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A METHOD FOR ASSESSING THE INNOVATIVENESS OF PRODUCT-SERVICE SYSTEMS

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1. Introduction

1.1 Initial situation

In order to survive, companies have to find a better strategy to compete with other companies on a global market and to satisfy different customer requirements. An effective approach to ensure competitiveness is by developing innovative products. Innovativeness is commonly accepted as a strong competitive advantage, which even enables companies to gain new market shares One strategy towards more innovative market offers is to combine products with services. These so-called Product-Service Systems (PSS) integrate product and service components in one market offer [Schenkl et al. 2013]. Tukker [2004] distinguishes three types of PSS: product-, use- and result-oriented. A product-oriented PSS has a product in the core of a market offer, enhanced by related services such as consulting. Use-oriented PSS embrace alternative business models compared to selling a technical product such as leasing and sharing. Result-oriented PSS sell a benefit, such as performance-based contracting or transportation instead of a car. An abstract model of a PSS is depicted in Figure 1. A PSS consists of one or more product elements (P) and one or more service elements (S1, S2). The product elements may consist of several modules (M).

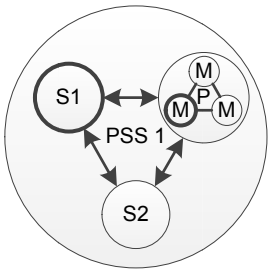

Figure 1. Product-Service System (P: Product element; S: Service element; M: module)

Various motivations are stated in literature for delivering PSS. The often stated motivation is an enhanced sustainability [Mont 2002a], [Tukker and Tischner 2006], [Sakao et al. 2009]. Other factors for the provider are differentiation from competition that is hard to imitate [Vasantha et al. 2012], long-term and direct customer relationships [Tukker 2004], [Meier et al. 2010], more stable and higher revenues [Cavalieri and Pezzotta 2012] as well as new market opportunities [Baines et al. 2007], especially in saturated markets. Customers benefit amongst others from a higher customer value

[Yoon et al. 2012], individualized offerings [Aurich et al. 2010] and sharing risks with the provider [Meier et al. 2010]. Besides that PSS are drivers for innovation [Tukker 2004], [Beuren et al. 2013].

1.2 Innovativeness of PSS

The term innovation has been adapted in many disciplines and defined from different perspectives [Damanpour and Schneider 2006]. Thompson [1965] defines innovation as the "generation, acceptance and implementation of new ideas, processes, products or services". According to Adams et al. [2006], innovation is "the successful exploitation of new ideas". Hansen and Wakonen [1997] mention that novelty and benefits of an invention do not have to be superior, but the market success needs to be achieved. The Commission of the European Community [1994] emphasize that an invention has to meet a real demand in order to become an innovation. To sum up the above definitions, innovation is proposed to refer to products, processes and services and to be characterized through its degree of *novelty, usefulness* and *market success.* Novelty comprises new ideas as well as new applications. Usefulness refers on solving a customer demand and delivering benefits to its stakeholders. Finally, market success is seen when the market accepts the innovation and thus the market diffusion is significant.
A PSS can thus be argued to be innovative when it fulfils all of the following three aspects:

- contains new technology or services or a new combination of existing products and services,
- satisfies customer requirements and
- has a high market success

PSS as a shift from designing and selling technical products to providing an integration of products and services [Manzini and Vezzoli 2003] and has the potential to be considered novel. PSS by definition "deliver value in use" [Baines et al. 2007] and are "designed to (…) satisfy customer needs" [Mont 2002a]. A customer demand is "met by selling satisfaction instead of providing a technical product" [Manzini and Vezzoli 2003]. If a PSS achieves the requirements stated by these scientific definitions, it has the potential to become useful. Market success is harder to evaluate on a general level. Whereas Manzini and Vezzoli [2003] state that "if the satisfaction is evident, the customer would see a PSS as a preferable choice", several authors admit that PSS many times lack a customer acceptance in practice (cp. [Mont 2002b], [Omann 2003]). To sum it up, on a general level, PSS have a high potential to be considered as "innovative".
An ambition to remove the "fuzziness" of the front end of innovation is found to be a feature of successful companies and the ability to systematically compare different ideas and concepts from an innovativeness perspective in the early phases of development is an important approach in such endeavour [Koen et al. 2001]. However it is hard to assess the innovativeness of ideas especially in the early phases of development both because innovativeness as a concept involves intangible elements that are not easy to quantify and since it is hard to predict what ideas and concepts will prove successful on the market. For designers, being familiar with tangible goods but less with intangible services, adds to the difficulties.
An exhaustive overview of the research fields in the context of PSS is given by Velamuri et al. [2011]. However the evaluation of innovativeness is not addressed so far. There is thus a lack of a systematic method for assessing the innovativeness of PSS concepts. Overall this topic is from interest for both science as well as industrial practice.

1.3 Contribution of the paper

This paper proposes a method for assessing innovativeness of PSS concepts in the early stages of development by suggesting the operationalization of innovativeness in terms of novelty, usefulness and market success. Further the applicability of the method is demonstrated by applying it in two case studies within a student project.

2. Research Methodology

The underlying research questions for this paper are:

- How can the innovativeness of an overall PSS concept, which includes the type of the PSS, the type of product and services and the main customer offer, be assessed in regard to other PSS concepts which fulfil the same purpose?
- How can the innovativeness of a detail of a PSS concept, which can be an element of the product or the service offer, be assessed in regard to the same detail of PSS of the same type, which are based on the same product?

Starting from the research questions, literature studies on PSS and assessment of innovativeness were conducted. For PSS, definitions of the term PSS, properties and specific types of PSS were analysed. Innovation literature was analysed in regard to the definition of innovative PSS as well as attributes and tools to measure the novelty, usefulness and market success. Afterwards the results of the PSS and literature survey on innovativeness were combined into a method to assess the innovativeness of PSS. In parallel to its development, the method was tested in two case studies. The PSS innovativeness assessment method was developed in several iterations by combining and adjusting the data from the literature survey and using the data from the case studies.

3. Method for assessment of innovativeness of PSS

The measurement of innovativeness of PSS is based on three components: novelty, usefulness and market success, as depicted in Figure 2. The lower part of the figure depicts the reference values for the evaluation. Novelty as the probable degree of novelty is assessed against existing market offers. Usefulness as the probable customer satisfaction is assessed using the Kano method (cp. [Kano et al. 1984]) the aspect of customer requirements. Market success as the probable market diffusion is assessed in regard to Roger's five factors (cp. [Rogers 2003]).

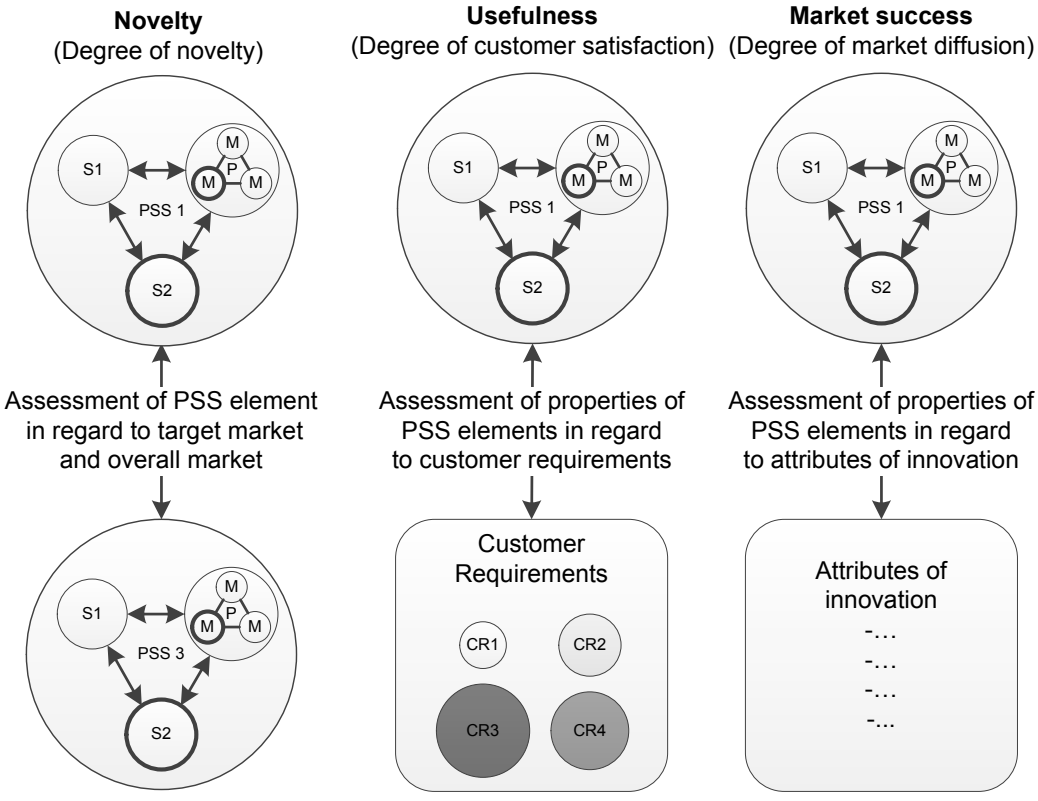

Figure 2. Overview method for evaluating innovativeness of PSS

The following section presents scales for assessing a score for novelty, usefulness and market success. The last part gives a formula for the integration of these partial values into one score for innovativeness.

3.1 Novelty

Novelty of PSS concepts is defined on the basis of product and service innovation literature. Garcia and Calantone [2002] present a literature review on innovativeness terminology, embracing both products and services. However the main focus is on products, and the service perspective is discussed only marginally. A deeper insight into novelty of services is given by Metters et al. [2006], who focus on the service delivery.

Garcia and Calantone [2002] define three types of innovation: radical innovation, really new innovation and incremental innovation that distinguish their novelty regarding technology and market. Novelty for services defined by Metters et al. [2006] distinguishes between new services for undefined markets and improvement of existing services.

Based on these definitions, a four-stepped scale between 0 and 3 is set up:

- +3: **Radical novelty**: Discontinuity in market and technology or service
- +2: **Really new novelty**: Discontinuity in market or technology or service
- +1: **Incremental novelty**: New features, benefits or improvements to existing technology or services in the existing market.
- 0: **No novelty**

This definition combines novelty aspects of products and services and thus is applicable for evaluating the novelty of PSS.

3.2 Usefulness

For evaluating the usefulness, as the degree of probable customer satisfaction, the achievement of given requirements on the PSS is evaluated. For doing this the widely used Kano-model is used. The Kano model sketches the correlation between the degree of achievement of requirements and the customer satisfaction in three classes: must-be, one-dimensional, and attractive attributes [Witell and Löfgren 2007]. Usefulness is assessed by evaluation of requirements depending on their type within the Kano model. Requirements on service quality can be extracted from the SERVQUAL model (cp. [Parasuraman et al. 1985], [Mont and Plepys 2003]).

The general scale is:

- +3: **Overachieved and best in class**: high probability of being very satisfying to the customer
- +2: **Overachieved**: high probability of being satisfying to the customer
- +1: **Achieved**: high probability of being neutral to the customer
- 0: **Underachieved**: high probability of being dissatisfying to very dissatisfying to the customer

Must-be criteria that lead to dissatisfaction in case of underachieving, but do not lead to satisfaction in case of overachieving are given scores within the value range (0;1). One-dimensional requirements can be scored with the complete value range (0;3). Attractive attributes that lead to a high satisfaction when achieved, but do not lead to dissatisfaction in case of underachievement are scored with (1;3). The value function is depicted in Figure 3.

The overall score for Usefulness is calculated as follows. For each class of requirements the medium value is calculated, by averaging n requirements within a class:

$$\overline{Must\ Be} = \frac{1}{n}\sum_n (Must\ Be)_n \tag{1}$$

$$\overline{One\ Dimensional} = \frac{1}{n}\sum_n (One\ Dimensional)_n \tag{2}$$

$$\overline{Attractive} = \frac{1}{n}\sum_n (Attractive)_n \tag{3}$$

The overall score for Usefulness is the product of Must be, One Dimensional and Attractive, normalized to a value range of (0; 3) in order to get the same weighting as Novelty and Market success. The maximum score for Must Be is 1, for One Dimensional and Attractive, 3. Thus the overall score for usefulness is divided with 3:

$$Usefulness = \overline{Must\ Be} * \overline{One\ Dimensional} * \overline{Attractive}/_3 \quad (4)$$

The three components are integrated by multiplying them. Thus dissatisfaction within one class of attributes leads to an overall score of 0 for usefulness.

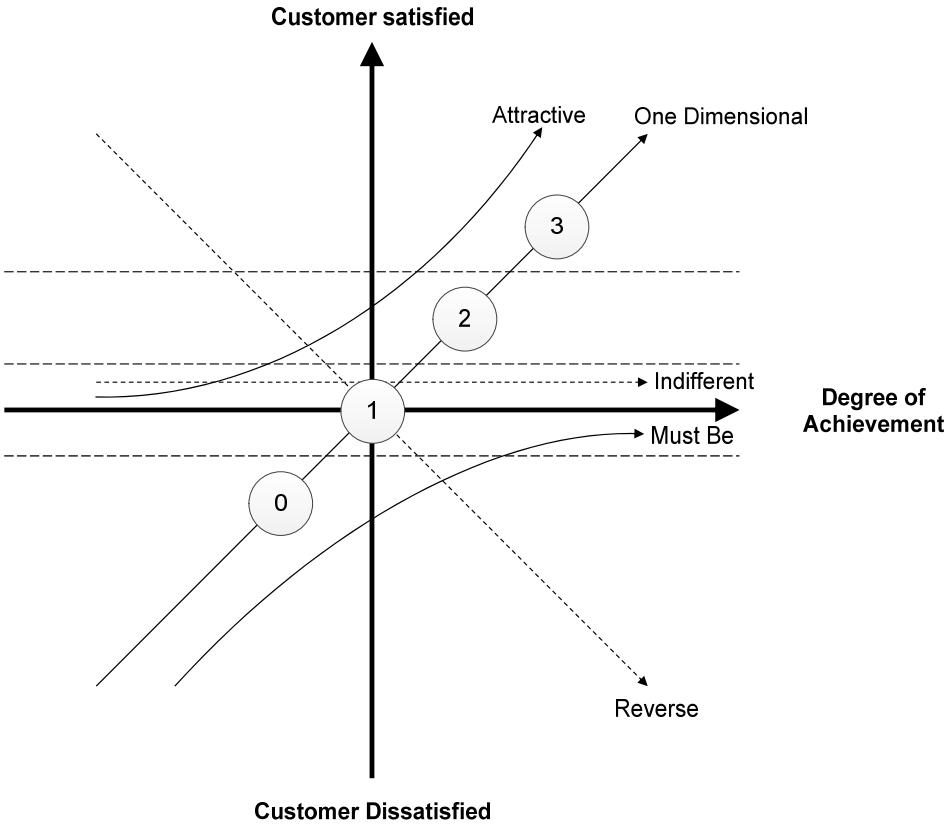

Figure 3. Value function for Usefulness (adapted from [Witell and Löfgren 2007])

3.3 Market success

Assessing the probable market success of a PSS concept is the most difficult step of the method. Based on uncertain and ambiguous information in early phases of PSS development, only a rough estimation can be done. The evaluation of success is based on factors influencing the market diffusion of innovations according to Rogers [2003]. These factors are one of the most popular models about the adoption on customer goods [Schenkl et al. 2013]. These factors are applicable for consumer goods. Schrader [1999] showed their applicability on PSS.

Based on definitions of the factors, relative advantage and compatibility, these factors can be split into sub-attributes. The set of attributes for the evaluation of market success are:

- Relative advantage
  low initial cost, decrease in discomfort, social prestige, saving of time and effort, immediacy of reward (experience of expected benefits)
- Compatibility
  sociocultural values and beliefs, previously introduced ideas (past experiences), client need for innovation
- Complexity
  understand and use the innovation
- Trialability
  possibility to experience the innovation
- Observability
  visibility of the results of an innovation to others

For each of the attributes and sub-attributes, scoring is given exemplarily for low initial cost:

- +3: lowest initial cost
- +2 initial costs are below average
- +1: initial costs are average
- 0: initial costs are above average

The other scales for the „market success"-attributes and sub-attributes are constructed similar to this scheme. The clients' need for innovation is not evaluated because it is the same as usefulness as assessed earlier. Complexity and observability use different scales that are given below.

Complexity:

- +3: Additional help is not necessary – Self explanatory
- +2: Additional help is necessary to get started, afterwards it is self-explaining – Manual (e. g. use of repeating patterns like in Android)
- +1: Additional help is necessary at the first time of use – Manual, tutorial (e. g. new software with unknown surface)
- 0: Additional help is necessary over a longer time period – Workshop, training

Observability

- +3: The result of the innovation is easy to observe (visible at the moment of observation) and easy to communicate (use of common language)
- +2: The result of the innovation is possible to observe (visible after a certain time period of observation) and easy to communicate (use of common language)
- +1: The result of the innovation is hard to observe (maybe visible after an unknown time period) and easy to communicate (use of common language)
- 0: The result of the innovation is hard/not possible to observe and hard/not possible to communicate (use of technical terms)

The score for the market success is the arithmetic average of the calculated scores for attributes and sub-attributes:

$$Market\ success = \frac{1}{n}\sum_{1}^{n}[(Subattributes\ market\ success)_n] \tag{5}$$

3.4 Integration into one key figure

Based on the survey of literature we find that the three factors of novelty, usefulness and market success are necessary for innovation. Therefore, to combine the scores of novelty, usefulness and market success into one performance indicator for innovativeness, we propose the following formula:

$$Innovativeness = Novelty * Usefulness * Market\ success \tag{6}$$

The three components are integrated using multiplication, because each single component is required for being "innovative" and must be directly proportional to innovativeness, as discussed in Section 1.2. Even if one of the scores is 0, the overall score for innovativeness becomes 0. Note that the above formulation of a measure of innovativeness assumes the following for the purpose of initiating this research: (a) other factors contributing to innovativeness are constant, (b) the factors of novelty, usefulness and market success have equal weightings, and (c) the three factors are mutually independent.

4. Assessment of innovativeness of PSS within the development process

Before presenting the method for assessing the innovativeness of PSS, we discuss two applications of the approach within the development process of PSS. These two cases are depicted in Figure 4. The upper case is the assessment of innovativeness in the early phases of the development process. Thereby the overall PSS concept draft is assessed in comparison with other PSS. For example a concept of a bike-sharing system may be compared to different market offers that deliver a similar benefit to the customers, namely urban mobility, such as car-sharing or public transportation. In the second case, the overall PSS concept is defined and single elements (service, product or module) are compared to similar existing elements. For example a concept of an on-board computer with electric

lock for bikes within a bike-sharing system is compared to other concept alternatives as well as existing alternatives on the market delivering a similar benefit (access to bikes) such as combination locks whose code is given to customers via SMS messages.

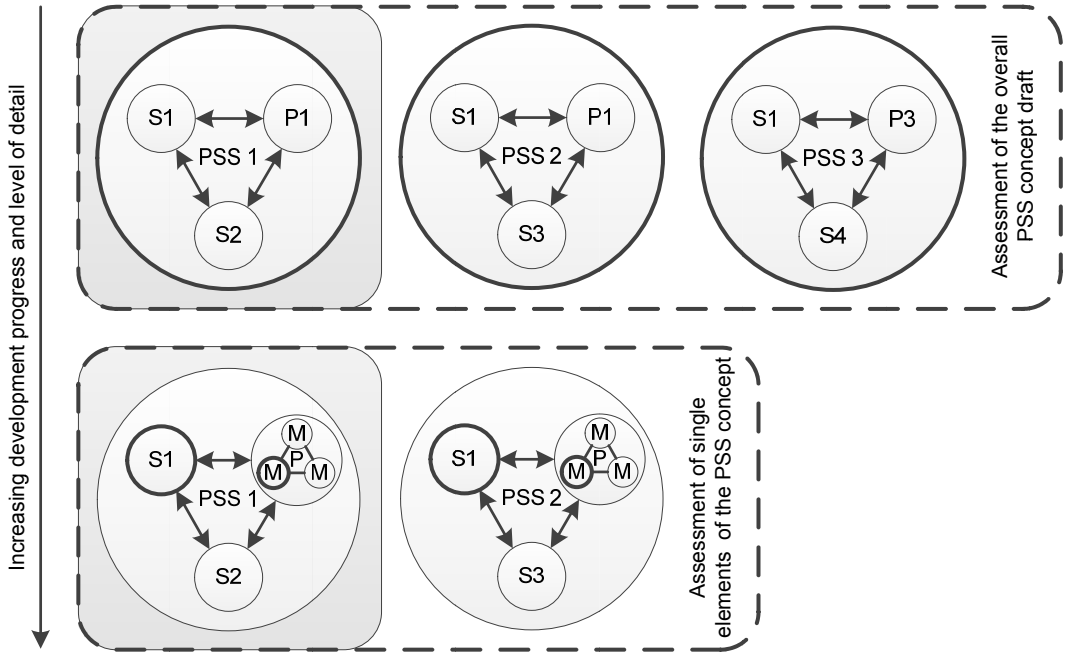

Figure 4. Innovation measurement within the development process

5. Case study

The proposed method is applied in two case studies, covering both applications of the method as described in Section 4. Within the first case study, the innovativeness of the overall PSS concept is evaluated. In the second one, the innovativeness of one component of the PSS is evaluated exemplarily. The method for measuring the innovativeness of PSS is applied on a case study within a student project. The goal of this student project, called PSSycle, is to develop a concept for a bike-sharing system based on electrical bikes. Therefore an electrical bike is enhanced for the usage in such a system as well as a supporting infrastructure is developed. The bike with its components for bike-sharing is depicted in Figure 5. The enhanced bike consists of an on-board computer, an electronic circuit for connecting the on-board computer to the bike, a charging interface and an automatic locking system. The locking system is chosen for evaluating the proposed method.

Figure 5. Overview PSSycle

5.1 Overall concept: Bike-sharing system

For evaluating the method on an overall PSS concept, the whole concept of the PSSycle is evaluated in relation to similar market offers that fulfil a similar customer need by delivering a similar result (transportation within a city for tourists). Compared offers are public transportation, car sharing, rental cars, rental bikes and taxis. The requirements are: visit tourist sights, preference for beautiful tracks, distances: 10-15 km, need for mobility for a whole day. The requirements are extracted from a customer survey that was conducted during the project. The concept of the PSSycle is a real novelty, as electrical bikes are used for bike-sharing in a floating concept. This means that there are no rental hubs, but bikes can rented and returned at every (legal parking) place within the area of operation. A score of + 2 is given for the criterion of novelty. The evaluation of usefulness by applying the Kano model is depicted in Figure 6. Preference for beautiful tracks is an attractive attribute, and this can be highly achieved by the flexible bike-sharing system. Visit tourist sights, as a one dimensional attribute can be highly achieved (due to the route flexibility) and therefore, a score of +3 is given. Longer distances can be traveled (but limited by the battery of the bicycle) and therefore, a score of +2 is given. Tours of a whole day can be made, which is a must-be criterion. Therefore, a score of +1 is given for that requirement. By applying the formulae (1) to (4), the overall score for usefulness is found to be 2.5. By applying the criteria described in Section 3.3, market success is found to be 1.8. The overall performance indicator for innovativeness of the overall PSS concept is calculated using (6) and is found to be 9. This value can be compared with alternative concepts allowing a condensed statement regarding innovativeness of the concepts. The value needs evaluations of other concepts for being interpreted. For a detailed evaluation, the criteria can be analysed discretely.

5.2 Component: Locking system

As an example for innovativeness assessment on component level, the locking system is chosen.
Firstly a new set of requirements on the component is set up, based on the customer survey:

- Fast rental and return
- Floating concept
- Close network of bicycles
- App with map to find the bicycle

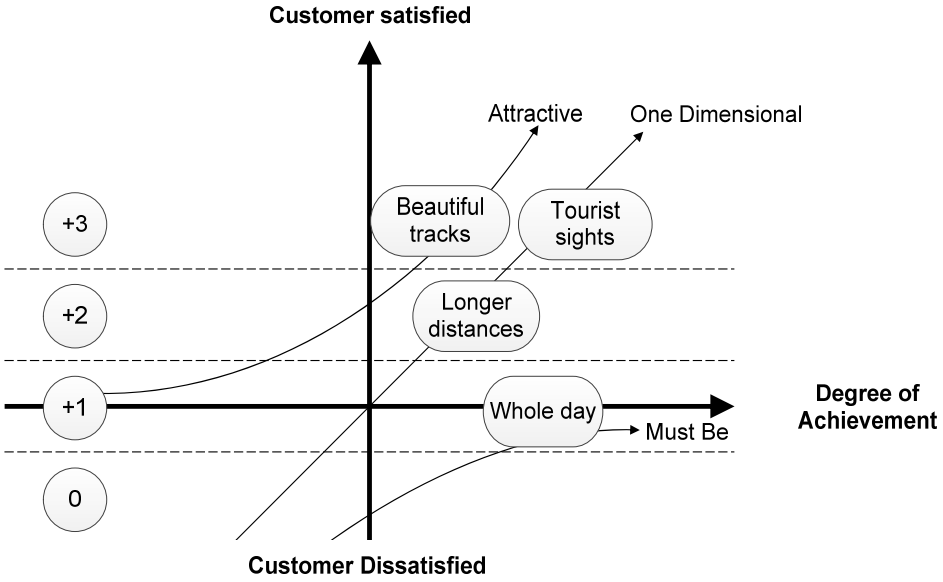

Figure 6. Evaluation of Usefulness for PSSycle

The component is compared to solutions of competing PSS, delivering a similar functionality (rent and return bike). Competing solutions in the city of Munich are *Call a bike* (www.callabike.de) and **nextbike** (www.nextbike.de). The PSSycle consists of an Android-based board computer (board computer in Figure 5), allowing for renting and returning the bike. The mechanical access is given by

an electronically actuated caliper brake (Locking system shown in Figure 5). This system allows for a floating concept. Nextbike only allows for renting and returning bikes at rental hubs. “Call a bike” allows for the floating concept, but using a manual lock. The method for assessing the innovativeness is applied exemplarily on these alternatives. This short example illustrates the possible application of the method.

6. Conclusions

The main goal of the proposed method is to assess innovativeness of PSS concepts in the early phase of the PSS development process. Innovativeness, as a combination of novelty, usefulness and market success is a crucial factor in PSS development since delivering innovation is a crucial factor for success in industries.
The innovativeness assessment method is applicable for an entire PSS concept during the early phases of the development process as well as for evaluation of components in later phases.
In the first case, the innovativeness of the whole concept is assessed in relation with comparable market offers, both conceptual alternatives as well as competing alternatives on the market. Comparable market offers fulfil the same purpose. For example, a bike sharing system competes with public transportation, taxis or rental cars. The method allows for evidences of how the innovativeness of the evaluated concept is compared to the alternatives. Applying the method gives not only a condensed performance figure, but also a detailed assessment of novelty, usefulness and probable market success. In the second case, the innovativeness of a component of the PSS concept is assessed using components of competing market offers, delivering a similar functionality.
The application of the methods within two academic case studies is shown and it is found that the proposed method is both suitable for assessing innovativeness of an overall PSS concept as well as specific components of PSS. However a couple of limitations are revealed. The results of the method are highly dependent on the knowledge about the customer and the market. Especially the anticipation of the probable market success needs a deep knowledge about the customer; due to uncertainty and ambiguity of this knowledge, a lot of approximation is involved. Overall applicability in an industrial context has still to be shown. Since the method is based on existing tools and characteristics such as the Kano model and Roger's five factors, it is well-grounded. Based on these we have set up scores and an integrated score to assess the innovativeness of PSS. The proposed factors may not be sufficient. Further, depending on the type of PSS, the weightings of each of these factors may not be equal and mutually independent. These issues are planned to be investigated in the future.

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