-system throughout the stages of use and following recycling or disposal should not only being taken into consideration separately. Instead, also interactions within and in-between the single stages of the lifecycle must be considered. On the other hand, an integrated understanding of the lifecycle of a product-service-system means that the lifecycle of the product, i.e. the physical component must not be seen separately from the lifecycle of the associated service.
Assuming that strategic planning is performed under consideration of an integrated lifecycle of the product-service-system, multiple options to combine functions and associated components and services of the system can be deduced. But which option should a company consider for further development? By only developing the most promisingly looking option after strategic planning, the company's effort to design the system will be relatively small compared to the design of multiple

options at the same time. But by following only one option, the company risks not being flexible enough to face market needs different from the most promisingly looking product-service-system after strategic planning. In contrast, by developing multiple product-service-systems after strategic planning, the company will be flexible enough to face most market needs, but following multiple options also includes the risk of designing options not at all being relevant for the market. Thus, a compromise between the company's effort (resources spent) and the flexibility in offering product-service-systems must be effected. Thereby, it is also important to find the right level of abstraction in 'predevelopment' of product-service-systems that are possibly interesting for the future.

2.2 Product flexibility

In this context, approaches in dealing with product flexibility represent a starting point for future research. For example, Sanderson and Uzumeri [1997] discussed different approaches in dealing the variety of products and product flexibility on the basis of product families. They deduce relations between the design of a product, production technologies and market needs based on extended monitoring of technologies and product lifecycles. Otto [2001] focuses on the modularization of platform-based product families. Beside modularization, Qureshi et al. [2006] also considered a 'Spatial Approach', an 'Interface Decoupling Approach' and an 'Adjustability Approach' for flexible developing and handling products. Research in this field shows that offering various product configurations to meet different market needs can be achieved with limited resources. Therefore, certain rules in dealing with product variety and flexibility must be followed.

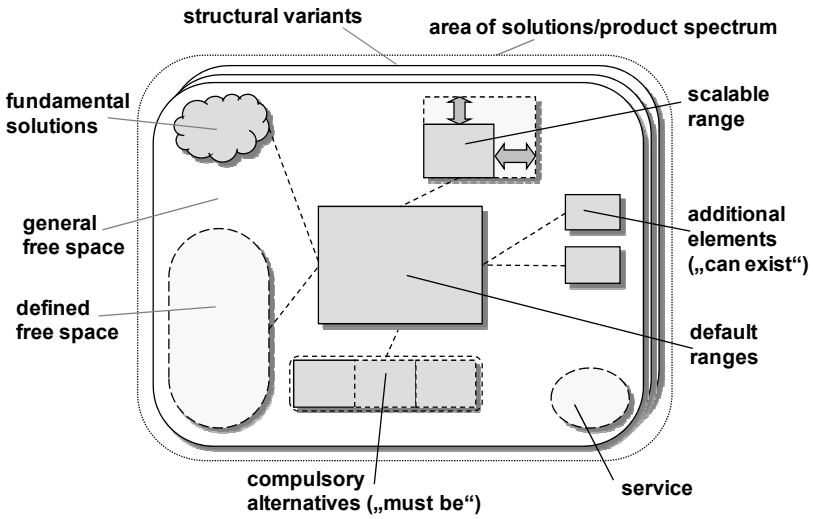

Figure 1. 'Product-spectrum' for individualized products and its main components [Lindemann and Maurer 2006]

The 'product-spectrum' [Lindemann and Maurer 2006] in Figure 1 also represents a model in order to flexibly deduce various products against the background of designing individualized products. A product deduced from the product-spectrum does not only consist of individualized components, but can have a predefined default range which is not changed when specifying certain individualized products. Compulsory alternatives ("must be") describe elements, without which the product would loose its basic functions, but which are available with different specifications. For example the combustion engine of a car is a compulsory element, which is available with different specifications. Additional elements ("can exist") are only selected if certain additional functionalities beside the main functionalities are desired. Scalable ranges can be individually adjusted due to the customer's needs within limited values. Fundamental solutions are already defined on a conceptual level (e.g. there is a

brake), but they are individually elaborated in detail on the basis of the customer's needs (e.g. the brake is pneumatic, or hydraulic, or magnetic, etc.).
The element 'service' was already considered as a part of the product-spectrum, but was not further researched in detail. Nevertheless, based on first experiences applying the structure of the product-spectrum to various examples and a case study dealing with high pressure cleaners [Baumberger 2007], the product-spectrum describes a promising basis for researching possible structures of a 'product-service-spectrum', which then shares an integrated perspective on products and services based on systematic strategic planning of prospective product-service-systems. On the basis of such a product-service-spectrum, singular product-service-systems may flexibly be deduced.

2.3 Conclusion

It is expected that managing innovation processes becomes more efficient by understanding and coordinating innovation cycles in the context of above mentioned topics. Therefore, the research program proposed in this paper addresses cycles concerning strategic planning and further structuring of data in a product-service-spectrum. Potential cycles concerning strategic planning are presented below.

3. Potential innovation cycles concerning strategic planning

Identifying, understanding and describing innovation cycles concerning strategic planning and further structuring results from strategic planning describe main objectives of the research program. As mentioned before, it is important to share an integrated understanding of the lifecycle of product-service-systems when strategically planning those. Thus, the first step is to look at innovation cycles occurring within the lifecycle. The following example shows one of these cycles which might possibly be relevant for strategic planning: A customer rents a copy machine from the company producing the copy machines. After the first period of use (e.g. 2 years), another customer takes over the two-year old copy machine – also for rent – and so the second period of use starts. As the copy machine receives an upgrade after another 2 years at this customer, the customer decides to buy the copy machine. Thus, a third period of use of the copy machine within the same lifecycle starts, again showing different characteristics than the two previous periods of use. This scenario addressed the period of use as one possible cycle within the lifecycle, but many more cycles exist in the various stages of the lifecycle of a product-service-system. For example, there might occur different cycles concerning design or production. Not all of those cycles are relevant for early strategic planning. But others are and identifying the relevant ones helps to early prevent uncertainty and risks along the lifecycle of a product-service-system.
Not only cycles within the field of vision of the strategic planning are of interest; repeatedly performing strategic planning also shows cyclic characteristics itself. For example, a company plans the first generation of a certain product-service-system. Shortly after or even before launching the first generation, the company already has to plan the next generation of the product-service-system. This scenario can be continued, which means another cycle in the strategic planning of product-service-systems itself can be identified.
Structuring the results from strategic planning in a product-service-spectrum has to be performed from time to time as well. But that does not necessarily mean that the complete process of generating a product-service-spectrum for the first time has to be performed again. Maybe only certain parts of it have to be replaced, added or disposed in order to meet the latest trends and tendencies of e.g. available design tools, production technologies and, of course, market needs. Thus, this cycle of adapting the product-service-spectrum describes another innovation cycle concerning strategic planning of product-service-systems. This cycle is illustrated in Figure 2.
The cycle of adapting the product-service-spectrum then raises questions about its characteristics. At first sight, this cycle can be looked at in the context of time, as for example in certain time distances a company adapts its product-service-spectrum. One question in this context might be how far these time distances can be influenced and which are levers to adjust these time distances. This consideration also includes other innovation cycles relevant as factors influencing time distances in-

between the adaptation of the product-service-spectrum. In the above mentioned example, the copy machine at least undergoes three periods of use which are all characterized differently. So this cycle is described by at least three, but potentially even more periods of use. With every additional period of use the next point of time for strategic planning might shift. Thus, the point of time of adapting the product-service-spectrum also shifts. Consequently the cycle of different periods of use also influences the cycle of adapting the product-service-spectrum.
Another cycle, which is also relevant for the cycle of adapting the product-service-spectrum, exists in launching product-service-systems (see also Figure 2). From time to time singular product-service-systems can be deduced from the product-service-spectrum and then be developed in detail in order to be launched later on. If the market is for example very dynamic, it is probable that a company launches products in very short time distances. This characteristic of the cycle might influence how the time distance in-between the adaptation of the product-service-spectrum is adjusted. Hence, this is another example of a cycle relevant when researching cycles concerning strategic planning of product-service-systems.

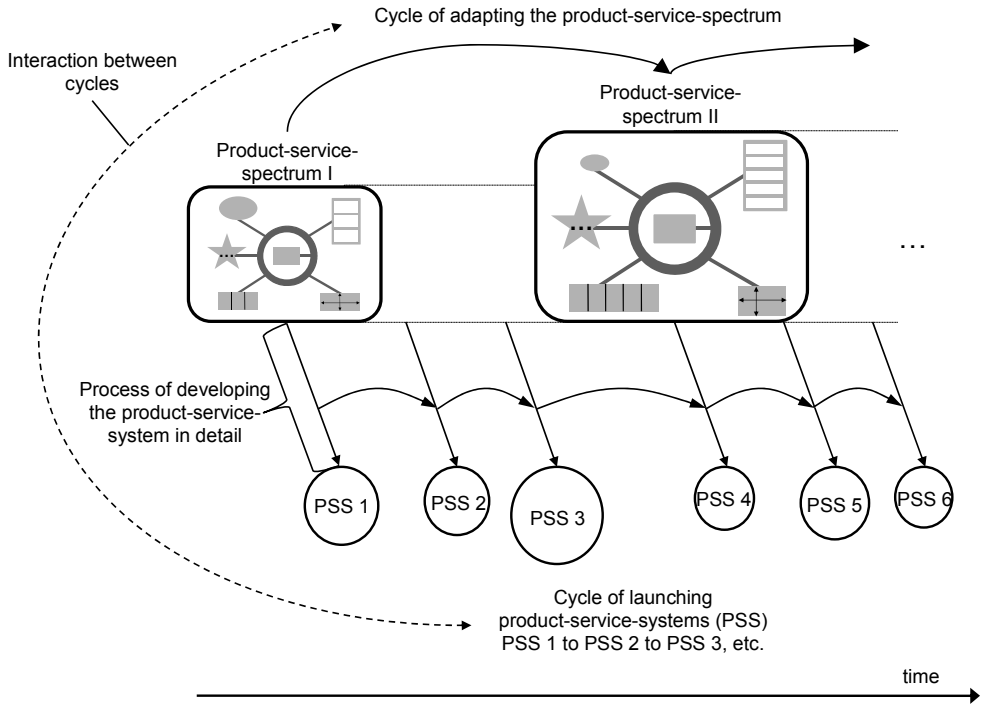

Figure 2. Exemplary cycles concerning strategic planning of product-service-systems

The examples show that consideration and management of cycles early in the innovation process may reduce uncertainty along the lifecycle of product-service-systems. But so far, cycles in innovation processes and therefore also concerning strategic planning have not been researched in detail. Thus, based on considerations in this paper it is the first step to identify cycles and describe them before trying to manage them. Thereby, a major focus is directed on interactions between the innovation cycles in order to preserve an integrated view on this topic. In the following, issues of the proposed research program are introduced.

4. Research issues

One first important step in researching innovation cycles concerning strategic planning is to generate an integrated model of the lifecycle of product-service-systems. On the one hand this model has to integrate the lifecycle of the product and the associated services. Further, the model should include all lifecycle stages from the early stages of designing the product-service-system to the later stages of using and recycling or disposing the product-service-system. The structure of such a lifecycle model shall be appropriate to present innovation cycles within and in-between the stages of the lifecycle. Therefore, data about certain fields of interest as the product design and the stages of recycling will be analysed in the context of an integrated lifecycle understanding. Further, data will be collected via collaborations with manifold scientists belonging to the Collaborative Research Centre (SFB 768). For example one team within the Collaborative Research Centre focuses on innovation cycles concerning aspects of information technology (IT) within the product-service-system. This team delivers detailed data about IT cycles for research proposed in this paper. Vice versa the team exploring IT-cycles receives data which are relevant for IT cycles against the background of an integrated lifecycle understanding of product-service-systems (e.g. data about interconnections of IT-cycles with cycles of reusing the product-service-system in different environments). Another collaboration relevant for strategic planning based on integrated system thinking exists with experts researching customers' buying patterns in detail. This team of experts elaborates strategies for example in deepening the customer relationship by offering certain higher value components (up-buying) or in broadening the customer relationship by offering additional components (cross-selling). Here the focus also lies on cyclic characteristics. Information about customers' buying patterns will help to embrace cycles concerning the customers' view on product-service-systems in the integrated lifecycle model. Further, an intense collaboration with experts in production sciences is planned. Two major issues are addressed in this collaboration. On the one hand, detailed information about innovation cycles in the field of production is made available by this research team. On the other hand, techniques for strategically planning production technologies in the context of an integrated perspective on the product-service-spectrum can be carried out together.

Based on the findings concerning an integrated lifecycle of a product-service-system, research in methods to support strategic planning is carried out. Different quantitative and qualitative prediction-methods will be identified, analysed and if necessary adapted in respect to the issue which should be prognosted. For example, trying to identify future market needs requires different prediction-methods from those being relevant for the identification of technologies available in the future.

As described, one major focus of the proposed research program can be seen in innovation cycles concerning the application of prediction-methods based on an integrated understanding of the lifecycle of product-service-systems. Another focus within the research procedure is on structuring the data gained by applying the prediction-methods. Therefore, research is carried out based on existing approaches and methods in industry and engineering sciences about dealing with product variety and flexibility. The first step is to analyse the above described product-spectrum (see Figure 1) which has the purpose of dealing with individualized products. But as the purpose of the product-spectrum differs from the purpose of structuring data from strategic planning in a product-service-spectrum, further aspects have to be analysed. For example, results from applying prediction-methods must have a format which can be represented within a product-service-spectrum. Furthermore, services must be equally taken into consideration beside products. And especially cycles relevant in the context of generating and adapting a product-service-spectrum have to be identified and described in order to find a suitable structure for a product-service-spectrum.

Although the process of generating and adapting a product-service-spectrum based on strategic planning is focused in this research program, this process must be coordinated with the process of deducing singular product-service-systems and developing those in detail (see Figure 3). Therefore, the interface between the processes will also be researched. For example, the level of abstraction in predeveloping certain components and services within the product-service-spectrum influences further processes in developing the components and services in detail. Also the size of the product-service-spectrum (e.g. number of considered components and services) influences the later design process.

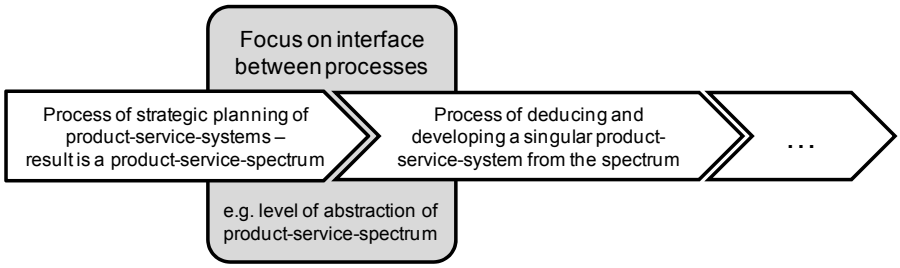

Figure 3. Process interface particularly looked at in the proposed research program

Major research issues in identifying and describing innovation cycles and interactions in-between those cycles concerning strategic planning have been mentioned above. In the following section, conclusions from the proposed research program are drawn and an outlook on further steps is provided.

5. Conclusions and outlook

Cycles throughout the innovation process are omnipresent, but so far they have not been researched in detail. Being part of the Collaborative Research Centre (SFB 768) with the title 'Managing cycles in innovation processes – Integrated development of product-service-systems based on technical products', the proposed research program focuses on innovation cycles concerning strategic planning. Early consideration of cycles is expected to reduce uncertainty in the innovation process and thus to enhance reliability in planning product-service-systems. Further, by early considering and managing innovation cycles in strategic planning, downstream processes throughout the lifecycle of product-service-systems are expected to be more robust and efficient. Consequently cycle management prevents a company from wasting resources. Moreover, by anticipating market cycles in strategic planning, the company becomes more flexible in disclosing and meeting future market needs.

Different issues have been mentioned for researching innovation cycles concerning strategic planning. First, an integrated understanding of the lifecycle of product-service-systems is focused. This is the basis for identifying cycles within and in-between the singular stages of the lifecycle, from the design and production, throughout to the stages of recycling and disposal of the product-service-system. Therefore, collaborations with scientists from engineering, business and social sciences take place in order to shed light on the lifecycle from different perspectives. Based on findings about an integrated lifecycle, prediction-methods are analysed in detail in order to assign the convenient prediction-method to the respective object of attention. Findings about prediction-methods based on an integrated understanding of the lifecycle of product-service-systems are one elementary basis for structuring results from strategic planning in a product-service-spectrum. Furthermore, the approach of structuring information from strategic planning in a product-service-spectrum is also researched on the basis of existing findings dealing with product variety and flexibility. Another major issue concerning the research of innovation cycles in respect to strategic planning applies to the interface between the process of generating and adapting a product-service-spectrum and the process of deducing a singular product-service-system from the spectrum and developing this singular product-service-system in detail.

The proposed research program describes the first period (from 2008-2011) in researching innovation cycles concerning strategic planning of product-service-systems. This period focuses on identifying, understanding and describing relevant innovation cycles. On the one hand, results from this first period are expected to present a valuable input for companies facing the challenges mentioned in managing innovation processes of complex products. In order to incorporate feedback from industry in research, findings will constantly be transferred to a demonstrator. On the other hand, findings of this first period describe the basis for later periods of research when trying to develop an integrated and consistent cycle-oriented model of the strategic planning process. In long term perspective, it is then planned to generate and provide methods and tools for managing cycles in innovation processes. In all

periods of researching cycles in innovation processes, it is important to continuously coordinate and combine the results from researching cycles concerning strategic planning with findings about many other innovation cycles researched in detail within the presented Collaborative Research Centre. Only then, it will be possible to make innovation processes as a whole more transparent and managable.

Acknowledgement

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