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Decision Support for the Selection of Appropriate Customer Integration Methods

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Abstract. Co-creating innovations with external stakeholders, such as customers, is gaining popularity among companies as a way to address the competitive and market pressures they face. To this end, research has brought forward a notable number of customer integration methods. The selection of a particular method is governed by various organizational constraints; there is, however, a paucity of research providing decision support for practitioners in terms of when to use which customer integration method. Using the design science approach, our research addresses this research gap by implementing a decision support system to assist practitioners in the selection of appropriate customer integration methods. We elicit requirements from literature and expert interviews, and subsequently design, implement, and evaluate a prototype of the system. Based on identified requirements, the prototype is implemented as a web-based tool (HTML5). The DSS tool aims to acquaint practitioners with use cases and experiences with different customer integration methods.

Keywords: Open innovation, customer integration methods, decision support system, design science research

1 Introduction

Companies need to be innovative in order to stay competitive in the marketplace [1]. One approach to enhance competitiveness is for companies to open up their innovation processes and co-create innovations with external stakeholders, such as customers, suppliers, or research institutions. Customers can give input across the entire innovation and life-cycle of a product or service, e.g., in the form of ideas, concepts, or prototype evaluations [2]. These customer inputs can be generated by companies through the use of different customer integration methods which include idea competitions, virtual concept testing, toolkits, or lead user workshops [2]. The selection of an appropriate method for customer integration is limited by several restrictions such as available time, budget, or other resources in the company. Additionally, each customer integration method entails particular tasks for practitioners in terms of preparing in advance of customer integration or post-processing afterwards [3].

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Unfortunately, many companies fail to select a customer integration method which is appropriate to gather the needed customer input. For instance, a Swiss engineering company decided to integrate their customers through a survey. The survey confirmed obvious market trends but failed to generate the needed customer input in the form of unarticulated customer needs [4]. As this example shows, it is crucial for companies to have an in-depth understanding of the benefits and prerequisites of different customer integration methods in order to choose the most appropriate one [3, 4].

To support practitioners in the selection of suitable customer integration methods, existing research provides decision criteria that guide the selection of customer integration methods [3] as well as two or three-dimensional frameworks and matrixes [5] to categorize and evaluate methods [6-8]. However, according to our research and knowledge, there are no existing solutions to automate the process of selecting appropriate methods. One approach to ease this manual selection process is decision support systems (DSS) allowing companies to instantly gather relevant information for decision-making, to receive recommendations for actions, or to create forecasts [9]. Sprague (1980) describes DSS as, *"interactive computer based systems, which help decision makers utilize data and models to solve unstructured problems"* [10]. Thus, a DSS aids the process of decision-making as it allows companies to gather information of relevance to the decision at the appropriate time [9, 11]. Further, DSS are used in practice to mitigate prejudices and risks related to decision-making [9].

Therefore, as a means of supporting practitioners in the selection of customer integration methods, this paper designs, implements, and evaluates a knowledge-driven DSS congruent with the design science paradigm [12]. The knowledge-driven DSS developed in this research is intended to aid decision makers in selecting customer integration methods suitable to generating required customer input for the innovation process considering organizational constraints (e.g., budget, time). Furthermore, the proposed DSS acquaints practitioners with different customer integration methods, provides access to further information on the methods, and allows experts to share and discuss their experiences with the different customer integration methods.

The remainder of this paper is structured as follows. First, the research methodology is described. Second, the findings from the literature review and the expert interviews are presented and synthesized into a list of requirements which the DSS needs to meet. Third, in-depth information on the design, implementation, and evaluation of the DSS are provided. Finally, the results as well as challenges we faced while implementing the DSS are discussed. We conclude with implications and limitations of the underlying research as well as possibilities for future research.

2 Research Methodology

The design science methodology covers the elicitation of requirements, and the subsequent design, implementation, and evaluation of design artifacts. Therefore, the development of the DSS was congruent with the design science paradigm [12], and in particular, the three cycle view on information systems design as proposed by Hevner (2007): relevance cycle, design cycle, and rigor cycle [13]. The two basic activities of the “design cycle” are building and evaluating an artifact [12]. The evaluation of design artifacts is usually conducted with regard to evaluation criteria such as functionality, performance, or usability. Most of these attributes of an artifact are closely related to its application environment [12]. Thus, the requirements the artifact needs to fulfill must be identified in the specific application environment. These requirements provide the necessary background know-how to build and subsequently evaluate the artifact. These iterative activities of eliciting requirements from the application environment and designing artifacts compose the “relevance cycle”. Further, the artifact design needs to be tied to a scientific knowledge base. The “rigor cycle” covers the iterative process of building on and adding to the knowledge base [13]. In the following, we describe how we followed these three cycles in this paper.

2.1 Rigor Cycle

To build our research on the existing knowledge base, we elicited requirements for the DSS through a systematic literature review as recommended by Webster and Watson (2002) [14]. For this purpose, we identified and analyzed literature in the fields of customer integration and DSS. The concepts of customer integration into innovation processes and DSS are of interdisciplinary nature. Thus, databases that allow access to different research fields were considered as a means of analyzing and understanding DSS and the requirements a DSS needs to fulfill in the context of customer integration. We searched the selected databases (search fields: title, abstract, and keywords) using keyword combinations related to customer integration, requirements, and DSS (see Table 1). The initial search yielded 2013 results.

Table 1. Overview of identified and relevant papers

	IEEE		ScienceDirect		EbscoHost	
keywords	identified	relevant	identified	relevant	identified	relevant
"decision support system" AND "customer integration"	87	15	84	20	6	1
"decision support model" OR "tool” AND “customer integration”	11	4	24	10	154	10
“decision support system” AND “requirements”	111	20	842	40	247	30
“knowledge-based” OR “knowledge-driven DSS”	238	14	184	15	25	5
Total (relevant without duplicates)		53		85		46

After removing duplicates and reading the title, abstract, and keywords of all obtained articles to identify their relevance for the underlying research, we narrowed the number of useable articles to 630. In order to reduce the number of research articles to those that are actually relevant, we conducted a second screening process. In this second screening process we evaluated each of the 630 papers by screening introduction, findings, discussion, and conclusion of the paper. In both screening processes, the research articles that were considered as relevant for the underlying research covered the concept of DSS, functional and non-functional requirements for the design of a

DSS, as well as different customer integration methods and decision criteria that guide the selection of customer integration methods. Finally, we evaluated 184 articles as relevant for the underlying research. Customer integration methods described in these 184 papers as well as decision factors and use cases on the application of the different customer integration methods are stored in the knowledge base of the DSS.

2.2 Relevance Cycle

We followed the relevance cycle by eliciting requirements for the DSS from the application environment, respectively the target users, through expert interviews. We conducted 14 qualitative interviews with industry experts from 14 companies to gain detailed insight into the process of customer integration and the selection of customer integration methods in practice. We interviewed experts working for more than three years in relevant areas including sales, marketing, research and development, product and innovation management. To gather diverse opinions on customer integration and the requirements that a DSS needs to meet in order to actually support practitioners in the selection of appropriate customer integration methods, we interviewed experts from different industries. Data was collected from February to June 2014. Table 2 provides a short overview of the interviews.

Table 2. List of interviews

ID	*Industry*	*Position of expert*	*Experience in this field (years)*	*Interview duration (minutes)*
I1	Automotive	Head Global Automotive	24	42
I2	Energy Sector	Senior Application Sales Engineer	11	37
I3	Health	Application Developer	6	30
I4	Health	Equipment Developer	3	47
I5	Transportation	Executive Director	15	35
I6	Mobile Application	Interactive Media Manager	8	35
I7	Health	Associate Vice President	21	45
I8	Electronics	Senior Developer	7	31
I9	Gaming	Manager	12	23
I10	Automotive	Vice President	35	30
I11	Software Industry	Senior Developer	13	33
I12	Banking	Vice President	25	49
I13	Gaming	Senior Manager	10	30
I14	Automotive	Senior Engineer	5	35

We used a semi-structured interview guideline to interview all 14 experts to ensure comparability of our findings. Before the actual interviews, the guidelines were pretested by one expert working in the area of requirements management and two independent researchers from related areas [15]. Experts were asked to: (1) name customer integration methods they apply to co-create innovations with customers; (2) identify decision criteria relevant for the selection of customer integration methods (e.g., budget, time, skills); (3) describe their decision process of selecting appropriate customer integration methods; (4) identify requirements that they expect the DSS to fulfill; and (5) reveal their previous experience in using DSS. The interviews were carried out via phone or face-to-face meetings with sessions lasting 36 minutes on average. When allowed, the interview was voice recorded, transcribed and checked for accuracy by the interviewee. In cases where voice recording was not allowed, notes were taken manually. The collected data was analyzed using qualitative content analysis [16]. Building on our interview guidelines, we developed a coding scheme which has been adapted iteratively throughout data collection and analysis due to new insights [16].

2.3 Design Cycle

The design cycle covers the design, implementation, and evaluation of the design artifact. Therefore, the requirements elicited from literature and experts have been analyzed to develop a set of requirements as a basis for the implementation of the DSS. To this end, the identified requirements were categorically classified as functional or non-functional requirements [17]. Further, each requirement was thoroughly analyzed and marked as necessary, good to have, or not relevant [18]. The priority of the requirements was based on the frequency with which a requirement was mentioned by the experts. Also, phrases used by the experts like "obviously" have been used to indicate the importance of a requirement. Such categorization helped us to map the core functionality expected of the DSS and the associated requirements. Similar to the steps followed in the software development lifecycle [9], the core requirements were first considered to design the core functionality of finding suitable methods. Later, some of the good to have expectations were considered and added as extensions; for example, a forum for experts to share their experiences in customer integration.

3 Results

3.1 Requirements

In the following, we present the set of requirements used to design the DSS. The identified requirements were categorized as functional and non-functional requirements [19]. The functional requirements describe the expected core functionalities of the DSS [18]. For instance, use cases that describe how to apply the different customer integration methods, reporting tools to understand the recommendations, or the ability to export the recommendations have been identified as functional requirements for the DSS (Table 3).

Table 3. List of functional requirements

Requirement	*Description*	*Source*
Analysis tool	The DSS tool allows users to query, browse and understand large amounts of data available in the knowledge base.	[9] Interview I1
Criteria and weights	The tool must deduce a subset of recommended customer integration methods based on an optimality condition and by weighting the contribution of each decision criterion.	[20] Interviews I7, I11
Data export	The tool must allow the export of further literature and information on the different customer integration methods in downloadable format.	[11] Interviews I1, I6
Facilitation	The tool must assist the decision maker by providing recommendations for the most suitable customer integration method(s).	[21] Interviews I1, I13
Input to the DSS	The DSS must use clear and well defined ranges for inputs.	[9, 21] Interview I7
Pre-supposed questionnaire	The tool's questions asked must be objective in nature aiming to accept data that can be used to generate suitable recommendations.	[9] Interview I1
Reporting tool	The tool needs to include a reporting tool which is able to explain why the method is recommended and how to apply the recommended customer integration method.	[17] Interviews I7, I11, I6, I13
Use case	The tool needs to provide specific use cases for the application of the recommended customer integration method.	[9] Interviews I4, I6, I7, I12, I13

The non-functional requirements, by contrast, describe the technical requirements (e.g., accessibility, navigability, user interface) that the tool is expected to satisfy [19]. The identified non-functional requirements for the DSS are summarized in Table 4.

Table 4. List of non-functional requirements

Requirement	*Description*	*Source*
Accessibility	The tool must be accessible at any given time and place.	[11] Interviews I1, I6, I7, I8, I12
Extensible interface	The tool must be easily extensible with respect to the user interface or the core logic.	[22]
Interoperability of the tool	The tool must provide transparent mechanisms for the interactions and be compatible with other systems.	[23] Interviews I1, I12, I14
Navigability	The tool must provide easy navigation using links to web pages (internal or external).	[24] Interviews I1, I11, I13
Responsive design	The tool should be responsive in adapting to various screen sizes.	[25] Interviews I1, I7, I8, I14
Scalability	The tool must be scalable and handle several concurrent requests in parallel without any performance degradation.	[23] Interviews I1, I6
User interface	The tool's interface must be designed efficiently using good visualization techniques.	[9, 25] Interviews I1, I7, I13, I14
Web-based	As a web-application, the tool has advantages such as better accuracy, more acceptance of the tool, accessibility.	[26] Interviews I2, I5, I8, I10, I11, I12, I14

3.2 Architecture of the DSS

The simplest level of abstraction that helps to understand the designed DSS is the architectural design of the system [27]. The architecture used in this research comprises three distinct tiers which provide dedicated functionality as illustrated in Figure 1. These are the storage, business logic, and presentation tier [28].

Storage tier: The most important tier for any knowledge-driven DSS is the storage tier. It comprises the knowledge base required for the proper execution of the tool [17]. In this research, the knowledge base of the DSS comprises all the details gathered about different customer integration methods through the literature review. The necessary knowledge in this context is the description and evaluation of the different customer integration methods with regard to the decision factors, as well as use cases and experiences shared by experts in applying customer integration methods.

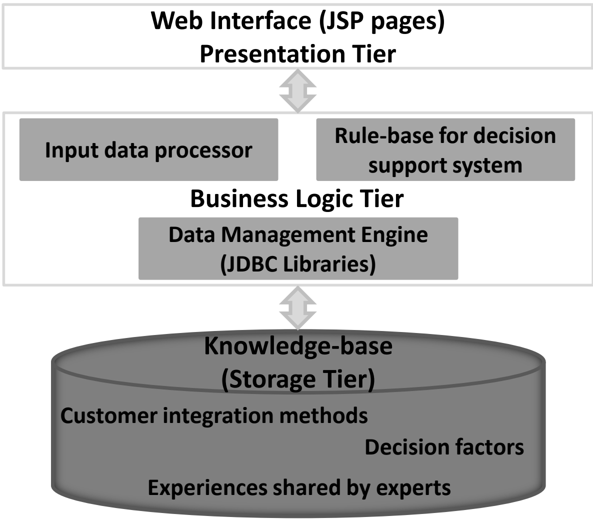

Fig. 1. Architecture of the DSS (Own illustration)

Business logic tier: This tier is the heart of the system, engulfing the analytics, the interaction of the decision makers with the system, and the generation of recommendations (most appropriate customer integration methods) based on the provided input by the decision maker [9, 17]. The selection of a particular customer integration method is governed by various organizational constraints and considerations such as available budget and time for customer integration, preparation effort of a method, required number of employees and customers, or phase in the innovation process [3]. The decision maker needs to provide information on these constraints, also called decision criteria, which enable the DSS to search for matching methods.

The DSS's logic is based on a decision tree. The main motivation for using a decision tree is the efficient traversal techniques that can be easily implemented as well as the ability to re-iterate through the decision tree. Thus, the decision maker is able to re-consider or even omit some of the decision criteria while searching for possible recommendations [29, 30]. The DSS first tries to find an exact match for the inputs provided by the user. If no exact match can be found, the DSS delivers a partial matching recommendation. In the underlying research, we ask the decision makers to provide multiple inputs to the system. Therefore, it is important that if no exact match is found, then the tool must search through its knowledge base if any partially matching method can be found by omitting some of the decision criteria.

To support partial matching, an iterative look up is conducted to find the most appropriate customer integration method. For this iterative look up, all the inputs and customer integration methods are considered as nodes of a decision tree. For each comparison, the tree is navigated iteratively to identify the most suitable customer integration method. The iterative traversal methodology used in this paper is the breadth-first search technique [31] using two steps of filtering to identify the matching customer integration methods. In the iterative traversal methodology, filtering rule

1 searches for customer integration methods that match the mandatory inputs from the decision makers. Filtering rule 2 checks for the optional inputs to further deduce the most suitable customer integration methods. According to the experts that we interviewed, the selection of customer integration methods is primarily based on the phase of the innovation, the target user of the innovation, and the available time and budget for the entire customer integration project. This helped us to identify phase, cost, duration, and customer type as mandatory inputs. In the filtering rules 1 and 2, the '&' defines a 'logical AND' combination.

Filtering rule 1: Phase & Cost & Duration & Customer type

Filtering rule 2: Customer count & Employee count & Preparation effort

For each match/customer integration method found after applying filtering rule 1, the second filtering rule is applied to search for further partial or full matching methods. The filtering rule 2 is only applied to the result subset (first order child nodes) identified from filtering rule 1. The tool is designed so that it aims to identify an exact match of an appropriate customer integration method based on the inputs given by the decision maker. In case there is a match identified from filtering rule 1, then filtering rule 2 checks for methods fulfilling the optional decision criteria. The results from filtering rule 2 are presented as final recommendations. If no exact match is found, then for both the filtering rules 1 and 2 one of the decision criteria is dropped and the whole search is re-iterated to check for partial matches. If filtering rule 1 fails to identify any match, then the tool is designed to recommend all customer integration methods that are identified based on the decision makers input regarding phase of the innovation process. If filtering rule 2 is unable to find any matches, then the results identified from filtering rule 1 are presented as the recommendations to the practitioners. The functional requirement “criteria and weights” (see Table 4) is specified in the business logic tier of the tool and the implemented filtering rules to search for matching customer integration methods.

Presentation tier: To meet the non-functional requirements “web-based” and ”accessibility” the tool is implemented as a web-based application. To achieve a responsive design of the web-based tool, HTML5 has been used as a technical solution.

The presentation tier is the first level of a web-based application having a multi-tier architecture [32]. The main function of this tier is to provide an interface to display information and to enable the user to interact with the system. The goal of this tier is to attain a clear and understandable interface for the decision makers (refers to the non-functional requirements navigability and user interface) [33]. Figure 2 depicts the website of the developed DSS. The web-based tool is available at *http://customer-integration.informatik.tu-muenchen.de/*. The structure of the website clearly shows the available functionalities of the web-based tool. For instance, one can have a brief overview of the open innovation and customer integration concept (Figure 2, top left). To meet the functional requirements “use case”, “facilitation”, “reporting tool” and “data export” (see Table 3), the website provides an overview of the various customer integration methods stored in the database as well as links to download academic articles on a certain customer integration method (Figure 2, bottom left), and a forum that allows experts to share their experiences in using certain customer integration methods (Figure 2, bottom right). A questionnaire asks the decision makers to provide the required input to process and recommend suitable customer integration methods. Each input has a tooltip providing a brief description of the required information (Figure 2, top right). This refers to the functional requirements "pre-supposed questionnaire" and "input to the DSS".

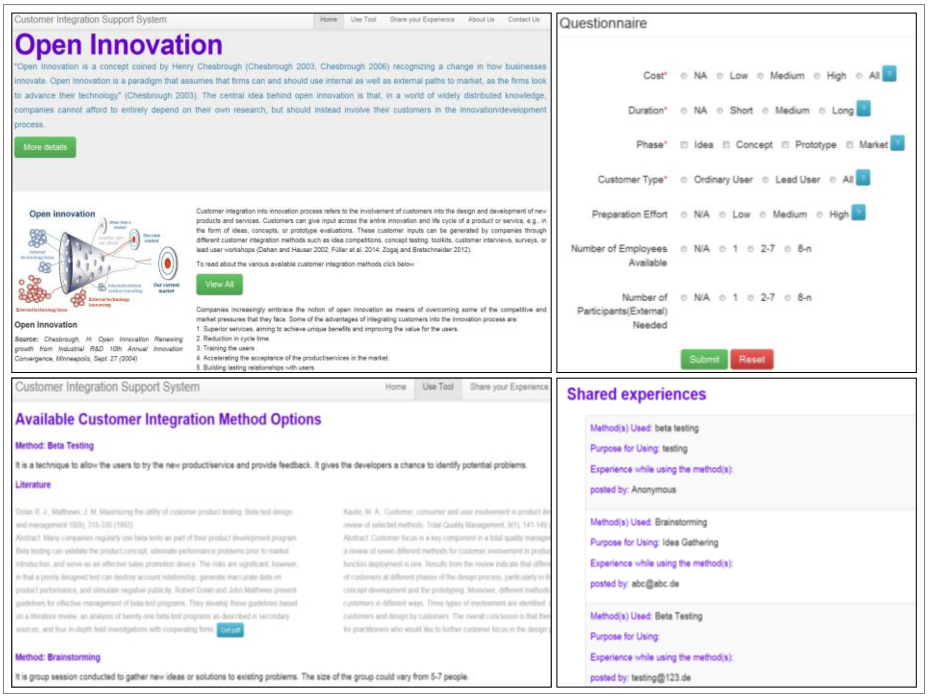

Fig. 2. Web-based DSS

3.3 Evaluation of the DSS

Similar to the evaluation of any product or service developed following the steps in a software development lifecycle, the implemented tool is also evaluated to assess if it satisfies the requirements of the user. To evaluate the DSS, we shared the link to the web-based DSS with experts and asked them to evaluate the tool by giving feedback through a survey. A semi-structured questionnaire containing 13 closed questions and three open questions was designed. The questions were selected in a manner to cover the identified requirements as well as evaluation criteria usually used to evaluate web-based prototypes (e.g., consistency, navigability). Table 5 shows the questions asked to gather the expert's opinion and feedback on the developed DSS. We emailed the survey to all 14 experts from the expert interviews and to others with experience in designing DSS. A total of 17 people were contacted, 12 completed the survey.

To understand and analyze the findings of the survey a coding scheme was developed based on heuristic evaluation for the gathered feedback data [34]. From the gathered feedback a mean value and variance were computed [35].

Table 5. Survey to evaluate the DSS

Evaluation criteria		Questions	Mean	Variance
Architecture & Navigability	*Consistency* [24, 36]	Is the same format used consistently throughout the site?	4.8	0.81
	Navigation [37]	Is the navigability within the website easy?	4.6	0.26
	Relevance of links [38]	Are the links relevant to the concept?	5.0	0.42
Content	*Information about content provider* [24]	Is sufficient information shared regarding the content provider?	5.0	0.15
	Graphics [24]	Do the shared graphics enhance the understandability?	3.0	1.18
	Access to relevant literature [39]	Is sufficient information provided for supporting literature?	3.5	2.08
	Relevance of information [24, 40]	Is the recommendation relevant to the described scenario?	4.0	0.51
Usability	*Working links* [35]	Are internal and external links working properly?	3.9	0.56
		Are the links to further information on the customer integration methods helpful and appropriate?	4.0	0.52
	Ease of use [41]	Are you able to move around within the web-based interface of the DSS with ease?	4.6	0.26
	Help prompts [37]	Is the information clearly labeled and organized?	4.5	0.27
UI	*Aesthetic features* [34, 38]	Is the tool's homepage attractive having a strong eye appeal?	5.0	0.44
Satisfaction	*Satisfaction* [36]	What is your overall satisfaction with the tool?	4.0	0.38

Participants used a 5-point scale to rate each question with 1=complete disagreement, 5= complete agreement.

Some of the positive feedback on the DSS we received was the simplicity and easy to use interface, the clear user workflow, and the easy navigability throughout the website. The tool was found to be able to impart knowledge as it provides a platform for experts to share and discuss previous experiences with the preparation and execution of customer integration methods. Some experts shared the opinion that the developed DSS could serve as a platform to bridge the gap between the theoretical concept of customer integration including the methods that can generally be used to co-create innovations with customers and the mundane functioning of business. Thus, the DSS could definitely ease the selection and the application of methods.

Suggestions for improving the DSS included metrics like hit-ratios in real time about the recommended and actually selected customer integration methods, and statistics about the past performance of each method or the ability to access the data programmatically for expert users. For future versions of the introduced web-based DSS, we can open source the project in some technical communities to acquire more feature requests from interested users which possibly further increase the value of the DSS.

4 Conclusion and Future Research

Previous research has brought forward and tested a notable number of customer integration methods [6]. However, methods need to be selected carefully to outweigh benefits (e.g., market success, customer satisfaction) over costs and risks related to customer integration [4]. There is a paucity of research providing decision support for practitioners in terms of when to use which method. Using the design science approach, our research addresses this gap by designing, implementing, and evaluating a knowledge-driven DSS that recommends suitable methods to the decision makers.

The paper contributes to theory by gathering requirements for a DSS that supports practitioners in the selection of customer integration methods. Based on the identified requirements, the prototype is implemented as a web-based tool in HTML5. The most surprising requirement identified from the expert interviews was the desire for different kinds of reporting and analysis tools.

According to previous research, customer integration literature is fragmented [8, 42]. Thus, this paper contributes to theory as the DSS accumulates knowledge and provides access to a knowledge base covering different customer integration methods, as well as experiences and use cases for the application of the different methods. Further, in our research we found that the body of literature on customer integration into innovation processes lacks quantification. Customer integration methods are frequently categorized in causing low, medium, or high costs, and taking low, medium, or high amount of time [3]. A DSS is better the more quantifiable parameters are known. If direct interrelationships are not known, only vague recommendations can be made.

From a practical perspective, this paper introduces a web-based knowledge-driven DSS that recommends suitable customer integration methods to the decision maker based on the provided input. The tool asks decision makers to provide information on the available time and budget for the entire customer integration project as well as information on the phase in the innovation process and customer type to search for matching or partially matching customer integration methods. Thus, the developed DSS offers an automated process of selecting suitable methods. To our knowledge, besides frameworks and matrixes [5-8] to categorize and evaluate customer integration methods, no such automatic approach for selecting suitable methods is available.

To evaluate the DSS, we shared the link to the developed web-based DSS with experts. Here, the tool was found to be capable of acquainting practitioners with information on the different customer integration methods and to provide access to further information on the methods (e.g., academic research). Additionally, the developed

DSS can provide a platform to bridge the gap between the theoretical concept of customer integration and its implementation in practice.

The challenge encountered while designing the DSS was the classification of the identified decision factors into mandatory and optional. The classification was primarily achieved using input from the interviews. The other challenge was to effectively and efficiently iterate multiple times amongst the various criteria and methods without omitting any possible recommendation. This challenge was met by iteratively traversing a decision tree using the breadth-first search technique [31].

Our research is subject to some limitations. First, the knowledge stored in the knowledge base of the DSS is based on the customer integration methods identified through the literature review. The literature review findings were obviously limited through the selection of the keywords and the three databases to use for the search. Second, the evaluation is based on a relatively small sample of experts that served as respondents to the survey. Further, the prototype presents a first rough version of the DSS. Future versions could provide even more information, use cases, and guidelines on the design and application of the different customer integration methods. The evaluation of the developed web-based DSS suggested the incorporation of metrics such as hit-ratios in real time about the recommended and actually selected customer integration methods in future versions of the tool. Further metrics or statistics could include success rates of the different customer integration methods. Research should evaluate the designed DSS with a larger sample of experts. To this end, in-depth interviews and focus groups could serve as methodological approaches to gain qualitative feedback from experts in the fields of DSS and customer integration.

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