Assessment of the Sustainability Effects of Product-Service Systems

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Abstract

The concept of Product-Service Systems (PSS) as a means to realize sustainable business models is a vividly discussed topic in management literature. Most approaches to evaluate the impacts of PSS focus on the economic as well as the ecological dimension of sustainability, whereas social implications are hardly analyzed. However, a more comprehensive evaluation of potential effects of all three dimensions of sustainability is indispensable to foster the diffusion of PSS. Therefore, this article offers an integrative assessment of the sustainability impacts of PSS based on expert interviews in the B2B as well as B2C sector.

Keywords

Product-Service Systems, Sustainability, Empirical Results, Manufacturing Sector, Wastewater Treatment

1 INTRODUCTION

Recently, it has been possible to observe a shift in many manufacturing industries from traditional product-oriented business models towards service-oriented business models [1]. Instead of simply selling physical products, the functionality of the product is sold to customers [2]. Characteristic for these new business models is the bundling of products and value-added service to offer customer solutions instead of mere products [3, 4].

There are many different terms used in literature to name service-oriented business models, i.e. functional sales [5], performance–based contracting [6] or high value integrated solutions [7]. The business concepts outlined hereunder aim to fully satisfy customer needs and at the same time offer advantages like higher profits, strengthened customer ties and generating benefits in mature markets [8]. Within the research arena dedicated to sustainability issues, these innovative business relations between equipment suppliers and their customers are discussed predominantly under the term "product service systems" (PSS) [9]. With focus on sustainability this strain of PSS research stresses the opportunity of decoupling material consumption from generating profit through integrating services and by this means reducing the environmental impact in production systems [10].

Although the potential of PSS to realize economic as well as ecological goals are approved by both research groups the implemented business models often emphasize mainly one perspective. While the economic sustainability of concepts like for example Total Cost of Ownership (TCO) is explicitly pursued, the ecological sustainability effects of such models remains unclear. In other models, for instance contracting in the energy sector, the ecological and economic motivations are more closely interrelated. Occasionally service models are promoted as beneficial to the environment, without their social-economic viability having been proven.

However, some approaches to investigate the effects of PSS on sustainability have been made in the past. An attempt to assess the economic and ecological impact of PSS was made by Tukker [10]. He estimated the environmental impacts of eight different types of PSS in comparison to the reference product on a scale from "Worse [than the reference product]" to "radical reduction". Implications of service orientation (product-, use- and result-oriented) on job creation and ecological effects were analyzed by Scholl [11]. Furthermore Maxwell and van der Vorst [12] in conjunction with practitioners from industry developed a procedural method that supports value chain partners in developing sustainable products and/or services under consideration of economic, ecological as well as social aspects.

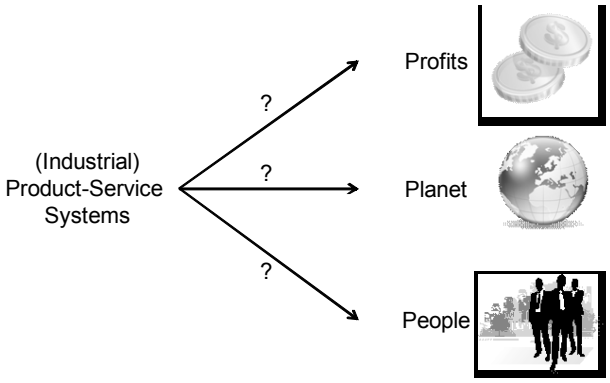

Figure 1: Dimensions of Sustainability.

Although in turbulent times like these the economic aspect is ranked first, the importance of a holistic assessment of economic, ecological and social aspects of sustainability can not be overemphasized. Dyllick and Hockerts [13] express it as follows: "*A single-minded focus on economic sustainability can succeed in the short run; however, in the long run sustainability requires all three dimensions to be satisfied simultaneously.*

However, in order to assess the contribution of PSS concepts to sustainability a comprehensive assessment of potential effects of all three dimensions of sustainability is indispensable (see Figure 1). A holistic approach allows the identification of cause-and-effect chains to set up a framework of generally admitted interdependencies over different types of PSS and different industry sectors.

Therefore, a literature review was performed with the aim of identifying the state-of-the-art in this field of research. As no consistent Product-Service Systems theory exists up to now giving theoretical explanations on the why and

how value added can be created neither in an economic, ecological or social sense the review process was used to look for first contributions to fill this gap. At the end of this process New Institutional Economics especially Property Rights Theory indicated by Hockerts [14], Transaction Cost Economics indicated by Toffel [15] and also incorporating considerations from Principal Agent Theory were identified. These are expanded by the interrelation of services and the Resource-based View of the firm implied by Burr [16] and insights from services science [17]. These approaches have been chosen to serve as theoretical backbone to derive hypotheses on possible cause-effect chains.

In this paper three key hypotheses out of the identified 15 on sustainability impacts of PSS are presented. Furthermore, a preliminary qualitative assessment of these hypotheses based on interviews with different stakeholders of PSS, e. g. industry associations, labor unions, policy-makers and also scientists withholding expertise with PSS is given.

Our research contributes to the existing research on the sustainability potential of PSS and will detect correlations and divergences over different manufacturing sectors. In the following section the applied research method is described in detail.

2 RESEARCH METHOD

The aim of the research described in this paper is to determine and evaluate the sustainability effects of PSS. For this purpose, a qualitative approach has been chosen, which is depicted in Figure 2. Although the research questions were deduced from already existing theory, a qualitative approach was chosen for the following reasons. Up to now no explicit theory on Product-Service Systems exists. Therefore, although hypotheses could be deduced from business management and economic theory, testing these hypotheses via a quantitative survey would not reveal interrelationships that are not yet covered by theory. Furthermore, the aim of this research was not only to validate the underlying assumptions, but also to identify conditions under which the cause-effect chains are true. Therefore, following a qualitative approach in a first step, the general research question was defined. In doing so, the research gap underlying the project was tapped and additionally a focus was set to avoid getting lost in the volume of information [18]. The overall research question was defined as:

- RQ: What are the sustainability effects of PSS?

On this basis a comprehensive literature review was conducted. Previous studies and publications on PSS and sustainability were the focus of this literature review and served as a foundation for both development of hypotheses and selection of potential interviewees. Against this background a set of hypotheses was established, bolstered by the literature findings on possible correlations of PSS on economic, ecological and social impacts. The three dimensions of sustainability must not be regarded as independent. However, as the sustainability effects of PSS are difficult to measure and to analyze, in the chosen approach the hypotheses only refer to one dimension. Furthermore this approach allows it to measure different shades of the impact level of the individual dimension. Nevertheless the concept of PSS resembles the node which all of the three aspects are tied to.

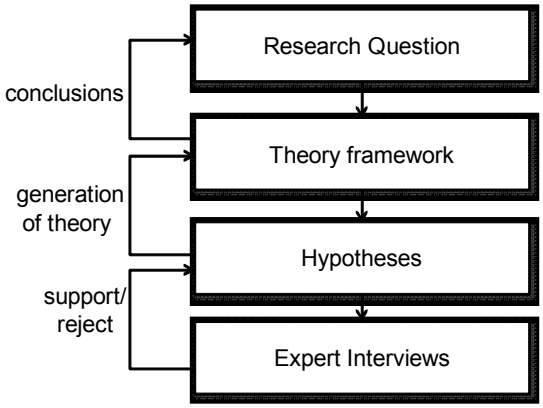

Figure 2: Research method.

Next, an interview guideline was elaborated, where the hypotheses were split up into one to three questions to disperse a complex interrelation into linear traceable relationships in order to capture most of the experts' knowledge, experience and thoughts on PSS.

This interview guideline also served as an orientation for the interviewers to cover all aspects, but allows going into more detail, especially in certain fields of the interviewee´s expertise [19]. In section three, it will be shown how the hypotheses were derived from literature and how they were operationalized in the interview guidelines. The results of the expert interviews can be found in section 4. The experts were identified on the basis of the literature review: persons from research, but also from industrial associations, companies and labor unions who had contributed to the PSS-sustainability debate during the last years were selected and were invited to give insights into their expertise. To shed light on possible differences caused whether the product-service system is delivered in a business-to-business or business-to-customer context experts from fields were interviewed. Thus, the focus was on two sectors: manufacturing and wastewater treatment.

For the manufacturing sector, a total of ten experts were interviewed. Of these, three experts were researchers, four employees of industrial associations and three from others, i.e. companies, consulting agencies and labor unions. As the manufacturing sector consists of several subsectors, two experts came from the machine tool industry, two from the compressors industry, one each from the assembly industry and the energy systems industry and four were experts on the manufacturing sector in general. (See Table 1) The experts came from several European countries.

Sector:	**Research**	**Association**	**Others**	**Total**
Machine Tool Industry	1	1		*2*
Compressed Air		1	1	*2*
Assembly Systems			1	*1*
Energy Systems			1	*1*
Manufacturing Sector (general)	2	2		*4*
Manufacturing Sector total	**3**	**4**	**3**	***10***
Wastewater Treatment	**1**	**2**	**2**	***5***

Table 1: Interviewees.

Six interviews were conducted overall for wastewater treatment. One of the wastewater experts came from research, one from an industrial association, one from a company offering PSS and three experts came from platforms dealing with different aspects of wastewater management.

Expert interviews were conducted from April 2009 to November 2009. They took between one and two hours and were done either face-to-face or via telephone. Two interviewers participated in the interview, one to lead the discussion and the other one to take written notes of the interview [18]. Afterwards the protocols of the interviews were sent back to the interviewee for revision.

After finishing the interviews, the interview reports were analyzed by three researchers independently to guarantee profound results. If there was a deflation concerning the interpretation of certain information this special issue was discussed again within the group of researchers. The interviews were evaluated by means of a content analysis.

Given the limited scope of this paper, we will discuss only 3 hypotheses in detail, one for each of the three dimensions of sustainability. The content analysis allows going away from the written interview text and tries to systematically reduce the volume of information as well as to structure the information according to pursued research question [19]. To extract the key information from the interviews, an evaluation matrix was developed. This was extremely important as experts from two different industrial sectors with individual peculiarities were evaluated. The matrix design contributed under these circumstances to a structured and consistent procedure of extracting information to assess the hypotheses. By doing so, the answers given during the interviews could be used to either support or reject the hypotheses. The results of these interviews can be found in section 4 of this paper. These finding will be used to contribute to the generation of theory on the sustainability effects of PSS. Before the results are presented the analyzed hypotheses and their theoretical roots are to be presented. Corresponding to the quality criteria of this qualitative research approach the operational steps of the study were previously defined to guarantee a structured execution of the study [20]. The sequential steps of the content analysis are depicted in Figure 3. To answer traditional criteria of reliability of the results the analyses of the answers was carried out by multiple researchers. Furthermore addressing newly established quality criteria of qualitative research, the procedural manner has been carefully documented and the evaluation of the hypotheses is embedded into a written argumentation. Contributing to the traditional criteria of validity the questions included in the guided interview are based on the hypotheses derived from theory that draw on a combination of well established organizational and management theories [20, 21].

3 FRAMEWORK OF RESEARCH HYPOTHESES

For the purpose of deriving hypotheses on the sustainability effects of PSS, at the beginning of this research project a literature review focused on the effects on sustainability was conducted and existing approaches of a theoretical derivation of the value added through these business concepts were scanned. Thereby, initial works were identified. Toffel [15] refers to the term servicizing that “involves suppliers providing functionality rather than products” and picks up the peculiarities of these models and their influence on the governance structure using transaction cost economics. Hockerts [14] draws on the property rights theory to explain why PSS are supposed to be superior market solutions in comparison to the traditional way of doing business. Transaction cost economics and property rights theory seem to be promising theoretical approaches, due to the fact that in PSS, compared to the traditional sale of equipment, changes in the mode of transaction are implied, as PSS providers retain some or all property rights of the physical good used in PSS and hence stay responsible for it. From a resource-based point of view, Product-Service Systems unfold their benefits due to the specialized knowledge of the provider. These capabilities in terms of PSS are based on, for example, certain engineering competencies, capabilities in process design or established long-term relationships with customers. These internally existing competencies enable the provider to perform activities in a better way than its customer and thus build the basis to achieve a value added through the PSS offer.

When analyzing PSS in this paper it is referred to Tukker´s [10] widely acknowledged categorization scheme, which differentiates into the following subcategories:

- Product-oriented services: sale of product including

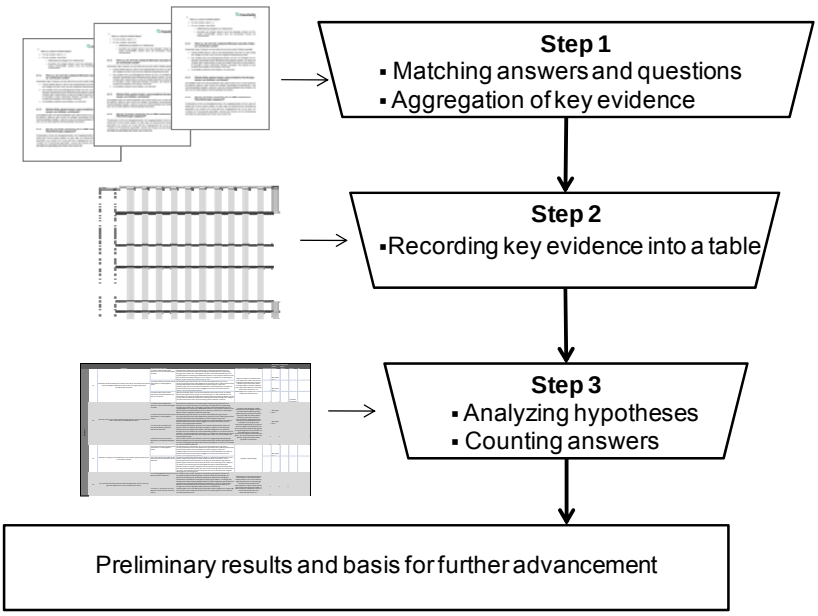

Figure 3: Procedural steps of qualitative content analysis.

add-on services

- Use-oriented services: selling use or availability of a product
- Result-oriented services: selling result or capability instead of a product [23]

Economic Sustainability

One underlying assumption of New Institution Economies is that behavior is motivated by maximizing individual wealth, referred to as opportunistic behavior. Especially in situations where one party has an information advantage over another [15], this behavior has to be anticipated. Information asymmetry is a crucial point in new business models as information asymmetries can result when one actor is not able to evaluate the conclusion of a contract before (adverse selection) or after (moral hazard). Also due to the fact that no contract can cover all possibilities that might come up during the transaction, both actors are subject to opportunism, especially if one actor made specific investments (hold-up) [24]. For example, due to its expert information on machine behavior, durability of spare parts, or time span of maintenance, the provider has an advantage over the customer, especially if the machine or product incorporates innovative technology. The problem of information asymmetries could apply also vice versa, as characteristic for services is the co-operation or co-creation of value [25] of the customer.

Information asymmetry exists when information on accidents or monitoring data of the product is withheld by the customer. If mechanisms of opportunistic behavior come into force, leading to a one-sided absorption of the value added, a persistent return on investment for one party might be not guaranteed. These considerations lead to the following hypotheses:

H 1: An unbalanced power structure in a PSS entails a one-sided absorption of the value added.

To test this hypothesis in the expert interviews, several questions in the interview guideline were dedicated to it. First, the interviewee was asked if PSS in the examined sector created an added value compared to the traditional business model at all. If the expert gave an affirmative answer to this question, the distribution of the value added was asked for.

Ecological Sustainability

According to Property Rights Theory [26], an efficient assignment of resources could be realized transferring the rights to these resources to the party that maximizes their value. Due to specialized knowledge of the provider for instance, in maintaining a good, its performance contributes at a higher degree to the value of the machine than the maintenance performed by the customer´s own department. Also holding the property rights of operating a resource e.g. a machine, could set incentives for the provider to pay more attention to the energy and material efficiency of the physical good. As with PSS, the product is no longer sold alone, the profit originates not from the sale price but from the input of resources to deliver the promised functionality to the customer. To assess if environmental benefits are achieved and how that is linked to provider´s expertise the following hypothesis was formulated:

H 2: The provider's know-how entails a more efficient use of material and energy during the use phase, resulting in less emissions and waste.

Also this hypothesis was split up for a better assessment. The question was posed if savings in energy and material consumption can be realized through PSS compared to the traditional business model.

Social Sustainability

As mentioned before, the impact on social aspects of PSS have so far been underrepresented in the academic literature. To detect correlations of PSS and the social life, the literature on services science in general was consulted. In doing so, different scenarios could be identified. Customer integration in the value creation process of service activities especially for use- and result-oriented services could not only lead to a rise of customer interfaces, but the interaction is often more labor-intensive. Additionally concepts for reducing environmental impact, for example extension of durability or offering new services targeting the end of the product´s life time, like recycling, could imply a rise in employment. Another line of argumentation could be that, through processing experiences gained in the industrial service business, learning curve effects can be realized and through advances in information technologies the need for human personnel could be reduced [11]. Often at first glance the transfer of activities from customer to provider could entail a shift of jobs, curtailed at the customer side and created at the provider side. The total effect on the number of jobs would be neutral. Dissecting social implications in terms of job creation led to the following hypothesis:

H3: PSS have a positive impact on the number of jobs on the provider side and equally a negative impact on the customer side.

The three hypotheses presented above were tested in the conducted expert interviews. Preliminary results from the qualitative content analysis are outlined in section 4.

4 QUALITATIVE ANALYSIS OF EXPERT INTERVIEWS

In the following section, the results of the qualitative analysis of the expert interviews will be presented. They are divided into the manufacturing sector and wastewater treatment.

4.1 Manufacturing Industry

Background

Ever since Wise and Baumgartner advised manufacturing firms to "go downstream" [27], the servitization of manufacturing has been discussed with increasing intensity [28-30]. The growing competitiveness on the market, especially based on the global rise of low-cost manufacturers [1], makes it impossible for manufacturers to merely rely on the innovativeness of their products. They have to move up the value chain, include services into their offers and cleverly combine their products with service components into product-service systems.

Whilst basic services like maintenance, training and spare-part management, referred to in the literature as product-oriented services [10], are widespread in the manufacturing sector, use-oriented, like leasing and renting services, and result-oriented services, like pay-on-production services, have only been offered reluctantly up to now. For example, in 2003, only 4% of the German machine tool builders have offered pay on production concepts to their customers [31], although these business models which focus on the sale of use or of results rather than the equipment itself have been promoted in the literature as leading to higher margins [27] and additionally foster ecological benefits [32].

Yet, what still needs to be investigated and proved are the often mentioned positive effects that offering product-service systems are supposed to imply for manufacturing companies. Therefore, experts from manufacturing industry in general but also from its subsectors were interviewed with the aim of verifying or rejecting the three hypotheses developed above.

Results

Hypothesis No. 1 was partially supported by the interviewees. Eight of the ten interviewees gave an affirmative answer to the question whether PSS contribute to added value creation, while two experts did not comment on this at all. When asked what causes the additional value derived from a PSS, the experts specified the following:

- a higher level of equipment availability,
- a higher degree of capacity utilization of the equipment employed,
- access to customer process know-how,
- extended equipment life-time,
- qualified partner for machinery design and maintenance services
- reduction of Total Cost of Ownership (TCO),
- energy efficiency and material savings,
- reuse of parts or components,
- increase in planning reliability and
- increase in flexibility.

Though various value added potentials were named by the interviewees, it was also marked that value generation through PSS is not automatic.

When confirming the creation of additional value, the experts were asked to give their position on how the value added was distributed between the provider and the customer of PSS. Four of the respondents consider the added value as shared between both, customer and provider of PSS. Three experts think that only the customers benefit from PSS whereas one interviewee states that all the value added remains with the supplier. Furthermore, it was also pointed out that especially the flexibility gained by the customer through PSS is borne by a shift of risks towards the provider.

In the course of the interview, three experts stated that the power structure in PSS was unbalanced and in favor of the customers. The customers used their power to force providers of machinery into offering PSS and hence fostered their diffusion. Furthermore, they considerably influence the contract negotiations for their own benefits and to the disadvantage of the providers so that contracts were “oppressive”. One expert stated that the providers of PSS also have power in the business relationship, however, according to this respondent, this only applies to major machine and plant suppliers, as these “have the power to implement their ideas in their relationship with OEMs”.

Summing up the experts’ answers, it can be concluded that PSS in the manufacturing sector contribute to creating added value in various ways. However, in this business transaction, power and risk are not balanced. More interviewees see advantages on the customers’ side and disadvantages on the suppliers’ side than vice versa. Yet, most experts consider the added value as divided between customer and supplier, but the majority of those respondents who point out that the value added is not shared but retained by one party see the customers as the profiteers.

Hypothesis No. 2 was only partially supported by the experts. They confirmed that PSS implies energy and material savings, yet they attributed this fact less to the suppliers’ superior know-how than to the stakeholders’ interests.

The question if product-service systems have an influence on the consumption of energy and material compared to the traditional business model was answered in the affirmative by eight experts. One interviewee did not see any influence on the consumption of either energy or material, whereas one further expert did not comment on this question. Three experts limited their affirmative answers, as in their opinion and experience material and energy savings were only possible for some cases, depending on the explicit conditions of the PSS contract. One of the experts claimed that up to 30% of energy could be saved by PSS in field of compressed air. Furthermore, one respondent specified that material savings were implied by PSS, but if reused components were assembled into the machinery used, the consumption of energy would increase.

The experts, who confirmed that PSS implied a decreased consumption of energy, material or both, were asked to point out the reasons for this relation. The interviewees argued that reusing machinery after their first use phase in PSS with other customers or reusing components in newly assembly equipment implies that resources are saved. Furthermore, they claimed that the life span of equipment used in PSS was longer, compared to equipment used in the traditional business model. They state that hence less equipment needs to be manufactured and material as well as energy would be saved. The accounting mode agreed upon in a PSS contract which would automatically make the customers save material and energy was mentioned as well. It was also stated that saving resources was in the essential interest of suppliers in PSS contracts and that they consequently designed the equipment used in PSS so that the components were power-saving and reusable. Technological progress was mentioned as well as it involved novel equipment which could be automatically adapted to capacities employed.

The remark was made that the possible savings to a large degree depend on the level of cooperation between customer and provider. Only if they established a close collaboration, could the entire potential be tapped. It was also stated that some obstacles persisted to tapping these potentials but that PSS contracts were contributing to overcome these constraints.

The third hypothesis was supported by the interviewed experts. They either stated that offering PSS would increase the number of job positions on the supply side while it stayed the same on the customer side, or they assumed that the overall number of job positions would stay the same, but that they were redistributed between PSS providers and PSS customers. It was pointed out that over time the job content of people involved in PSS would change with the consequence that different competences and an increase in flexibility would be required and hence further training of the employees would become necessary.

4.2 Wastewater treatment

Background

Up to now, in Germany about 3.75 million private households are not connected to a central wastewater treatment plant [33]. Most of these households are located in rural areas, where decentralized small-scale wastewater treatment can be considered as a competitive alternative to centralized water treatment. As new regulations, such as the EU Water Framework Directive, prescribe the adoption of the best available technology in wastewater

treatment, new technologies and business models for decentralized wastewater treatment are increasingly catching the attention of researchers [21], public water associations and private water utilities. Within the decentralized setting, the homeowners themselves are in charge of the operation of the wastewater treatment plant. However, many homeowners face severe difficulties in dealing with the technical, financial, legal and administrative issues associated with the operation of a wastewater treatment plant. As planning and operating errors can lead to the pollution of water bodies, decentralized wastewater treatment facilities were suspected of not meeting the high quality standards of centralized wastewater treatment plants. Against this backdrop, Product-Service-Systems initiated by public water associations or private water utilities can be considered as a viable alternative which allows for a centralized operation of decentralized wastewater treatment plants.

The Lippe River Association, a large German water association, recently established a small pilot project in a rural residential area near the city of Selm (North Rhine-Westphalia), where it offers a comprehensive service package comprising the planning, procurement, construction, operation and maintenance of private wastewater treatment plants. The homeowners pay a fixed monthly fee for wastewater services, which also covers the investment cost. Besides the Lippe River Association, other public and private water utilities plan to introduce similar business models, so the study could draw on representatives from public and private water utilities as well as public research institutes to answer the questionnaire.

Results

Hypothesis No. 1 relates to the value added created by the PSS. The respondents found the question difficult to answer because the new business model is still in an experimental stage. However, some respondents hinted at possible sources of value added created by the PSS. As the service provider is a public utility, the value added does not necessarily lead to higher profits, but may result in a greater efficacy of the organization. First of all, the public utility gains more administrative control over decentralized wastewater treatment plants, because the plants can be equipped with remote monitoring. Thus, the water association can immediately discover a malfunctioning plant and send out service personnel to fix the problem. If the homeowner is solely responsible for the operation of the plant, technical disruptions of the plant might happen unnoticed, leading to a pollution of recipient water bodies. This might be the case if too much cleaning agent ends up in the wastewater treatment plant and leads to a destruction of the biochemical reactor. Additionally, remote monitoring would allow for a rationalization of the administrative processes associated with decentralized wastewater plants. On the clients' side, there might be a substantial increase in the value added because the homeowner can utilize the competencies of the water utility. During the planning stage, the provider will make sure that the wastewater treatment plant matches the needs of the individual household. Due to economies of scale the provider is also able to negotiate favorable prices and financing conditions for wastewater treatment plants. Furthermore, the homeowner is relieved from most of the technical and administrative tasks associated with the operation of the plant. Obviously, this increase in utility on the suppliers and customers side has to outweigh the additional costs associated with the PSS in order to create added value.

The first part of hypothesis No. 2 relates to the reduction of energy and materials consumption. The respondents largely confirmed this hypothesis, although the effects were assumed to be of a marginal nature. Minor energy and materials savings might result from the fact that the provider will operate the wastewater treatment plant in a more professional manner, thus avoiding frequently made mistakes which result in a high consumption of energy and raw materials. The second part of hypothesis No. 2 concerns the reduction of emissions and waste. This hypothesis was confirmed by all respondents because the provider has the technological capabilities to ensure the compliance with high environmental standards.

Although during the set-up period new jobs will be created at the provider, eventually these positive effects will be counteracted by job losses once the new business model has reached maturity. Thus, the first part of hypothesis No. 3 was rejected. The second part of hypothesis No. 3 is not applicable in this context because the clients are households not companies. Initially, administrative and technical tasks which were performed by the households are performed by the provider. This substitution of homework by professional work creates new jobs and, in the short term leads to a positive impact on the number of jobs on the provider side. Subsequently, the provider will invest in remote monitoring and remote control devices in order to economize on personnel costs. Thus, the long-term impact of the PSS on jobs is expected to be neutral, not positive. However, one interviewee suggested that a successful PSS might generate additional jobs in Germany if the business model can be exported to other countries.

Concerning the impact of regulation on PSS in the wastewater sector the results were ambiguous. A strong positive regulatory impact results from the conversion of the European Water Framework into national law, which will trigger huge investments in new decentralized wastewater treatment plants and provides impetus for the concept of PSS. Additionally, there are new public funding schemes at a federal level to facilitate private investment in new wastewater technologies. A barrier stemming from regulation was mentioned by a representative from a river association: The German law of corporate union currently impinges on economic activities of river associations such as PSS.

5 CONCLUSIONS AND NEED FOR FURTHER RESEARCH

This paper contributes to PSS research by exploring the sustainability effects of PSS in two traditional industrial sectors: manufacturing industry and the wastewater treatment sector.

Three main hypotheses with regard to the sustainability effects of PSS were described and tested in 15 interviews with experts from each sector. By comparing the outcomes of the expert interviews in the two sectors, it seems that the sustainability effects of PSS in these sectors differ slightly. One reason can definitely be seen in the fact that wastewater treatment deals with business-to-customer transactions whereas the PSS in the manufacturing industry are based on business-to-business transactions.

The first hypothesis, which describes the effects of an unbalanced power structure in a PSS on the absorption of the value added by one actor, was accepted by the experts in both sectors. However, whereas most of the experts in the manufacturing sector stated that in their sector the customer usually has more power than the provider, the expert in the wastewater treatment sector claimed a reverse situation for their sector. For future research it would be interesting to examine how the less powerful actor, either the customer or the provider in the

PSS, could improve his position of power to increase the fairness of the relationships in the considered business concept.

The second hypothesis relates to the positive ecological effects of PSS based on the provider´s superior knowledge of the efficient use of materials and energy during the usage phase of the equipment. This hypothesis is only partially supported by the experts in both sectors. The knowledge of how to decrease material and energy consumption is indeed mentioned as an important factor, but if there is no corresponding incentive specified in the PSS contract, or related legal environmental requirements like in the wastewater treatment sector, resource efficiency potentials will not be fully realized.

The third hypothesis was accepted by the experts in both sectors. They concluded that PSS would lead merely to a redistribution of jobs between PSS provider and PSS customers. Even if they expect no increase in the number of jobs through PSS, they suggested that there will be a change in the job content of people involved. As a next step, it would be fruitful to examine if these changes would be advantageous or detrimental for the job quality of these workers.

Since the research field of the sustainability effects of PSS has not been explored exhaustively, there is still need for further analysis. Further research activities should encompass in-depth case studies with companies as well as a quantitative survey with regard to the diffusion of PSS and its effect on cost and resource efficiency.

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