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Analysis of value creation through product-service-systems in the German medical engineering industry

Felix Köbler[1], Jens Fähling[1], Alex Vattai[1], Jan Marco Leimeister[2], Helmut Krcmar[1]

[1] Technische Universität München
Boltzmannstr. 3
85748 Garching b. München, Germany
{felix.koebler; jens.faehling;
alex.vattai; krcmar}@in.tum.de

[2] Universität Kassel
Nora-Platiel-Str. 4
34127 Kassel, Germany
leimeister@uni-kassel.de

Abstract: Our analysis of seven companies from the German medical engineering industry revealed that product-service-systems play a central role in value creation. Customer solutions are highly individual and often consist of a medical product and corresponding services spanning the complete product life cycle. This paper shows on an empirical basis that information technology becomes an enabler for services around medical equipment and that information technology implements products and services towards an integrated customer solution. Strategic objectives indicate a trend towards continuous partner-relationship between manufacturers and their clients. In particular, the ability to co-develop services and products simultaneously was considered as an important success factor related to integrated product-service design. The companies intend to build individual customer solutions with the help of standardization and modularization to successfully drive the challenging strategic expansion and commercialization of product-service-systems in the medical engineering industry.

1 Introduction

Even increased complexity of products is no longer a guarantee against the imitation of products [Lei08]. Health care engineering companies are increasingly confronted with growing competition from manufacturers residing in developing countries that penetrate national and international markets with easily copied simple products. In addition, a change in customer behavior in product and service demands is observable, as the customer is not interested in the product and service itself, but rather the solution to a problem [Saw06]. To deal with this change in behavior, and to maintain and boost competitiveness in future market settings, companies increasingly offer secondary services to their end consumers and retail partners alongside their primary products [Bru07]. The integration of both products and services provides customers a solution tailored to fit their specific problem, whereas products or services offered separately often only partially address customer challenges. Toshiba Medical Systems, which is one of many examples that describe value creation through product-service-systems (PSS) in the medical engineering industry, offers technical products in combination with financial services to implement medical applications, and positions itself as an implementation and operating partner for complex clinical, logistical and commercial solutions [Tos07]. Medical engineering is strongly driven by mechanical engineering research, with a strong understanding and long history of developing and managing technical products for various markets [Lin06], and is increasingly influenced by the integration of IT components. In comparison, service engineering or service science research is a relatively new discipline focusing on development and management of services [Bul03].

This paper presents the current state-of-the-art in the value creation by PSSs in the German medical engineering industry that is driven by rising costs for technical innovations [Spe08], increasing complexity of technical innovations, soaring connectivity of technical devices [Ist04] and specialization of hospitals providing individualized health care offers [Lee08].

The first section of this paper illustrates the challenges in the medical engineering industry and its economic importance. The next section presents a definition of product-service-systems (PSS) in the scope of this publication. The following section depicts the methodological approach and describes the chosen research units, followed by a section that reports the findings. Limitations and future research approaches are presented in the closing section.

1.1 Challenges in the medical engineering industry

The market for health care products and services is one of the largest sub-segments in the German national economy. It is estimated that about 4.3 million people were employed in the public health care sector in the year 2005, which represents about 10% of total employment in Germany [Spe05]. The resulting total branch turnover is about 240 billion Euros, which constitutes more than 11% of the gross domestic product of Germany [Spe05]. An important segment of the health care sector is the medical engineering industry which is the focus of this study.

The German Industry Association for Optical, Medical and Mechatronical Technologies (Spectaris) calls for reactions to challenges, such as innovation, internationalization and the availability of capital [Spe05], to assure growth and a future market leading position for medical engineering products. The industry sector is characterized by high research and development expenses and market dynamics, and represents not only an emerging industry but the backbone of a functioning national health care system [Sag05]. Innovative medical equipment and instruments increase success rates of operational intrusions, reduce the stress of patients, shorten treatment cycles and prevent secondary complications. A fast-growing and aging world population, increasing professionalism in health care and fostering services drive the total expenses for health care: in developing countries through the growth in the number of patients and in industrialized nations through the demand of modernized methods of treatment and accordingly through the shift to privately paid treatments [Spe05].

In Germany medical engineering manufacturers focus primarily on technology-oriented strategies and drive the development of high-quality products. The consequence is that market success depends primarily on the product quality and less on the price of the product. Therefore innovation and quality lead guarantee growth and profitability for manufacturers [Vog04]. Furthermore, manufacturers of medical engineering products need to develop, maintain and extend know-how on multiple technologies in order to deliver state-of-the-art and high quality products to national and international markets: one possible solution is the delivery of product-service-systems.

1.2 Characteristics of product service systems

While management research underlines differentiation and output expansion, many researchers focus more on economical aspects of PSS. One of the first formal definitions on PSS was developed by Goedkoop et al. [Goe99] in the late 1990s:

> "A product service-system is a system of products, services, networks of 'players' and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models." [Goe99]

Mont [Mon02] identifies a "clear lack of common understanding of PSS elements" and gives an overview on different facets. PSSs may consist of products and services in various combinations including additional service elements at the point of sale, e.g. personal assistance in shops, financial schemes or marketing. Maintenance services with the goal of prolonging product life cycles, revalorization services that close the product material cycle by taking products back and utilization of usable parts in new products and recycle of materials are further elements. Figure 1 provides a summary of various PSS classifications and identifies three categories of PSS occurrence by Tukker [Tuk04] and includes examples from the medical engineering industry.

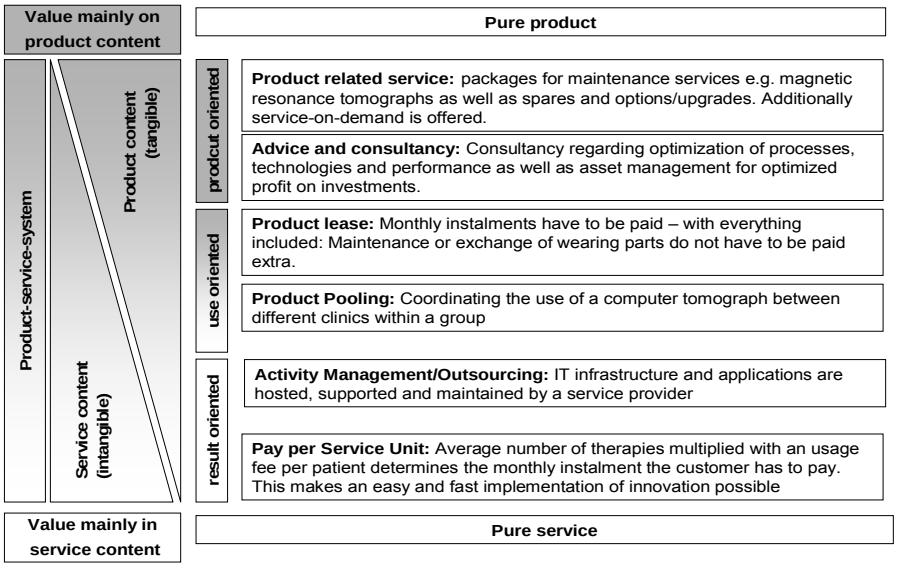

Figure 1: Main and subcategories of PSS (adapted from [Tuk04])

The first main category, *product-oriented services* contains business models that are dominated by product sales and some extra additional services. Product-oriented services can be distinguished in product-related services as well as advice and consultancy [Tuk04]. Product-related services include the sale of products with additional services that are needed during the use phase of the product, like maintenance contracting, financing schemes or the supply of consumables. In contrast to simply selling a product, advice and consultancy include hints and directions for the most efficient use, such as through organizational structure or optimization of logistics.

The second main category contains *use-oriented services*. In this category the product still plays a central role. In contrast to product-oriented services, however, the products' ownership remains with the provider. This enables the provider to make the product available in different

forms and to various customers. Use-oriented services are product leasing, product renting or sharing as well as product pooling [Tuk04]. Because there is no transfer of the ownership from the provider to customer in product leasing, the provider is also often responsible for maintenance, repair and control. The customer normally has unlimited and individual access to the leased product. Product renting or sharing is quite similar to product leasing, but differs in how the product is accessed. Unlimited and individual access is not usually found in product renting and sharing. In this case, the customer has to share access with other customers, where the product is sequentially used by different users. Furthermore, product pooling permits simultaneous use of the product.

Finally, *result-oriented services* represent the third main category. In this case, no predetermined product is involved, because the customer and provider agree on a specific result. Result-oriented services can be distinguished in activity management and outsourcing, pay per service unit and the agreement on a functional result [Tuk04]. Activity management and outsourcing means that a provider delivers parts of activities or whole processes to a customer, like cleaning or catering. These services are assigned to this category, because most of these contracts contain performance indicators for quality control of the outsourced services.

2 Research method

2.1 Methodological approach

The aim of this study is to generate a state-of-the-art analysis of the systematic product-service compilation in the German medical engineering industry. Based on the current literature in the field of PSSs, a semi-structured interview guideline was created. Individuals employed at medical equipment and medical instrumentation manufacturers, a consulting company and a large university clinic were then contacted and interviewed. The interviews were transcribed and software-supported coded through MAX QDA 2007 and coding matrices. Based on the coding, qualitative interview data was converted into quantitative data for an enhanced style of presentation [Bor06].

2.2 Research units

The selection process for the research units focused on representatives from large medical engineering manufacturers. In particular, contact was established with equipment manufacturers offering medical imaging technologies and with medical instrumentation manufacturers offering the complete product range of surgical instrumentation. Furthermore, the research unit selection was aligned to the availability of individuals, the company structures and range of products. This allowed comparison between companies offering similar products.

Both research unit types - equipment manufacturers and medical instrumentation manufacturers – differ greatly in corporation structures and products (see Table 1). Equipment manufacturers are large international corporate groups which operate additional divisions alongside health care products. The health care product portfolio is dominated by imaging technologies such as X-ray examination, angiography devices, magnetic resonance tomography and computer tomography scanners.

	Equipment manufacturers	Ind.	Instrumentation manufacturers	Ind.
Type of equipment	Large medical appliance	ζ,θ	Surgical medical/ endoscopic surgery instruments	ζ, η.
Price segment	200.000 – 6.000.000 EUR	ε,δ	-	
Software ratio	50% - 100%	α,β,ι,γ	low (increasing)	η, θ
Product life cycle	5 – 8 years 5 - 15 years	β,γ,δ,ι	-	

Table 1: Research unit structure (with interviewee references)

In contrast instrumentation manufacturers developed from medium-sized regional or national market-focused companies to companies that distribute their range of products internationally and specialize in surgical instrumentation tools and complementary products. In total, eight interviews were conducted with individuals from medical engineering manufactures, of which five individuals were employed at equipment manufacturers and three at medical instrumentation manufacturers. Two individuals worked at the same equipment manufacturer (individual β, γ).

Ind.	Description
α	The individual is a *service sales manager* at an equipment manufacturer offering medical imaging technologies. The company currently positions itself as a solution provider.
β, γ	The individuals are employed as *service manager* and *key account manager* at an equipment manufacturer offering the complete product range of medical imaging technologies.
δ	The individual is a *senior manager technical consultant internationa*l at an equipment manufacturer offering the complete product range of hard- and software for image-supported operation tools and radiation therapy.
ε	The individual is *head of service management* at an equipment manufacturer and solution provider offering the complete product range of medical imaging technologies.
ζ	The individual is a *product manager* at an international instrumentation manufacturer offering the complete product range of endoscopy equipment
η	The individual is a *product manager* at an instrumentation manufacturer offering endoscopy equipment, the complete product range of surgical instrumentation and implants.
θ	The individual is *head of service management* at an instrumentation manufacturer offering endoscopy equipment and medical instrumentations.
ι	The individual is the *chief executive officer* of an independent consulting company offering services for the efficient procurement and optimized operations of medical equipment for medical imaging technologies.
κ	The individual is *head of the medical engineering unit* of a large-scale university hospital

Table 2: Research units overview

In addition, the client perspective was included through an interview with the head of the medical engineering unit of a large-scale university hospital (individual κ). One interviewee was the chief executive officer at an independent consulting company which offers services for the efficient procurement and optimized operations of medical equipment for medical imaging technologies and radiation therapy to provide a non-biased perspective (individual ι). Neither of the interviews are representative, but their inclusion enriched the interview series by offering additional input during the analysis process.

3 Findings

3.1 Service portfolio

The first set of questions targeted the service portfolio of the participating companies, which were partitioned based on a process-oriented perspective into services that are offered in the sales phase and utilization phase.

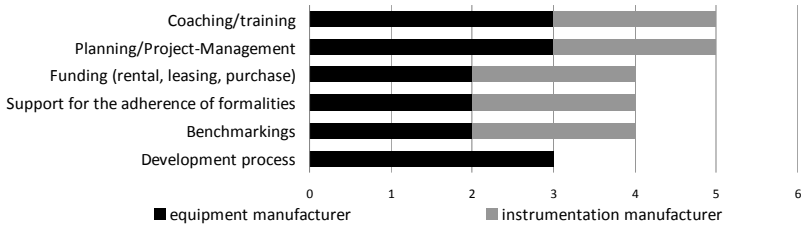

Figure 2: Service portfolio within the sales phase (n=7)

Both phases are characterized by a different service range. In the sales phase, according to the interviewees, consulting, planning and project management services are prior-ranked including requirements engineering processes to establish an integrated development process (individual ε). For instance, instrumentation manufactures provide specially designed product showrooms to simulate possible implementations of products and services implying the customer's in-use products and future optimized combinations of products. Four participants also mentioned consulting services in the area of legal formalities, and the composition of service-level agreements that include performance and service life warranties, as important features in the sales phase. Customized financial services which support the implementation and utilization of PSSs through optional leasing, buying or renting concepts or any combination of the mentioned concepts, are required to establish a purposeful product-service system compilation.

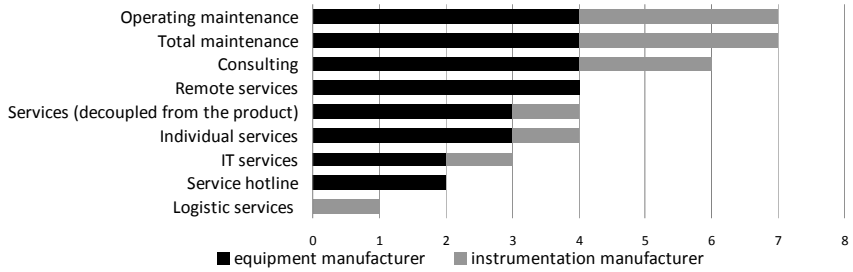

Figure 3: Service portfolio within the utilization phase (n=7)

In the utilization phase, total and operating maintenance services are deployed from all participating equipment and instrumentation manufactures to guarantee full coverage of the complete product-service life cycle span. Furthermore, all participating equipment manufactures implement remote services driven by advancements and the integration of state-of-the-art information and communication technologies. The role of remote services could be best explained through the enabling of remotely administrated maintenance services and the creation of additional *individual services and product-independent services* which facilitate customer integration and the standardization of product-service-systems.

3.2 Strategic objectives

Figure 4 displays the frequency of general and service-specific strategic objectives mentioned by participants. The questions targeted on the current strategic importance of services and if the company plans and/or has executed strategic decisions that drive a positioning as a service and solution provider. An objective conformance of customer orientation and integration, as well as

the transformation of a *customer-vendor relationship* into a cooperative *customer-partner relationship,* are essential for both equipment and instrumentation manufacturers. To establish a level of transparency and efficiency, a strategic interest is to provide complete solution systems instead of elementary solutions. Customer retention and support are essential service-based strategic objectives for equipment as well as instrumentation manufacturers.

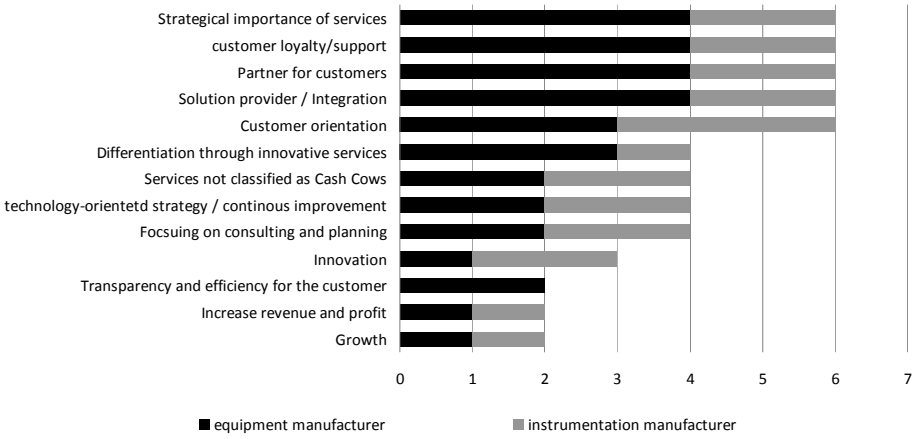

Figure 4: Strategic objectives (n=7)

A fraction of the participating companies identified a differentiation potential towards competitors through the initiation and inclusion of innovative services in the existing range of products and services as an important strategic objective.

3.3 Product-service delivery factors

The frequency of mentioned product-service delivery factors are shown in Figure 5. The majority of participants mentioned that a factor for the optimized product-service compilation is a parallel development process of products and services, starting in the sales phase. Nevertheless, ex post alignments and adjustments are common: “First, the product is developed and then I start to think about solutions for developing an aligned service or one starts to develop a service and initiates considerations to develop an aligned product” (individual δ).

Additionally, services need to be aligned to react on possible changes to market developments. The most important factors in the product-service delivery are standardization and modularization of processes and components, as well as the definition and description of precise process implementations. For both equipment and instrumentation manufacturers, cooperating with other companies to foster cooperative partnerships is essential to optimize supply chain and value creation networks, and in order to cover a complete range of product-services. Furthermore, it is hypothesized that the quality of the product-service delivery in particular, is essential in a highly-competitive medical engineering industry setting, which results in the implementation of a strategic quality management. To establish a target-oriented quality management, two participants mentioned a clearly defined processes and proximity to customers as the crucial success factors.

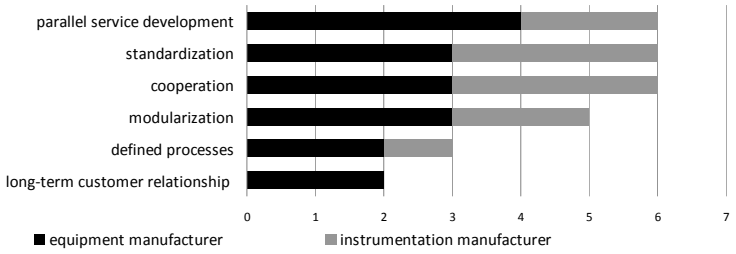

Figure 5: Product-service delivery factors (n=7)

Proximity to the customers is established through "key users" which are preferable research institutions, e.g. university hospitals. The choice of key users should be guided by the degree of experience and level of familiarity of a key user partner. One participant mentioned the fact that for manufacturers without a reputable key user, efforts to penetrate established and aggressive markets – such as the German medical engineering market – are extremely expensive and wasteful.

3.4 Challenges to strategic expansion

The majority of the participants mentioned the persuasion of the customer through a suitable and adequate configuration of the offered PSS as the most challenging problem in strategic expansion. In this context, the benefits and advantages of the offered PSSs need to be clearly arranged between the vendor and customer, e.g. through enforced customer participation.

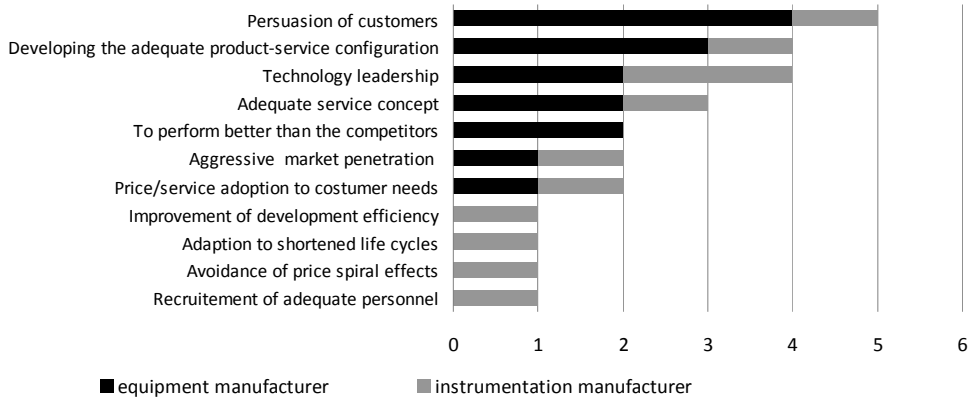

Figure 6: Challenges in strategic expansion (n=7)

According to the participants, the convincing might be negatively influenced by technologically-driven innovative services, e.g. remote services that enable vendors to carry out distributed maintenance tasks which are not perceived by the customer, e.g. lack of the physical presence of maintenance personnel in contrast to on-site maintenance. The deployment of highly-innovative service packages which additionally display the necessity to establish a technological lead position in the market and the persuasion of the client of offered suitable and adequate product-service configurations are the most challenging problems to solve to successfully ac-

quire new customers. Furthermore, the participating individuals that represent the customer and consultant side in the study also mentioned the management of shortened product-service life cycles as a key to strategic expansion.

3.5 Success factors for the commercialization of PSSs

Factors with the highest-perceived influence on the successful commercialization of PSSs are the quality, the individually- and situationally-optimized product-service compilation and service network, reaction time and reliability. All of these factors enable broad, qualitative solutions to specific customer needs and problem settings at all times. The service network reaction time and reliability constitute the requirement "that doctors do not perceive failing instruments and/or equipment" (individual θ). The execution of all factors mentioned is a precondition to ensure competitive advantage and a leading technological position in the market. In contrast to the factors mentioned above, physical product size and life cycle related problems are regarded as subordinate factors in enabling successful commercialization of PSSs.

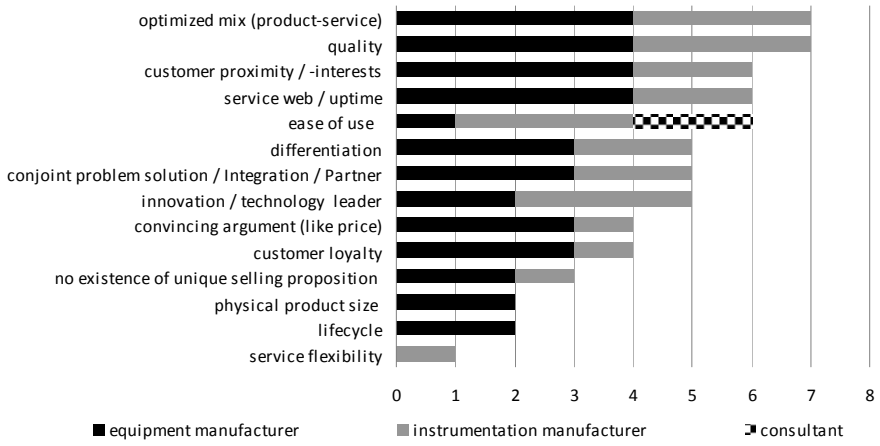

Figure 7: Success factors for the commercialization of PSSs (n=9)

4 Conclusion of key findings

A first pattern is derived from the goal of customer integration to *'develop the right solutions'* reflected by market and client expectations of the individualization of products and services. A second pattern was found in the context of the *'right development of customer solutions'*. This contains the standardization and modularization of products to offer individual products that combine and support product modules and functions with specific services. One purposeful tactic, to deliver individualized PSS solutions, is to standardize product components and create differentiation by offering customized services. Based on this trend, products and services must be developed in an integrated fashion and in precisely defined processes. It was found that not all companies use standardized processes for integrated product-service development. Therefore, the preparation of methods, processes and tools for an integrated development through best-practices or theory-driven approaches is a precondition to provide integrated PSS solutions. Another trend is the increased influence and importance of information and communication

technology in medical engineered products and innovative prospects of service integration: through standardized interfaces and communication technology enabling remotely conducted maintenance services.

5 Limitations and future research

This basic explorative study is simply a starting point to explore implications and conditions for successful development, commercialization concepts and methods for an integrated development of products and services. The study is not only limited by its qualitative research method but by the focus on the medical engineering industry. Based on the findings described above, future research should highlight other industries and quantitatively scrutinize presented findings to describe opportunities for and characteristics of customer integration in PSSs.

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