Design Science in Service Research: A Framework-Based Review of IT Artifacts in Germany

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Abstract. The purpose of this study is to analyze the nature of IT artifacts that have been proposed in the emerging discipline of Service Science, Management and Engineering (SSME) as well as to provide further directions for design research in the service discipline. We review a sample of 123 service-related IT artifacts – that we identified on a German online research portal – by coding them with a framework for design research in the service science discipline. The key insights derived from the analysis are: (1) methods dominate other artifact types; (2) instantiations are almost exclusively developed for supporting the potential dimension of services; (3) research on customer solutions focuses on an inside-out perspective; (4) new constructs are predominantly developed for modeling the outcome dimension of services; (5) artifacts often possess a narrow scope; and (6) artifacts are seldom instantiated into software tools. These novel insights are expected to guide future design research in the service discipline by identifying areas which have only been sparsely addressed by design research or are yet to evolve to a sufficient state of maturity. Our approach is original as it features an early and innovative endeavor for identifying the nature of IT artifacts in SSME.

Keywords: Design Science, Service Science, IT Artifacts, Germany, Hybrid Value Creation, Customer Solutions, Product-Service Systems.

1 Introduction

Over the last decades, we have been witnessing a transition from a primarily goods-based to a more and more service-based economy in most developed countries [1]. Today, services are ubiquitous and they account, for example, for more than 80% of the gross domestic product (GDP) and total employment of the United States and about 70% of the GDP in Germany [2-4]. Interestingly, "[t]he service sector accounts for most of the world's economic activity, but it's the least-studied part of the economy" [5, p. 71]. Even up to today, researchers and practitioners within and across

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fields have not yet agreed upon a common definition of the term "service" [6]. Researchers from different disciplines have so far investigated the phenomenon from rather distinct angles, e.g., from an economic, business, or technical perspective [7].

Information Systems (IS) is an integrative research discipline "that is at the intersection of knowledge of the properties of physical objects (machines) and knowledge of human behavior" [8, p. 613]. Therefore, IS not only emphasizes to build theories that represent knowledge on how the world is like, but also focuses on engineering IT artifacts. Orlikowski and Iacono [9] call the IT artifact the "core subject matter" of IS research, while Gregor [8] states that what "distinguishes IS from other fields is that it concerns the use of artifacts in human-machine systems." With appropriately designed IT artifacts, management and engineering problems in service systems can be supported, such as defining service portfolios, customizing individual value propositions for customers, and efficiently delivering services. Hence, the design and evaluation of IT artifacts for engineering and managing service systems is a major contribution IS research can render [10].

Against this background, the goal of this study is to review existing contributions of design science research to the service science discipline in Germany, which has not been in the main focus of similar studies [7,11]. We chose the field of hybrid customer solutions as an exemplary subset of the service discipline. Hybrid customer solutions (also referred to as hybrid products) are integrated bundles of physical goods and related value-added services that are intended to jointly solve a specific customer problem. Focusing on this research stream seems especially fruitful since numerous researchers, companies, and funding agencies have been involved in governmentally funded research projects in this area during the recent years. The purpose of this study is to provide these stakeholders with a status quo and perspectives for further design science research in the service discipline. Using an existing framework [12] as a device of mind, we analyzed a repository of 123 research results that had been published on the German online research portal "Research Map of Hybrid Value Creation" (German: Forschungslandkarte zur hybriden Wertschöpfung). This web portal collects, categorizes, and shares results of German service science research projects. The remainder of the paper is structured as follows: Next, we briefly review the framework for design science research in the service science discipline. With this framework, we then analyze artifacts that have been contributed to the research on hybrid customer solutions as a part of service science in Germany. Key insights are discussed subsequently. Finally, we give a brief conclusion and discuss limitations and prospects of the presented study.

2 Framework for Design Science Research in Service Science

In previous work [12], we developed a framework for structuring design-oriented research activities in the area of service management and engineering (Figure 1). The original framework encompasses three dimensions (artifact type; service perspective; and level of analysis, i.e., macro-, meso-, and micro-level), from which the following two form the basis for our analysis presented in this paper.

The first dimension is based on the outputs of design science research constituted by the four types of IT artifacts according to March and Smith [13]. *Constructs* form the vocabulary of a domain. They build the basis for defining problems and

specifying their solutions. Modeling languages, such as the Business Process Model and Notation (BPMN) are common collections of constructs. *Models* are sets of statements expressing relationships between constructs. Reference models, for example, describe a class of real-world phenomena on an abstract level. Their purpose is to give guidance to the design of other company-specific models. *Methods* are sequences of steps used to perform a task. Typical examples are algorithms, procedures, or guidelines. Constructs and models typically represent the inputs and outputs of methods. Service Blueprinting [14], for instance, is a well-known exemplar of a method for service design. *Instantiations* are realizations of constructs, models, or methods in information systems. Instantiations are valuable for demonstrating the utility of artifacts. In addition, they test the feasibility of both the design process and the designed artifact. The utility and feasibility of a method for simulating service processes, for instance, can be demonstrated by a software tool.

The second dimension of our framework comprises different perspectives on the phenomenon of service [15]. The *potential* perspective accentuates that firms have to build up resources in order to provide services to clients. It focuses on the infrastructure basis which is used to design, configure, offer, and deliver services. Those resources might be operant resources (i.e., resources that operate on other resources, such as human resources, knowledge, or skills) or operand resources (i.e., resources to work on, such as raw material) [16]. The *process* perspective focuses on the business processes and activities for delivering services to customers. Due to the fact that value co-creation is a key characteristic of services [17], one central challenge in business process design is to determine the degrees of cooperation and visibility for each activity of the service process. The *outcome* perspective is concerned with determining the structure and the functional and non-functional properties of a service. In contrast to the process perspective, which focuses on how a service is delivered, it focuses on what is delivered. The *market* perspective respects the customer as a co-creator of value. The market perspective therefore comprises tasks such as identifying customer problems or determining a customer's willingness to pay for particular service offerings.

The two perspectives are in line with the components of other frameworks that have been developed to systematically study services or service systems respectively [18-21]. To illustrate the application of the proposed framework, Fig. 1 shows a classification of fictional artifacts. A typical artifact of the *construct-outcome* cell would be a modeling language that allows for an unambiguous specification of the function and form of a service. Similar modeling languages, e.g., EXPRESS-G / STEP, are commonly used to describe physical goods in a standardized and machine-readable format. However, due to the distinct characteristics of services widely accepted standards for the description of services are still missing. A typical artifact categorized in the *model-potential* cell would be a reference model depicting a best-practice organizational structure for service units in a certain industry. A mathematical procedure to calculate the optimal price of a service would be a compelling representative of the *method-market* cell. Such price optimizations for services are complex tasks due to the heterogeneous and perishable nature of services. An example for the *instantiation-process* cell would be a workflow system supporting the execution of service processes.

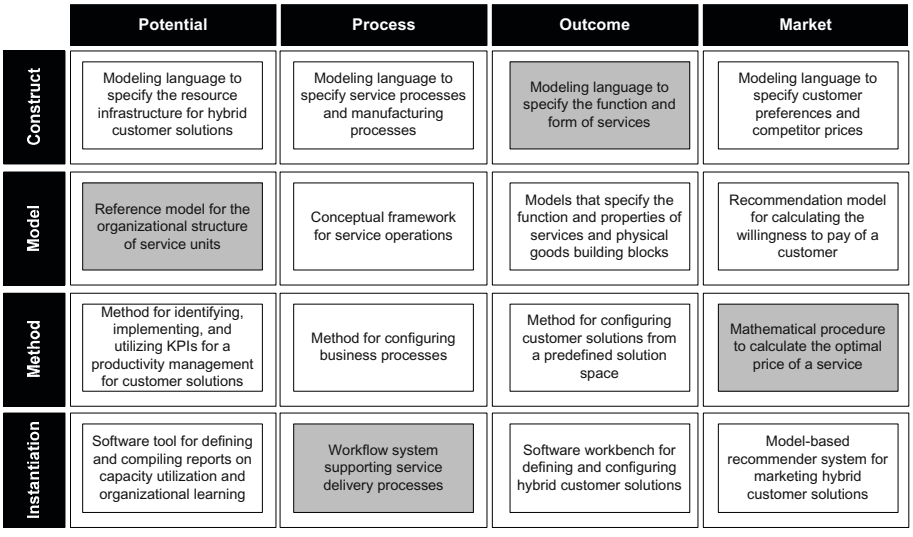

Fig. 1. Framework for design science research in service science [12] and exemplary artifacts

3 Review of IT Artifacts

3.1 Data Collection

In the following, we apply the framework for analyzing the area of hybrid customer solutions in Germany, a specific research stream within service science. The objective is to analyze the research results that design-oriented research has so far contributed to this very subarea. A substantial collection of such research results is listed in the Research Map of Hybrid Value Creation, which is accessible at http://www.forschungslandkarte-hybridewertschoepfung.de. This web portal invites researchers and practitioners to publish, categorize, and share research results on the engineering and management of hybrid customer solutions. Up to today, more than 300 users have registered at the portal, which underlines the site's status as a valuable source of information. We were able to identify a total of 123 research results listed in the portal (as of 2010-11-29). Since we intended to analyze the contributions of design science research only, we excluded theories and purely empirical work (about 1/3 of all entries) from our further analysis. 78 entries remained for analysis.

3.2 Data Analysis

We conducted a structured content analysis and drew the relevant data from the descriptions of research results as published on the abovementioned online portal. In a content analysis, case descriptions and other accessible sources of data are coded. Multiple readings of data and multiple coders are employed to enhance reliability and validity of the analysis [22]. Content analysis may be used in an inductive or deductive way [23]. We pursued a deductive approach as the framework introduced in

Section 2 provided the categorization matrix for our structured content analysis. Each of the 78 descriptions of design-oriented research results was thoroughly studied and classified according to the framework's dimensions. We solely relied on the textual descriptions of the research results as a basis for coding and neglected the categorizations which the portal users had already assigned to their contributions. This was necessary, since the categorizations provided by portal users were partly incomplete or contradictory to the textual descriptions. The categorization of research results was done in a team of four researchers. For each research portal entry, two researchers independently coded the textual description. The four service perspectives and four artifact types together represent eight characteristics that were used to describe an artifact. It was allowed that a particular artifact may represent both more than one service perspective and more than one artifact type. After the independent categorization by two researchers, 11 out of the 78 results featured completely consistent classification across these eight characteristics. Inter-coder-reliability – computed based on a pairwise comparison of the coders' decisions made for each attribute – showed that in more than half of the decisions the reviewers came to the same result (Perc. Agreement: 55.6%, Scott's Pi: 0.051, Cohen's Kappa: 0.054, Krippendorff's Alpha (nominal): 0.051, N Agreements: 347, N Disagreements: 277, N Decisions: 1248) [24]. In all other cases, the remaining two researchers mutually analyzed the deviations and agreed on appropriate classifications.

3.3 Results

The analysis shows how often research results of a certain artifact type and a certain perspective on the service phenomenon have been entered into the research portal. Some artifacts are quite specialized, i.e., they represent a specific artifact type and are supposed to support a particular service perspective only. Other entries, however, are meant to address multiple perspectives and cannot clearly be assigned to one artifact type only. This is illustrated by the sums for the two analysis dimensions that both exceed the total number of artifacts (Table 1).

Table 1. Number of artifacts by service perspectives and artifact types

	Service perspective				Artifact type			
	Potential	Process	Outcome	Market	Construct	Model	Method	Instantiation
# Artifacts	45	34	35	29	26	22	47	20

With regard to artifact type, methods dominate by far. 47 out of the 78 artifacts are categorized as methods. Constructs (26), models (22) and instantiations (20) are found less often than methods. Concerning service perspectives, the analyzed artifacts predominantly address the potential perspective (45). The market perspective is addressed by 29 research results only.

We conducted a normalization of values by weighing the values according to the total number of classifications for each research result and each dimension of analysis. Thus, we made sure that all research results contribute equally to the further analysis. The cell values for each research entry were calculated as 'artifact type

Table 2. Cross tabulation of service perspectives and artifact types

	Potential	Process	Outcome	Market
Construct	13 (2.6)	14 (3.6)	16 (5.7)	9 (3.0)
Model	13 (5.4)	14 (5.0)	7 (1.9)	8 (2.9)
Method	29 (11.4)	21 (7.1)	21 (7.5)	17 (8.)
Instantiation	14 (6.1)	8 (2.8)	7 (2.69)	6 (2.2)

value' times 'perspective value'. For instance, the framework of hybrid value creation [25], which is a model, was found to address both potential and process dimension. It therefore contributes to the first two cells in the second line with a value of 0.5 each. Table 2 shows the values before and after (in brackets) normalization.

Looking at the combination of both classification aspects, the peak is at 29 artifacts that represent methods for the potential perspective. The normalized value for this perspective-artifact combination is 11.4. Instantiations for the market perspective are scarce (6 instances, normalized value of 2.2). The normalized value for models that address the outcome perspective (1.9) is even smaller. Instantiations, i.e. software tools, are almost exclusively used to support the potential perspective. 14 out of a total of 20 instantiations have this scope. Similarly, models are hardly found apart from the potential and process perspectives. Constructs are especially used to describe the outcome perspective of customer solutions (16 out of 26, normalized: 5.7). Fig. 2 charts the normalized results.

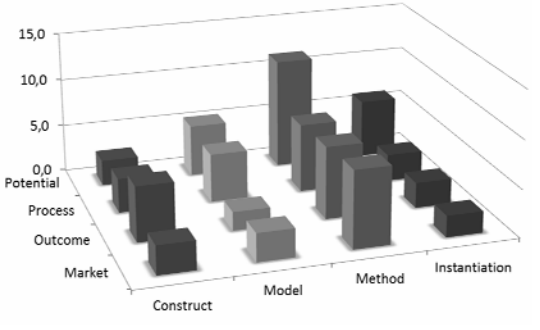

Fig. 2. Visualization of normalized results

Research results can be assigned to more than one characteristic in each dimension. Hence, it is promising to analyze, what combinations of characteristics within one dimension appear in conjunction with each other. As is illustrated in Table 3, by far the most frequent combination of two artifact types is the combination of constructs and methods (16 research results, i.e., 20.5% of all research results). At a closer look, this stems from modeling languages that comprise modeling constructs as well as they constitute methods for modeling. Other pairs are only seldom found or are non-existent. We further investigated whether three-out-of-four combinations or even combinations of all four artifact types can be found. Accordingly, we were able to identify 4 triples of models, methods, and instantiations and 2 triples of constructs,

models, and instantiations. Surprisingly, although the construct-method combination is the most frequent pair of artifacts, no construct-method-instantiation triples have been found. Only one combination of all four artifact types was identified.

Table 3 shows the results of an analogous analysis of the service perspective dimension. Potential-process (13) and outcome-market (10) are the most frequent combinations. The occurrence of these combinations is quite self-evident, as potential and process are both rather inside-oriented and outcome and market more outside-oriented perspectives. By far the most numerous triple is the combination of the perspectives potential, process, and outcome (6). In total, 4 combinations of all four perspectives have been found.

Table 3. Absolute and relative frequencies of combinations of artifact types (left) and service perspectives (right)

	Construct	Model	Method	Instantiation	# (%)
1	●	○	○	○	5 (6.4%)
	○	●	○	○	11 (14.1%)
	○	○	●	○	23 (29.5%)
	○	○	○	●	10 (12.8%)
2	●	●	○	○	2 (2.6%)
	○	●	●	○	1 (1.3%)
	○	○	●	●	2 (2.6%)
	●	○	○	●	0 (0%)
	●	○	●	○	16 (20.5%)
	○	●	○	●	1 (1.3%)
3	●	●	●	○	0 (0%)
	○	●	●	●	4 (5.1%)
	●	●	○	●	2 (2.6%)
	●	○	●	●	0 (0%)
4	●	●	●	●	1 (1.3%)
					78 (100%)

	Potential	Process	Outcome	Market	# (%)
1	●	○	○	○	11 (14.1%)
	○	●	○	○	8 (10.3%)
	○	○	●	○	6 (7.7%)
	○	○	○	●	7 (9.0%)
2	●	●	○	○	13 (16.7%)
	○	●	●	○	0 (0%)
	○	○	●	●	10 (12.8%)
	●	○	○	●	3 (3.6%)
	●	○	●	○	5 (6.4%)
	○	●	○	●	0 (0%)
3	●	●	●	○	6 (7.7%)
	○	●	●	●	2 (2.6%)
	●	●	○	●	1 (1.3%)
	●	○	●	●	2 (2.6%)
4	●	●	●	●	4 (5.1%)
					78 (100%)

Finally, we analyzed whether there are many narrowly focused research results, solely concentrating on one characteristic in each dimension (see also Table 3). Among these focused research results, methods (23) dominate the artifact dimension. The distribution in the service perspective dimension is more uniform, with potential being the most frequent perspective.

4 Discussion

The objective of the research portal that we used as the data source for our analysis is to provide an overview of research that is already completed, still ongoing, or – indirectly – yet to be tackled in future research on hybrid costumer solutions.

Therefore, the results of our study can serve researchers in identifying hot spots and blind spots in this particular field. Some key insights, which we were able to derive from our study, are discussed in the following subsections.

Method is the dominating IT artifact type: Methods are the dominating type of artifact in research on hybrid customer solutions. Methods identified are, for instance, procedure models and guidelines that address tasks of all perspectives, but especially the potential perspective. The focus on methods can be explained by the research disciplines that are involved in service research in Germany and research on hybrid customer solutions in particular. Especially the German business administration and engineering disciplines both aim at proposing normative procedures that help to cope with economic and technological challenges. From the perspective of the involved researchers, methods obviously seem to provide a more innovative contribution to the body of knowledge than constructs or models do, which are in essence the inputs and outputs of methods.

Instantiations mainly focus on service potential: Not many instantiations have been found in the examined online research portal. Most of those existing instantiations found address the potential dimension. These instantiations mainly comprise lightweight online questionnaires and assessment tools, which can be implemented on tight budgets and do not require data integration with other application systems. They are often supposed to allow for a (semi-)automatic analysis of the participating company's resources and service potentials. Other instantiations comprise modeling tools that are intended to support the conceptual development or engineering of new services and hybrid customer solutions. This service engineering approach is built on the premise that services can be engineered just like tangible products can. Service engineering traditionally is at the core of (manufacturing-focused) service research in Germany. Therefore, instantiations related to the potential perspective can build upon an extensive base of prior research. However, opportunities for the development of new instantiations also lie within the other perspectives. For instance, workflow applications could be used to make service processes run more efficiently and smoothly. Software support may also prove useful to let customers configure services by themselves so that the outcomes better meet their requirements.

The inside-out perspective dominates the outside-in perspective: Most of the IT artifacts support the potential perspective, whereas few artifacts are found to address the market and outcome perspectives. It can be argued that there is a dominating inside-out approach to the design of new services due to the manufacturing/industry focus of service science in Germany. This industry-stamped approach rather represents a technology-push than a market-pull mechanism. Therefore, a change towards a more customer-driven outside-in perspective still seems difficult to be accomplished for manufacturing companies as well as for researchers working in the field of SSME.

Constructs mainly focus on service outcomes: Innovative constructs are especially developed to describe the outcome perspective of customer solutions. This seems logical, since it is the integration of product and service components that is at the heart of research on hybrid value creation. Referring to the process and potential perspectives, existing constructs in terms of (process) modeling languages have

already reached a considerable degree of maturity. These artifacts probably also have proven useful in service research and there has hardly been a need to develop additional service-specific artifacts for these perspectives.

Artifacts tend to be focused on isolated service phenomena and lack an integration of different perspectives: The cross reference matrix in Table 3 shows that few artifacts have been designed to holistically support several perspectives on services. Although it seems intuitive that narrowing the design problem to isolated – and perhaps more easily to grasp – phenomena speeds up the design process, this approach might also lead to a high degree of fragmentation of the results. This is disturbing, since companies require holistic solutions to support their everyday service business and cannot rely on a collection of isolated artifacts simultaneously. Therefore, one objective to be tackled in the future would be to integrate isolated artifacts with each other.

Artifacts tend to get stuck in a low degree of maturity and are seldom translated into applicable software instantiations: In addition to the apparent narrowness of IT artifacts in service science, their depth also seems quite limited, as can be inferred from Table 3. According to these figures, only a minority of artifacts is incorporated into software tools. This represents a barrier to the successful transfer of research results into practice, as constructs, models, and methods that only exist "on paper" might be difficult to apply in real-world business contexts.

5 Conclusions and Limitations

In this paper, we applied the framework for design science research in the service science discipline in order to analyze the IT artifacts that have been contributed to service science. We conducted an in-depth analysis of 123 research results taken from a German research portal that focuses on the research stream of hybrid value creation. We classified the 78 IT artifacts within this sample according to the service perspectives (potential, process, outcome, and market) and the artifact types (construct, model, method, and instantiation) distinguished by the framework. We discussed six key insights and gave some reasons for the observations made. Hot spots of design research within the service science discipline as well as opportunities for future research were disclosed.

Admittedly, the survey results and their discussion suffer from some limitations. The sample of artifacts analyzed can neither be labeled exhaustive nor representative. Our study relies on a research portal that is operated by a German research institution and which is open to all researchers and practitioners without further reviewing. The entries in this portal are dominated by German and governmentally funded research initiatives and thus do not represent the international service science community as a whole. Nevertheless, the portal represents the most exhaustive collection of research results – and especially of IT artifacts – available in the German-speaking service research community to date. Therefore, this study sheds light on the achievements generated in the recent 15 years of governmentally-funded service research initiatives in Germany and might also guide some directions for shaping future national as well as international research programs.

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