

Value Potentials and Challenges of Service-Oriented Architectures

Results of an Empirical Survey from User and Vendor Perspective

This article presents descriptive empirical results on the value potentials and challenges of service-oriented architectures (SOA). 33 of the 250 largest German enterprises were interviewed to derive the presented results. Currently only a small share of the IT landscape of these companies is covered by services. The judgment on the overall benefit/cost ratio of SOA usage is slightly negative at the moment; however, a positive trend is expected for the upcoming years. Among the 21 discussed value potentials, especially business process optimization, agility, and reduction of development cost by parallel re-use of services are confirmed by the majority of users. In addition to the issues regarding operations (security and performance), the main challenges of SOA are seen in the management of the resulting architecture.

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survive the economic crisis (e.g., Ried 2009), and in 2010 the Burton Group (2009) had already diagnosed that “SOA is dead”.

This article summarizes the results of a descriptive cross-industry study among users and vendors of SOA-based information systems (IS), which aimed at answering questions regarding SOA value potentials and challenges.

In this article, SOA is defined as an IT architecture concept in which business processes are supported by IS whose software systems are composed of services. Services are clearly capsulated and loosely coupled software building blocks which provide a certain business functionality via a standardized interface (Erl 2008, pp. 290 ff.; Papazoglou and van den Heuvel 2007, p. 389). Further elements of a SOA are: Enterprise Service-Bus (ESB), which orchestrates the communication between services (Chappell 2004), Service-Repository, which allows the administration of services via metadata, as well as an Application Frontend representing the interface to users (Krafzig et al. 2005, pp. 60 ff.). In order to orchestrate the flow of business processes, so-called workflow- or process-engines are used in addition to the Service Bus (EABPM 2009, pp. 242 ff.). The SOA-concept itself is technology independent; however, it is de facto mostly realized via

1 Introduction

The value of introducing a SOA for an enterprise has been discussed increasingly critically in the past years. While there is still a high interest in the concept in practice and science, combined with high expectations (Kaczmarek and Welcel 2008, pp. 52 ff.), some voices doubt the paradigm's benefits. Several authors raised the question whether SOA would

the Web-Service-Technology and associated standards.

There are basically two types of enterprises that can benefit from the use of the concept: On the one hand, there are the users of SOA-based IS, which e.g. experience competitive advantages due to lower IT cost and/or business benefits by the use of the systems. On the other hand, there are companies who develop software products adhering to the SOA-principles and offer them to the users. They can gain internal advantages through an investment in SOA as well as a possible differentiation towards competitors. As there are several dependencies between those groups and as users often act as “producers” themselves when they customize standard software or even build their own applications, both perspectives were incorporated in our research. Due to space limitations, the article focuses on the user side. Wherever the vendor side provided interesting data to validate or falsify certain observations the corresponding results are added. The vendor side often serves as a benchmark for users since vendors can be seen as a more mature group due to their specialization on the field of software development as well as due to their typically higher SOA experience (cf. Sect. 4.1). Comparability of the results, however, is only feasible in the phase of “system development”. In the “system use” phase both groups certainly differ: While the benefit for the users in this phase manifests in revenue or cost advantages generated by the use of the systems in their business processes, the benefit for the vendors rather results from a higher sales volume of the product.

In the course of the article, results to the following research questions are presented: (1) How do large German enterprises implement the SOA-paradigm? (2) Which impact does SOA have on the performance of these companies? This analysis is structured along three sub-questions: (2a) What is the assessed overall benefit in relation to the overall cost? (2b) Which individual value potentials contribute in theory to the overall benefit and what is their importance in practice? (2c) Which challenges are associated with the realization of these value potentials? To provide an answer to these questions, the article starts with a summary of the work in the context of SOA value research (Sect. 2), followed by an introduction to the preparatory work and the methodology of the oral interviews (Sect. 3). The results regarding research question 1 are

presented in Sect. 4.1, the findings regarding question 2 in Sect. 4.2 ff. A summary of the most important insights in combination with the derived implications for practice and further research conclude the article in Sect. 5.

2 Value Concept and Related Work

2.1 Value Concept

The value concept applied in this study is based on the assumption that IT is a potentially valuable resource for a company and can represent a competitive advantage according to the resource-based view (RBV) (Barney 1991). In this context, value is defined as “all factors that have a positive effect on the objectives and purpose of an investment” (Okujava 2006, p. 3).

In an empirical study, Bharadwaj (2000, pp. 181 ff.) verifies the positive effect of IT resources on a company’s performance according to the RBV. Consequently, the IT architecture as distinctive characteristic of these IT resources has an impact on business performance as well, because in contrast to other IT elements (such as hardware) IT architecture fulfills the criteria defined by Barney (1991, pp. 106 ff.): “valuable”, “rare”, “imperfectly imitable”, and “non-substitutable by strategically equivalent resources”.

Therefore, it is an essential objective of this article to analyze the value of SOA in terms of positive effects on business performance. Bharadwaj determines business performance by utilizing revenue and expenditure ratios. This value definition will be adopted for this article by interpreting value according to the neoclassical view as contribution to the business goal profit maximization.

For the final assessment of an investment, as for example the introduction of SOA, the resulting value has to be examined in relation to the incurred costs in order to determine profitability. This article focuses on the value side of this economic analysis as it is typically more difficult to determine the value of an IS investment than to determine the cost (Murphy and Simon 2002, pp. 301 ff.); this is especially true as many types of costs, for example implementation and operation cost, can be calculated employing known cost evaluation methods.

In this study, we mainly focus on value potentials whose effects are monetarily

measurable (quantitative potentials). Besides these value potentials, there are value potentials that only have an indirect and just subjectively observable effect on revenue and costs, i.e. can hardly be determined in numerical terms or objectified (Ward and Daniel 2006, p. 172). In the literature, these value potentials are often described as “qualitative” or “hardly measurable” potentials. In addition to the described positive effects, there can also be negative effects for a company which are not accounted for in classical cost estimation. In the following, these negative effects will be labeled as “challenges”.

2.2 Related Work

As shown by Kaczmarek and Wecel (2008, pp. 52 ff.) as well as Viering et al. (2009, pp. 54 ff.), scientific research currently focuses on conceptual questions regarding the configuration of SOA in respect to implementation and realization. Even though the value of the concept is covered in nearly all business oriented papers concerning SOA, in most cases just a simple enumeration of single arguments is to be found without a profound logical deduction or proof (for a value related literature analysis cf. Becker et al. 2009, p. 617). To the authors’ knowledge, there are only few publications that fully focus on the value of SOA. **Table 1** provides an overview of these papers:

In the upper section of the table, conceptual papers are listed in which models for the systematization of value potentials of SOA in a structured way are suggested (type 1). Analyzing these existing approaches, it became clear that value is often examined only partially and that a critical perspective, which contrasts the challenges of SOA with its value, is often missing (Abelein et al. 2009). In their development, all models partially rely on the findings of qualitative papers (type 2), but up to now there is no practical verification of the postulated value potentials. As a consequence, this paper was based on an advanced model (cf. Sect. 3.1). The middle section of **Table 1** provides an overview of the above mentioned qualitative papers published in the early phase of SOA adoption (publication mostly 2005–2007). Due to the early phase of research, these papers are in most cases not complete and lack a structured analysis of value potentials as well as comparability due to the qualitative method. Only Löhe and Legner (2009) provided a first

Table 1 Overview of related research (Extended overview based on Beimborn et al. 2008, p. 8)

Paper	Method	Core results
Type 1 – Models for value identification:		
Qualitative model		
Oey (2006)		Derivation of a list of criteria with the help of which quality and cost of software architectures in general and SOA in particular can be assessed
Dreifus et al. (2007)		Proposal to categorize the SOA benefits along the perspectives: process, organization and IT
Fiedler and Seufert (2007)		The return on investment (ROI) based methods for determining the profitability of IT investments in general are also applicable to the specific questions of SOA
Müller et al. (2007)		Derivation of a detailed framework of benefits from the core principles of SOA
Beimborn et al. (2008)		Model to describe the business benefits of SOA and possible influencing factors on a high level of abstraction
vom Brocke et al. (2008)		Model to measure the monetary impact of SOA on business processes (Service oriented process controlling – SOPC)
Abelein et al. (2009)		Model for classification of value potentials of SOA according to impact level in the company and type at a detailed level
Type 2 – Qualitative empirical paper		
Baskerville et al. (2005)	2 case studies (1 US- and 1 EU-Bank)	Both banks achieved a better extensibility of their IT architecture with SOA
Yoon and Carter (2007)	5 case studies based on literature cases	SOA benefits result from increased agility and cost reduction. In addition, success factors, such as governance, top management support and change management, are determined
Brahe (2007)	1 case study (bank)	SOA supports management and integration of business processes
Eisenecher and Friberg (2008)	4 case studies (retails)	List of potential benefits and challenges of SOA in the retail industry
Löhe and Legner (2009)	14 Expert Interviews (car dealer)	Identification and assessment of 19 potential benefits for networks of used car dealers by means of expert interviews
Tewary et al. (2009)	1 case study (oil company)	Description of five process- and one IT-related benefit effect(s) of a SOA pilot application
Luthria and Rabhi (2009)	15 Expert interviews	SOA enables in particular the integration of processes within the company, faster product development and the creation of new offers
Klischewski and Abubakr (2010)	1 case study (government institution)	The desired potential of process automation and quality improvement of E-Government processes could not be reached yet as the chosen approach was too strictly focused on technology
Type 3 – Quantitative empirical paper		
Kumar et al. (2007)	Written survey (500 US-companies)	The introduction of SOA improves the performance of the supply chain
Oh et al. (2007)	Written survey (188 companies in Singapore)	SOA allows an increased flexibility and integration of processes both within an organization and across companies

article based on an expert interview series, which aims to completely record and to prioritize the value potentials of the second-hand car market using a structured approach. In a third type of papers, the quantitative empiricisms, merely Kumar et al. (2007) and Oh et al. (2007) investigate the value of SOA by means of quantitative methods. However, with the influence on the supply chain or the effect on the integration of processes in each

case they only cover one of many possible value potentials.

3 Methodology of the Study

3.1 Identification and Structuring of the Value Potentials and Challenges

As described in Sect. 2.2, at the beginning of the research project only two quan-

titative studies concerning the value of SOA existed. Therefore an extensive literature research and a preliminary study based on expert interviews (Gläser and Laudel 2009; Denzin and Lincoln 2000, pp. 653 ff.) were conducted. It was the latter study's objective to obtain a structured overview of the variety of arguments for and against SOA and to prioritize the most important aspects according to their practical relevance (hereto see

Becker et al. 2009). Due to the limited empirical literature, new operationalizations¹ had to be found for most of the value potentials and challenges of the main study. Especially it had to be assured that the value potentials were mutually exclusive. For this purpose the value potentials, identified during the preliminary study, were structured according to a newly developed model building on the approaches introduced in Sect. 2.2. Here the value potentials are classified in the two dimensions “Impact level in the company” and “Type of value”. The chosen structure ensures a holistic view (cf. for a detailed representation of the model Abelein et al. 2009). In addition, possible obstacles to the realization of value potentials (“challenges”) are shown, which to the authors’ knowledge have not been taken into consideration in other models before. The impact levels are structured in the *IT, process and strategic level*. The *IT level* covers all value potentials concerning the development and operation of IT systems; on the *process level* all value potentials of SOA regarding operative business processes are summarized, whereas all value potentials relevant for the advancement and management of the business are assigned to the *strategic level*. In the second dimension, we differentiate according to the type of value (revenue, costs, effects difficult to quantify, see Sect. 2.1).² For a representation of the model see also Tables 2 to 4, where however only the categories relevant for the respective level are shown.

All value potentials identified in the pre-study were formulated according to a unified syntax: “Due to (1...n design principles) SOA leads to a (value potential) which results in (type of value) on the (impact level).” This wording is based on the effect-chain logic of Müller et al. (2007) and is intended to illustrate the assumed connection between SOA and value impact.

3.2 Design of the survey

According to the research questions, the study was set up as descriptive cross-industrial study (Diekmann 2007, pp. 304 ff.; Bryman 2008, pp. 44 ff.). As

shown in Sect. 2.2, only few quantitative investigations have been conducted so far in this field. Therefore, a large-scale empiricism using inductive statistics was avoided. It was the objective of the study to lay the foundations for future quantitative research by employing a descriptive approach. It should therefore for the first time allow a holistic view on the practical characteristics of the object of study. Due to this research objective only companies that had already made experiences with SOA could be interviewed. As information regarding the characteristic “SOA-usage” is missing, the basic population is hard to identify (Diekmann 2007, p. 399; Bryman 2008, pp. 183 ff.). According to the statements of the pre-study’s experts, SOA is particularly interesting for large and (from IT perspective) complex companies, meaning that the highest rate of adoption can be expected here. The number of employees was utilized as a criteria for determining size, as this, in the authors’ opinion, is a better indicator for complexity than, e.g., revenue. In order to decrease the risk of bias due to comprehension problems, the study was restricted to Germany (Berekoven et al. 2006, p. 328, respectively; Harzing et al. 2009, pp. 418 ff.). Based on these criteria, a list of the 250 largest private companies was compiled from three data sources (Hoppenstedt Firmendatenbank, FAZ Top 250, Welt Top 500).

Given the assumed low SOA adoption rates, a small number of study participants was expected. Therefore it had to be ensured that the data sets were of high quality and completeness. Furthermore, it became apparent during the pre-study, that the understanding of the SOA concept is very heterogeneous. For these reasons, the oral interview was chosen as survey method because it offers the possibility of clarifying remarks and questions during the process.

The possible disadvantage of a distortion of results by the interviewer was counteracted by a highly standardized questionnaire.³ As a normal distribution of data is necessary for the applicability of the commonly used *t*-test for significance testing (Diekmann 2007, p. 403; Anderson et al. 2008, p. 271) and (by the

central limit theorem) only for $n \geq 30$ a sufficient convergence of random values to the normal distribution can be expected, 30 was defined as the minimum of records. Based on the experience from the pre-study and the experts’ feedback regarding the adoption level, a return of about 20% was expected. Thus, in a first step, 150 companies were chosen by chance from the population and contacted: The recipient of the survey was the head of IT architecture (alternatively, head of IT strategy) or – if existing – the head of the SOA program/project in the company.

As to the vendors, a sample was selected by the authors since the special population of the software companies offering SOA-based products was expected to be even smaller than the user group. Therefore, the restriction to Germany was abolished, and 86 software companies were identified on the basis of three data sources (Software Magazine Top 500, Truffle100 Europe, Lünendonk Software Report Germany) and via Internet research. The request for an interview was directed to the chief architect/developer or the Chief Technology Officer (CTO).

As outlined in the Sect. 3.1, new questions and scales for the operationalization had to be developed for most variables. Here, the content validity was expertly assessed by three researchers and three practitioners. Reliability was checked using the split-sample method (Kleinbaum et al. 2007, p. 398 ff.) and an analysis of the discrepancies between early and late responses (Armstrong and Overton 1977). In both cases, there were no significant mean differences between the respective groups. For the core part of the assessment of potential benefits and challenges, the structure and wording of the questions is based on the model described in Sect. 3.1. To record the assessments, rating scales were used. After a pretest with two interviews per group, the survey took place from mid-May to mid-September 2009. Figure 1 shows the distribution of the participants according to industry sector and size in terms of revenue and employees.

On the user side, 33 companies took part in the survey, whereas on the manu-

¹Following the procedure proposed by Diekmann (2007, pp. 239 ff.) cf. (Bryman 2008, pp. 141 ff.).

²This structure differs slightly from the model presented in Abelein et al. (2009), which divides the effects difficult to quantify even further. Since these effects are not focused on here (see, description of the value concept in Chapter 1), the model has been simplified.

³The survey was designed for 60 minutes (avg. 63 min). The interviews were conducted by telephone, except for four conducted in person at the request of the respondents. In three interviews two company experts participated.

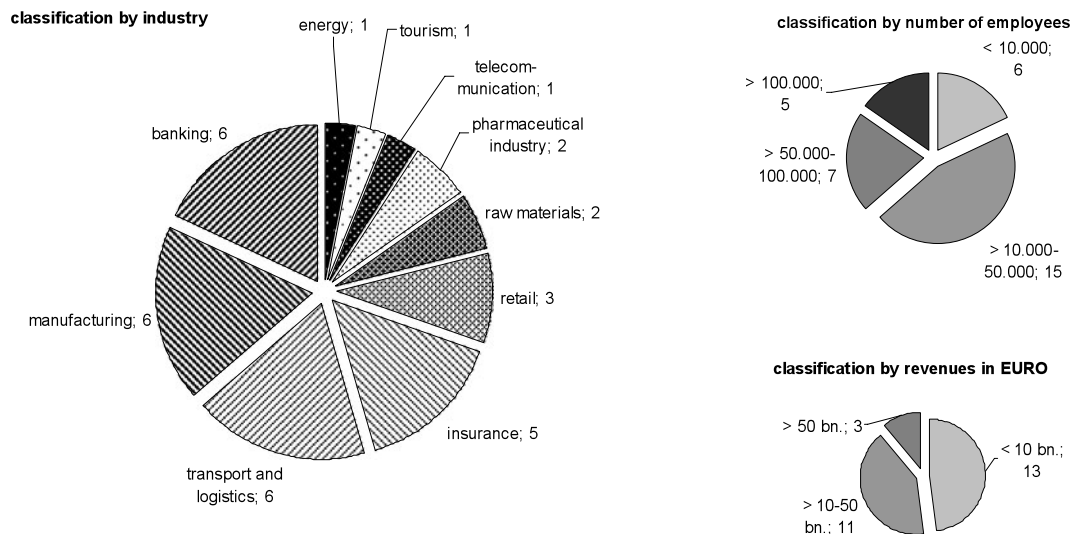


Fig. 1 Sample characteristics (In the classification by revenue the six banks are not included, as banks use the not comparable total assets as financial size indicator.)

facturing side 23 interviews could be obtained. In some interviews with vendors, a positive bias was noted – as expected due to the behavior in the pre-study. For example, some interviewees deviated from the structured questions and only spoke about the SOA benefits for their customers instead of the internal impact addressed by the interviewer. By means of known methods, such as a balanced scaling of response options, a request at the beginning of the interview to be objective, and critical inquiries during the conversation, it was attempted to avoid this bias. However, a complete elimination of the effect cannot be guaranteed (Raab-Steiner and Benesch 2008, p. 60). Therefore, the course of each interview was critically reflected directly after the conversation, and in two cases the data set was rejected.

4 Results of the Study as Regards Implementation Status, Value Potentials, and Challenges of SOA

4.1 Status of the SOA Implementation

To interpret the value judgments of the respondents in the context of each company, the state of SOA implementation was discussed at the beginning of the interviews (research question 1) (“How do large German enterprises implement

the SOA paradigm?”). Thereby, the SOA-share in the IT landscape, the use of individual components, and the application of design principles were analyzed. With regard to the SOA-share measured by the number of existing services in comparison to the theoretical maximum (based on an estimate of the respective interview partner), most users have about 10% of SOA-based IS in their IT-landscape (with low variance, 2 outliers > 50%).

The share correlates with duration of use. Among the vendors, a higher degree of penetration of the SOA approach becomes apparent in the products. Thus, more than half of the vendors (15 of 23) state that most of their products (10) or all of their products (5) have been developed according to SOA principles. In respect of the technical elements, all of the 33 users have stated to use services. 24 companies use an ESB and additional eight companies are planning its implementation. Moreover, 13 users (all of them also ESB users) have a Service Repository in place; additional 13 are planning the implementation of such a tool. Workflow-engines for the sequential flow control are deployed by 16 users; additional 14 are planning their usage. According to the design principles defined by Heutschi (2007, p. 47), the aspects rated highly by the users are first and foremost loose coupling and stability resp. good documentation of the interfaces. The principles of unique capsulation and the definition of service level

agreements (SLAs) are implemented less consequently. For the vendors, a nearly identical pattern in respect to the ranking of the design principles emerges, only loose coupling is rated lower (rank 4). Overall, the judgment in most cases is approx. one unit higher than on user side (significance between $\alpha_U = 0.003$ and $\alpha_U = 0.05$,⁴ depending on design principle), which leads to the assumption that the vendors adhere to the principles more strictly. (In the online appendix 1, there are two figures with detailed results covering the aspects discussed above.)

4.2 Value of SOA

Figure 2 illustrates the assessment of the overall value of SOA from the users’ and vendors’ point of view and answers research question 2a (“What is the assessed overall benefit, in relation to the overall expense?”). In this context, in order to improve comparability, the questions focused on how the relation between actual cost and realized value in each of the companies was judged in 2009 and how the companies estimated the future development.

At the date of the survey, the users estimate the value/cost-ratio as “slightly negative” and have, similarly to the software vendors who rate “neutral” on average, optimistic expectations for the upcoming years.

These optimistic expectations can be explained by the fact that some value po-

⁴The U-Test according to Mann-Whitney (Rasch et al. 2010, pp. 143 f.) was used to test for significance between user and vendor groups, as – due to the small number of data sets on the vendor side – the assumption of normally distributed data for the *t*-test could not be sufficiently verified.

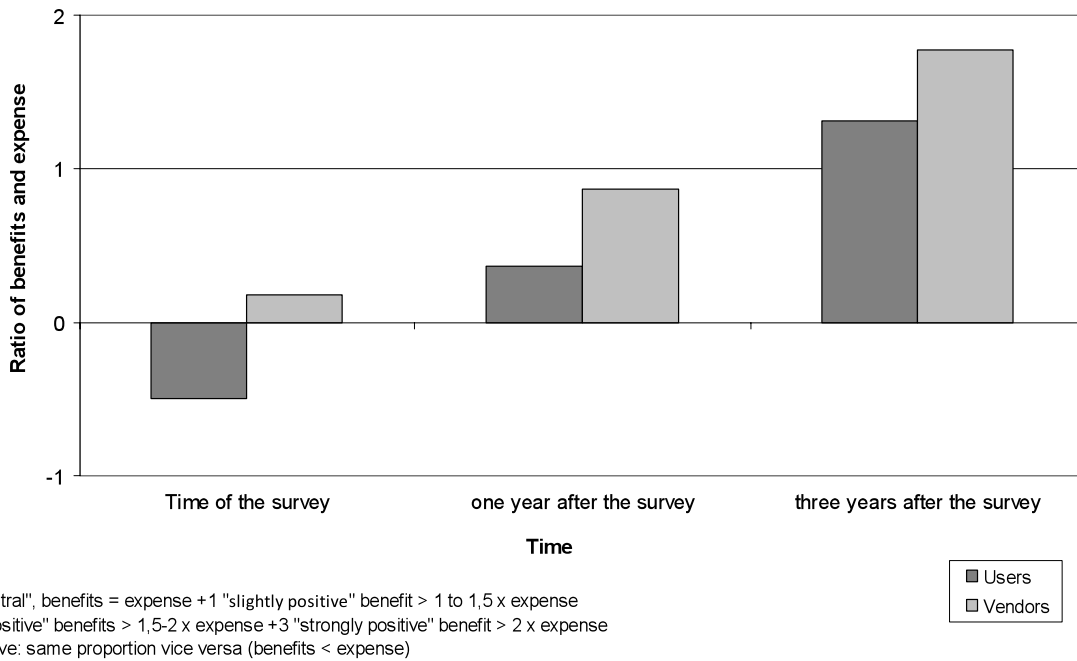
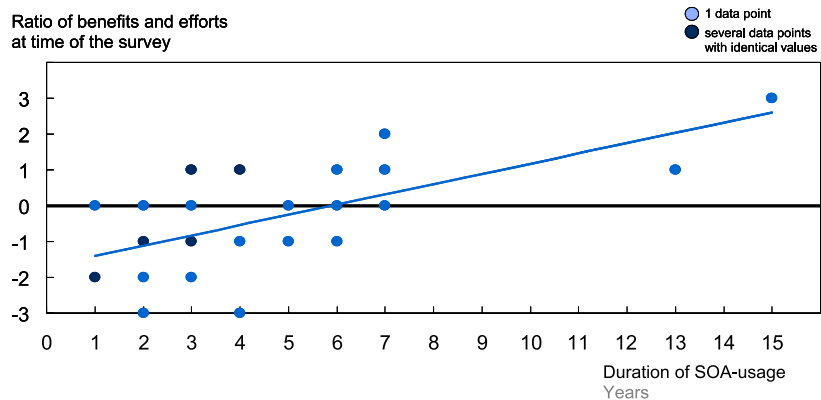


Fig. 2 Estimation of the value and cost of SOA in total

Fig. 3 Estimation of the value/cost-ratio in dependency of the period of application



tentials only have a long-term effect, e.g., when follow-up projects benefit from the initial investment in the SOA (especially due to re-use of services and increased agility). The validity of this assumption can be proven by the evaluation shown in Fig. 3. It illustrates the value estimation at the time of the survey, i.e., the different data points, which, when aggregated, lead to the mean -0.5 in the first bar in Fig. 2, and the respective duration of SOA-usage. There is a strong positive correlation ($r = 0.69, ***$) between the two variables. From this fact, the positive message for the users can be derived that there will be a positive value development over time. Their hopes, as expressed in the previously presented results, seem justified. However, this also shows that on average an investment will not amortize (i.e., the hitherto cumu-

lated value exceeds the cumulated cost, so-called "break-even point") before 5–6 years. But for few exceptions, the short amortization period (e.g., 1–2 years in the case of Chappell 2009) promised by the SOA producers in most cases do not come true for large-scale German enterprises and have to be challenged; especially, as the data show an average payoff time of about four years also on the vendor's side.

According to research question 2b ("Which individual value potentials contribute in theory to the overall benefit and what is their importance in practice?"), not only the overall benefit was of interest, but the companies were also asked for the particular value potentials leading to their assessment. An estimation of the ratio of value and cost could only be carried out on an aggregated level

as an allocation of monetary measures (especially of the cost) to individual value potentials was hardly or not at all possible. Therefore, on the detail level the following rating scale was applied in order to evaluate the individual potentials: On a scale from "+3 = strongly positive value" to "-3 = the opposite is the case", the interview partner could agree with or reject the value potential. "0" means that SOA does not have an effect in this regard from the interview partner's point of view. In the following sections, the detailed results will be introduced according to the structure explained in Sect. 3.1. Following a tabular representation of the results, there is a textual explanation which focuses on the two highest-ranked aspects for each of the three impact levels for reasons of space. For the same reason, the formulation of the value potentials does

Table 2 Empirical results on IT-level

Ongoing expenses	One-off expenses	Difficult to quantify	Challenges
<i>Reduced costs of interface maintenance</i> ($\varnothing = 1$; $\sigma = 0.94$): By means of encapsulation and loose coupling, SOA enables reducing the number of interfaces. Thus the charges for interface maintenance are reduced.	<i>Easier application integration</i> ($\varnothing = 1.69$; $\sigma = 0.93$): By means of standardized interfaces, encapsulation, and independence of the technical implementation, SOA enables an expense reduction for the integration of applications.	<i>Evolutionary Modernization</i> ($\varnothing = 1.24$; $\sigma = 1.50$): By means of loose coupling and independence of the technical realization, SOA enables an evolutionary modernization of IT, which minimizes the risk of failure compared to “big bang” upgrades.	<i>Technological problems</i> (such as performance, security) complicate the realization of SOA benefits ($\varnothing = 5.10$; $\sigma = 1.44$). The <i>elaborate design</i> of generic services complicates the realization of SOA benefits ($\varnothing = 4.68$; $\sigma = 1.76$). The <i>complexity of an SOA</i> based on the distributed and fine-grained services complicates the realization of SOA benefits ($\varnothing = 3.61$; $\sigma = 1.80$). The <i>lack of availability of service-oriented software</i> on the market complicates the realization of SOA benefits ($\varnothing = 3.24$; $\sigma = 2.11$). The lack of <i>interoperability of the manufacturer</i> impedes the realization of SOA benefits ($\varnothing = 3.21$; $\sigma = 1.75$).
<i>Reduced maintenance and enhancement expense</i> ($\varnothing = 0.9$; $\sigma = 1$): Due to encapsulation as well as the well-documented, stable interfaces, SOA enables a reduction of maintenance expenses since code changes occur in a far more targeted and effective way.	<i>Parallel re-use</i> ($\varnothing = 1.55$; $\sigma = 1.09$): Due to encapsulation and well-documented, stable interfaces, SOA enables the parallel (or multiple) use of a service in several processes simultaneously.		
<i>Development efficiency</i> ($\varnothing = 0.69$; $\sigma = 1.35$): By means of loose coupling and specific tools and methods, SOA enables more efficient development ^a .	<i>Sequential re-use</i> ($\varnothing = 1.06$; $\sigma = 0.89$): Due to capsulation and well-documented, stable interface, SOA enables the re-use of services after changes. Thus development expenses are reduced.		
<i>Testing efficiency</i> ($\varnothing = 0.57$; $\sigma = 1.19$): Loose coupling and specific tools and methods * enable a more efficient testing.	<i>Further use</i> ($\varnothing = 0.96$; $\sigma = 1.03$): By means of encapsulation of legacy systems through service facades, SOA enables the extension of the life cycle and saving of development expenses.		
<i>Better understanding of requirements</i> ($\varnothing = 0.3$; $\sigma = 1.09$): SOA's process orientation enables a better understanding of requirements by developers.			

^aThe tools and methods are not a SOA design principle but assistances provided by so-called “SOA-suites” which can also generate specific SOA benefits

not contain the type of value and the impact level, as those become apparent through the allocation in the corresponding cells of the table. Mean and standard deviation of the results are indicated in parentheses. It is noteworthy that the mean of all value potentials ranges in the positive area between 0.3 and 1.69. The depicted standard deviations show that the opinions regarding particular value potentials disperse. The exact distribution of answers for the evaluation of the individual value potentials is represented in the online Appendix 2. The following sections will also cover the results regarding research question 2c (“Which challenges lie in the realization of these value potentials in practice?”).

4.3 Detailed Results on IT Level

4.3.1 Value Potentials on IT-Level

Almost all highly rated potentials relate to the expenses incurred once in new IT projects (see **Table 2**). Potentials concerning ongoing expenses, such as system maintenance and efficiency improvements, are generally lower rated.

The highest level of consent is given to *easier application integration*, which can be explained by the SOA design principle of uniform technical interface standards. By reaching agreement on a syntactic standard for interfaces, complex developments for adapters are omitted. It should be noted that web service stan-

dards must not necessarily be used to realize these benefits. In case of integration beyond the corporation's boundaries, the use of a widely accepted standard is necessary.

The second-highest level of consent is given to *parallel re-use* as one out of three aspects of re-use. In this article, parallel use is defined as the multiple (parallel) use of a service in different applications or process contexts at the same time. When a service is in parallel, but sequentially reused, e.g., when it is used this year in process A and next year in process B (or in the same process at another location), this is called sequential re-use. If a service interface is used to encapsulate existing functionalities of a legacy

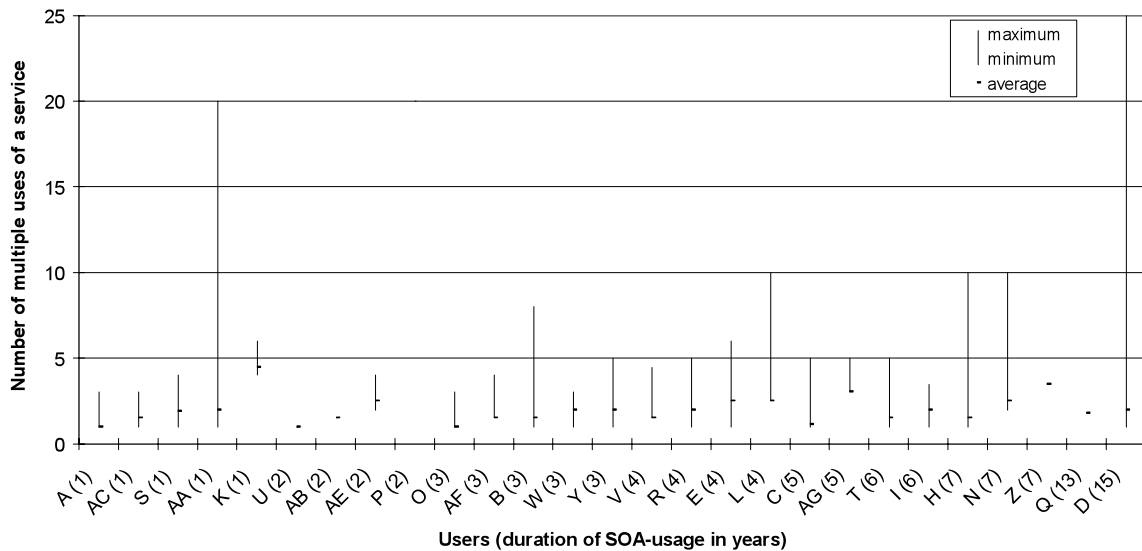


Fig. 4 Number of parallel re-use of a service (Since not all users were able to mention concrete figures, less than 33 data points are listed. Furthermore some interviewees were only able to mention the average, so minimum and maximum are lacking.)

system, this is referred to as *further use* according to the authors' definition. All three aspects of re-use lead to a reduction in IT project costs because existing functionality must not be implemented anew.

Since the benefit of parallel use was discussed very controversially during the pre-study, this aspect was discussed by means of a separate question. **Figure 4** shows the answers to the question concerning the maximum use of a service, the minimum, and the average across all services (not all users were able to give a value for each of the three aspects). The analysis confirms the pre-study's hypothesis that very frequently just a few services are used again and again. Mentioned examples are services delivering the master data information to key business objects ("Customer/Partner Management" – named by user A or "bill of information" – named by user-AF) as well as services for basic functions, such as printing, archiving (user-AE), or E-mail (User-O). But the majority of the services is only used in one process. Hence, the average re-use value is near to the minimum 1 in almost all cases. Most interviewees who provided data on this variable see the average parallel re-use between 1 and 2. The arithmetical average for the sample is about 1.9. Many interviewees found it difficult to name an exact number and rather mentioned intervals with range 1 ("two to three", "one to two"), of which we used the average as value for the analysis. As a result of internal measurements

three interviewees were able to provide a very accurate value for the average parallel re-use (1.1-user C, 1.8-user-Q and 1.9-user S). It is interesting that only the maximum value is positively correlated with duration of use. The parallel re-use rises over time – as assumed –, but only in case of the few frequently requested services. For most services, however, the average value remains almost constant between 1 and 2. This is consistent with the results of Louridas et al. (2008, p. 15) who studied the multiple use of software modules in general. On the vendor side, the comparison of maximum, minimum, and average re-use yields a similar result. Only the average re-use rate is higher than 2 (at 2.35).

4.3.2 Challenges on IT-Level

Problems with the implementation of SOA technology are seen as the biggest challenge on the IT-level (\emptyset 5.1).⁵ Specific examples are performance and security which are not conceptually mature enough yet. Four interviewees noted that in particular the operational aspects of SOA are a challenge and have so far been given too little attention in the discussion of the advantages and disadvantages of SOA. Consistent with the previous findings about the limitations of the parallel use of services, many users agreed with the statement that a lot of effort is needed to design a service in the way that it is reusable (\emptyset 4.7).

4.4 Detailed Results on the Process Level

4.4.1 Value Potentials on Process-Level

Assessing the potential benefits of the SOA concept in terms of operational procedures within the company (processes), the potential benefits of process quality improvement dominate (see **Table 3**). According to the results of the pre-study, this is an indirect consequence of the parallel service re-use on IT-level, which was confirmed by the interviewees in their qualitative statements. The re-use of services or entire parts of the process leads to the standardization of processes across the enterprise.

At the same time, information availability is increased by the design principle of encapsulation, since for example the use of a central service makes current, accurate, and complete master data available. According to the definition (see Sect. 1), one objective of SOA is to support business processes continuously by using IS. Therefore, a central element of SOA is often a workflow-engine that orchestrates the services and thereby creates process flows on the technical level. Thus, manual work, such as transfer of information between systems, can be digitized and automated. In addition, it became clear in the discussions that the benefits of that process automation do not only result from the SOA paradigm. SOA indeed has a share in the success of automation projects.

⁵The challenge could be assessed on a scale from 1 = "to disagree strongly" up to 7 = "strongly agree to", with 4 being a neutral assessment.

Table 3 Empirical results on the process level

Revenues	Ongoing expenses	One-off expenses	Difficult to quantify	Challenges
<i>New process functionality</i> ($\varnothing = 0.47$; $\sigma = 1.25$): By means of standardized interfaces and encapsulation, SOA enables easier integration of services from third parties, and thus the provision of new functionalities, leading to new revenue sources.	<i>Process Automation</i> ($\varnothing = 1.33$; $\sigma = 1.18$): By means of process orientation and process-oriented application integration, SOA enables an automation of processes. <i>Continuous process improvement</i> ($\varnothing = 0.85$; $\sigma = 1$): By means of loose coupling, SOA enables continuous process improvement since a rapid adaptation of business processes and rules is possible.	<i>Facilitated outsourcing</i> ($\varnothing = 0.41$; $\sigma = 0.95$): By means of loose coupling and encapsulation, SOA enables a simpler outsourcing of certain process steps.	<i>Process quality improvement</i> ($\varnothing = 1.63$; $\sigma = 1.22$): SOA enables the reuse of services with a standardized, proven functionality through encapsulation and in this way leads to quality improvement in the processes.	The <i>lack of semantic standardization</i> complicates the realization of SOA benefits ($\varnothing = 4.21$; $\sigma = 2.0$). The <i>lack of availability of services</i> in the market complicates the realization of SOA benefits ($\varnothing = 3.25$; $\sigma = 1.75$). The <i>lack of standards or methods</i> for modeling processes complicates the realization of SOA benefits ($\varnothing = 3.08$; $\sigma = 1.76$).

However, also other technical and business concepts, such as “Business Process Management” (BPM) and “Business Process Reengineering” (BPR), play an important role in this context according to the respondents. Many of the neutral respondents argued that these concepts are applicable even without SOA, and that the benefits thus did not result from SOA itself. Other interviewees saw a stronger correlation. They indicated that the idea of the orchestration of services to processes would be an essential precondition for the success of BPM.

The question regarding the impact of SOA on the “costs of a process cycle” was intended to illustrate the economic effects. Here, about half of the companies that offered this information (14/27) could achieve a reduction of process cycle costs for their processes supported by SOA. Most users estimated a cost reduction between 0% and 10%.

4.4.2 Challenges on the Process-Level

The challenges on this level are assessed as low in general. Based on the pre-study only three possible challenges were identified, of which just the problem of semantic integration is on average rated slightly positively ($\varnothing 4.2$). A lack of standards in process modeling as well as a lack of availability of services from third parties for integration into the processes, which were mentioned by the experts in the pre-study, are on average no longer seen as a challenge by users ($\varnothing 3.1$

and 3.3). With regard to the availability of third-party services, many companies confirmed that indeed few offers existed, their rejection of the challenge, however, was due to the fact that they also had no need for more services.

4.5 Detailed Results on the Strategic Level

4.5.1 Value Potentials on the Strategic Level

In assessing the value potentials which affect management and further development of the company, the value potential of agility receives the highest agreement (see **Table 4**). 78% of the users assign a value between +1 and +3 for this value potential. In this context, increased *agility* means that a company can implement changes faster. As this term was used very often throughout the pre-study, but many experts remained vague in the concrete definition, the attempt was made to examine the manifestation of this value potential through a concrete key performance indicator. As proposed by Dreifus et al. (2007, p. 30), the question was asked if the “time-to-market” of new/changed products resp. services had changed. This key performance indicator measures the duration from the decision to make a change to the measurable impact of this change on the market. 14 users had experienced a “slight reduction” of this key performance indicator (−1), four rated a “reduction” (−2) and two users stated a “strong reduction”

(−3), in one case of “over 60%” (user P). Only one user reported an increase in time-to-market. The ten statements regarding specific values were mostly in the range between 10% and 20%. Due to two upward outliers (50% and 60%), an average reduction of about 22.75% resulted. Often the interviewees remarked that the numbers are rough estimates, as the SOA concept’s effect on this key performance indicator can hardly be isolated from the many other influencing factors.

The value potential with the second highest agreement on this level is *supply chain integration* facilitated by the SOA concept. This potential describes that standardization and well-documented stable interfaces enable a better integration with suppliers, customers, and partners. Due to different economic effects that may result from this value potential, a difference was made between cost- and revenue-impacting effects. It is important to note that in these cases, SOA is only a means and not the trigger of such a benefit as such integration scenarios in the business world do not emerge solely due to SOA. However, standardization and well-documented, stable interfaces facilitate this development. Therefore, 69% of the users saw a positive contribution of SOA in the cost related value potential ($\varnothing 1.2$). In respect to an increase in revenues due to a better supply chain integration on the customer side, the agreement is more moderate (only 45% assign values >0 , $\varnothing 0.7$).

Table 4 Empirical results on the strategic level

Revenues	Ongoing expenses	Difficult to quantify	Challenges
<p><i>Agility</i> ($\varnothing = 1.31$; $\sigma = 0.93$): By means of loose coupling and encapsulation, SOA enables a higher flexibility of IS, which accelerates the implementation of new products/features.</p> <p><i>Enabling new business models</i> ($\varnothing = 0.51$; $\sigma = 0.99$): By means of standardized interfaces and encapsulation, SOA enables an easier integration of services from third parties, which allows for new business models.</p> <p><i>Supply Chain Integration – Revenue Advantage</i> ($\varnothing = 0.74$; $\sigma = 1.06$): By means of standardized interfaces and encapsulation, SOA enables faster and more extensive integration with customers, suppliers, and partners, resulting in increased revenue.</p>	<p><i>Supply Chain Integration – costs advantage</i> ($\varnothing = 1.19$; $\sigma = 1.12$): By means of standardized interfaces and encapsulation, SOA enables faster and more extensive integration with customers, suppliers and partners, which reduces transaction costs.</p>	<p><i>Support of business objectives</i> ($\varnothing = 1$; $\sigma = 1$): By means of process orientation, SOA enables IS to better support business objectives compared to previous architectures.</p> <p><i>Common language IT/Business</i> ($\varnothing = 1.16$; $\sigma = 1.11$): By means of process orientation, SOA enables a “common language” which allows a more efficient cooperation between IT and business departments.</p>	<p>The <i>heterogeneous understanding</i> complicates the realization of SOA benefits ($\varnothing = 5.75$; $\sigma = 1.32$).</p> <p>The <i>complex governance</i> impedes the realization of SOA benefits ($\varnothing = 4.67$; $\sigma = 1.64$).</p> <p>The high training efforts in SOA lead at the beginning to <i>counter-agility</i> ($\varnothing = 4.48$; $\sigma = 1.77$).</p> <p>The <i>unclear allocation of the investments and operation expense</i> between the involved departments complicates the implementation of SOA benefits ($\varnothing = 4.34$; $\sigma = 2.22$).</p> <p>The often only <i>long-term effects of many value potentials</i> in relation to the high investment complicate the realization of SOA benefits ($\varnothing = 4.19$; $\sigma = 2.15$).</p>

4.5.2 Challenges on the Strategic Level

On average, all challenges on this level as identified in the pre-study find agreement. The users' most complete agreement and mutual consent appears in relation to the problem of “heterogeneous understanding” ($\varnothing 5.8$). This implies that the SOA concept can be understood in various ways and therefore high investments in internal and external coordination are necessary to ensure a consistent understanding of the SOA concept among all parties concerned. The challenge “Governance” ($\varnothing 4.7$), which refers to the costs for the adjustment of organizational structure and processes for the administration and regulation of the SOA, ranks second. For example, two users report that they had to employ an additional person responsible for the administration of the services. Both pointed out that this only represented a part of the overall governance expenditures.

5 Summary and Outlook

SOA adoption in large German enterprises is still in its initial stage. The benefit/expense ratio of the SOA concept was assessed as slightly negative by the

users in the enquiry period 2009. The additional value of SOA postulated by the resource based view, however, can be identified especially for users with a high percentage of SOA in the overall IT-landscape – the estimation of the benefit/expense ratio is improving with increasing SOA usage or increasing scope and is on average assessed positively after five to six years. Especially the highly rated value potentials of increased agility as well as cost reduction due to re-use of services are clearly correlated with the duration of usage, i.e., they take some time to be realized to full extent. The business related value potentials resulting from improvements of the business processes have faster effects. As a consequence, they are strongly positively rated by the interviewed companies. Instead of hoping for a high number of positive effects, users should actively focus on the realization of potentials on this level, as the specific business process orientation of the SOA seems to promise the highest increase in value. The majority of the expense-related potentials on IT level do not seem to result in a high value contribution, due to the mixed results on re-use as well as the low prioritization of efficiency advantages in development, testing, and maintenance.

Existing calculations of profitability or promises of vendors which rely mainly on IT expense savings should be examined critically in the light of these results. The qualitative statements of pre-study and main study show that especially services for saving and modifying the master data of a company can often be re-used. Several highly rated challenges of the SOA concept emerge on the IT level. In this context, especially technological problems during operations (performance and security) are seen critically. Even though these problems will be increasingly solved while the concepts mature according to some of the experts, users should not underestimate these obstacles. On the strategic level, however, management issues (common understanding, governance) are perceived as big challenge by the enterprises. In addition to the traditional costs of an IT project, the resulting coordination expenses should be considered in the calculations of profitability and particularly regarding project duration. When conducting these calculations of profitability, the users may apply the value potentials acquired in this study as a checklist and the suggested key performance indicators may be consulted as means for quantifying the value of SOA. The values

surveyed in this study can serve as reference values. When interpreting the results, the positive self-representation effect of the interviewees (with the vendors as well as with the users) should be taken into account. Therefore the stated estimates should be viewed as upper limit of what can be achieved.

As a limiting factor, it must be pointed out again that these results cannot be generalized for all SOA users, because of the small number of interviewees resulting from the chosen method. Nevertheless, as explained in Sect. 3, we consider the chosen method to be the best form of empirical observation at the current state of adoption. The paper is the first to provide a holistic view of the value potentials and challenges of the SOA concept as well as an indication for their importance in practice. Therefore, the results can serve as foundation for further empirical investigations. All in all, a repetition of this study in a few years with a large sample size seems to be advisable in order to investigate if the future value expected by the “early adopters” can be realized for a higher number of companies. It would be interesting to conduct a two-group comparison of users and non-users of the concept – ideally also in the form of a secondary analysis based on publicly available information on enterprise performance in order to enable a better evaluation of the postulated value potentials, especially for agility.

In regard to the statements outlined in the beginning of the paper concerning SOA value between the two extremes of the “all-encompassing solution of all IT problems” and a “dead concept”, the results show that the reality of German enterprises lies somewhere in between. The value estimation of the users is quite cautious, especially in consideration of the above mentioned positive bias. In addition, overall only few value potentials receive a broad agreement. The expectations of the majority of users, however, are optimistic regarding the future and the experienced users can confirm the hopes for the value potentials connected with the SOA concept at least partially. Considering the challenges and the long duration until the value can be realized, further adoption will probably proceed in small steps. Especially in light of the positive value estimation of the software vendors, for which a product adjustment looks profitable in view of the results, it must be assumed that there will be a further spread of the architecture concept in

standard software products. Therefore, it can be a successful strategy for potential users to wait for an increasing SOA capability of standard software instead of taking the risk of an individual SOA realization.

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Abstract

Alexander Becker, Thomas Widjaja, Peter Buxmann

Value Potentials and Challenges of Service-Oriented Architectures

Results of an Empirical Survey from User and Vendor Perspective

This article summarizes the results of an empirical study among large German enterprises regarding the value potentials and challenges of service-oriented architectures (SOA).

The 21 value potentials and 13 challenges examined were identified and structured based on an advancement of SOA value models already existing in literature as well as on a series of expert interviews.

Key results regarding the implementation and evaluation of the SOA-Concept are: The majority of the users only run one or a few SOA-based applications and the share of services in their IT-landscape is on average about 10%. Among the design principles proposed in literature, especially loose coupling and good documentation of interfaces are implemented. Clear capsulation of functionality and the definition of Service Level Agreements (SLAs), however, are hardly applied. The interviewed companies assess the relation of the value of a SOA introduction compared to its cost currently as slightly negative, but with a positive trend for the upcoming years. It is shown that the assessment of the overall value positively correlates with the duration of SOA usage. Among the 21 examined value potentials, optimization of business processes, increased agility and cost reduction due to parallel re-use of services receive the highest ratings. According to the interviewed experts, the main challenges are operation (performance/security) and the management (governance) of the architecture. These challenges hinder value realization and lead to a moderately positive assessment of the overall concept.

Keywords: Service-oriented architecture (SOA), IT-architecture, Empirical study, Value assessment, Business value of IT

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Appendix (available online via <http://springerlink.com>)

Appendix 1 – Detailed data on the status of SOA implementation

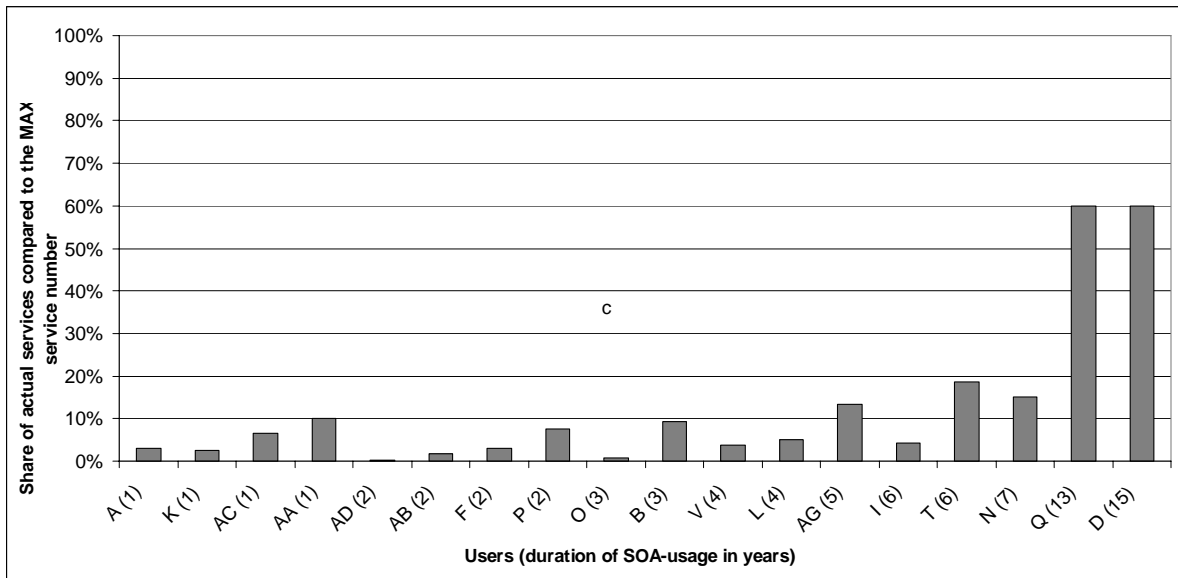


Fig. A-1 SOA-Share in the IS-landscape

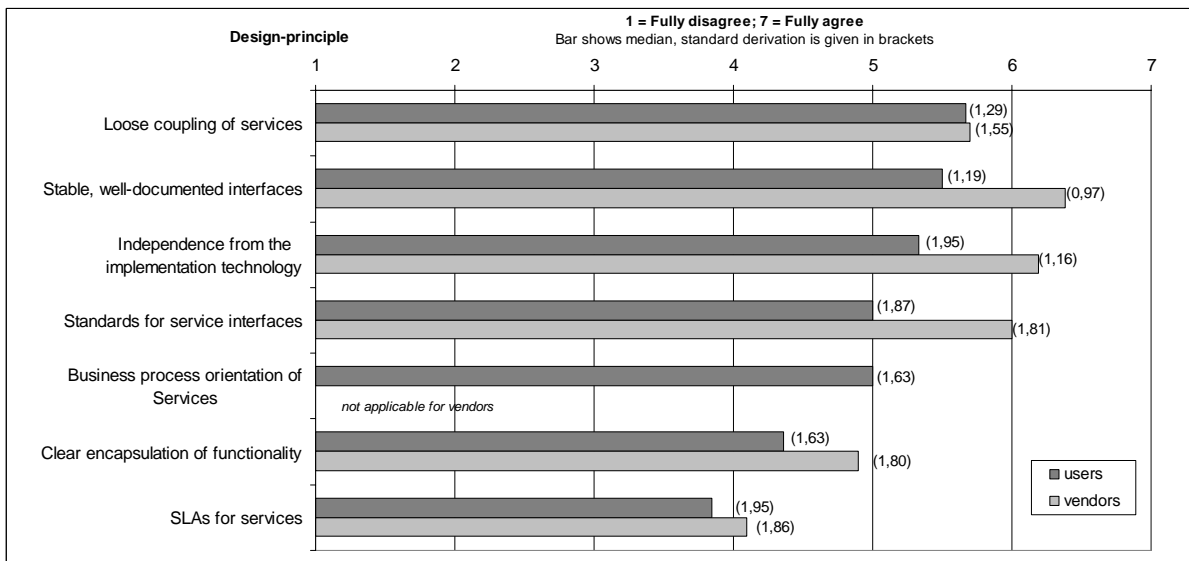


Fig. A-2 Self-judgement on adherence of design-principles in the company's SOA implementation

Appendix 2 – Detailed data on the evaluation of individual value potentials

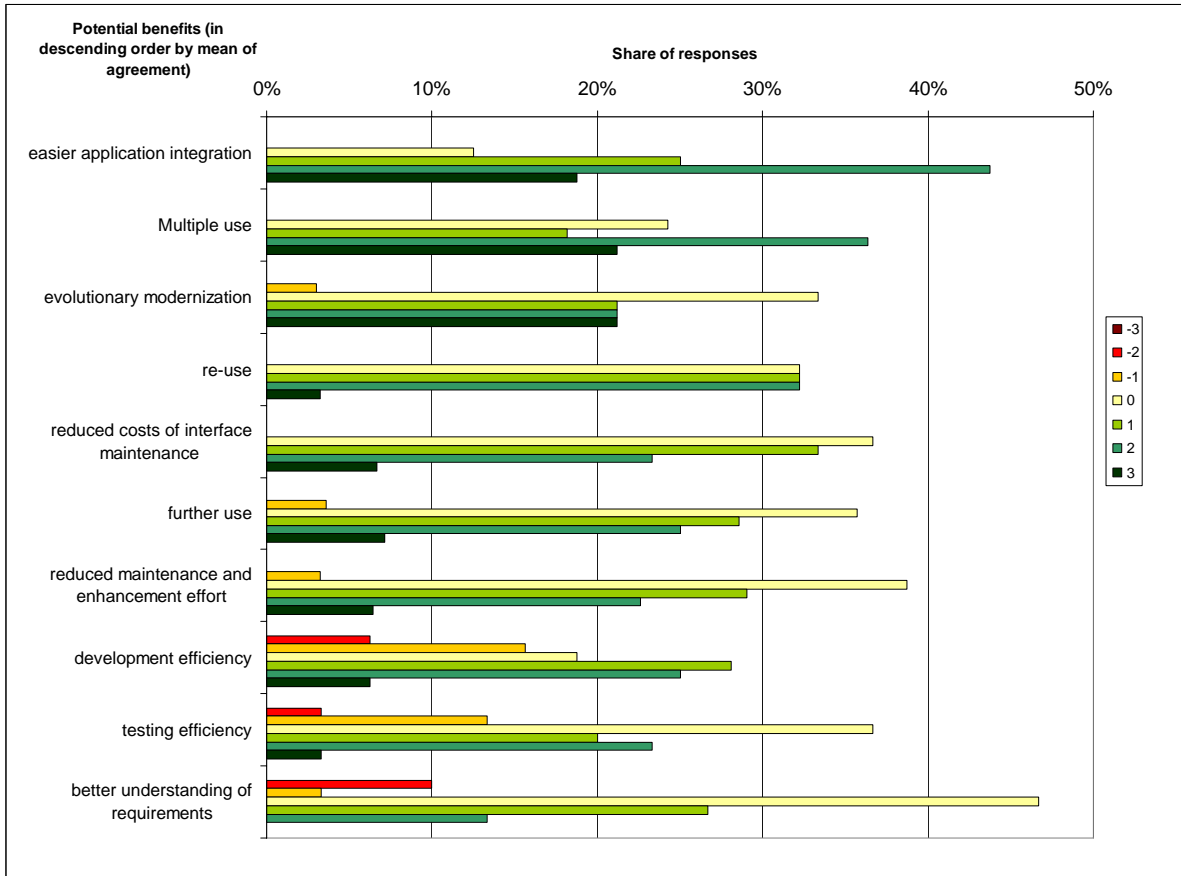


Fig. A-3 Judgment on the value potentials on IT level

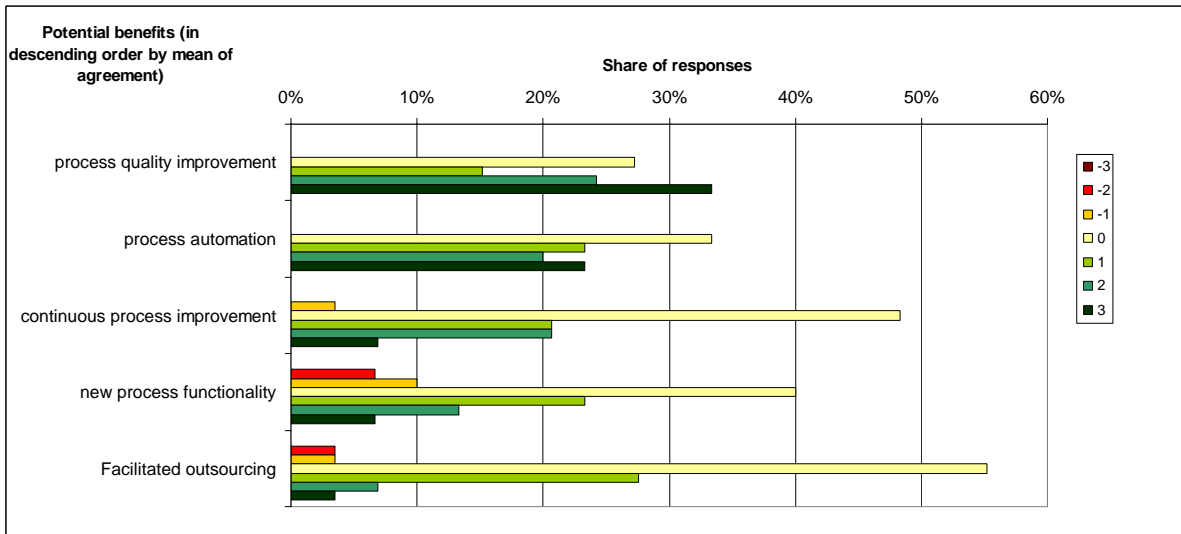


Fig. A-4 Judgment on the value potentials on IT level

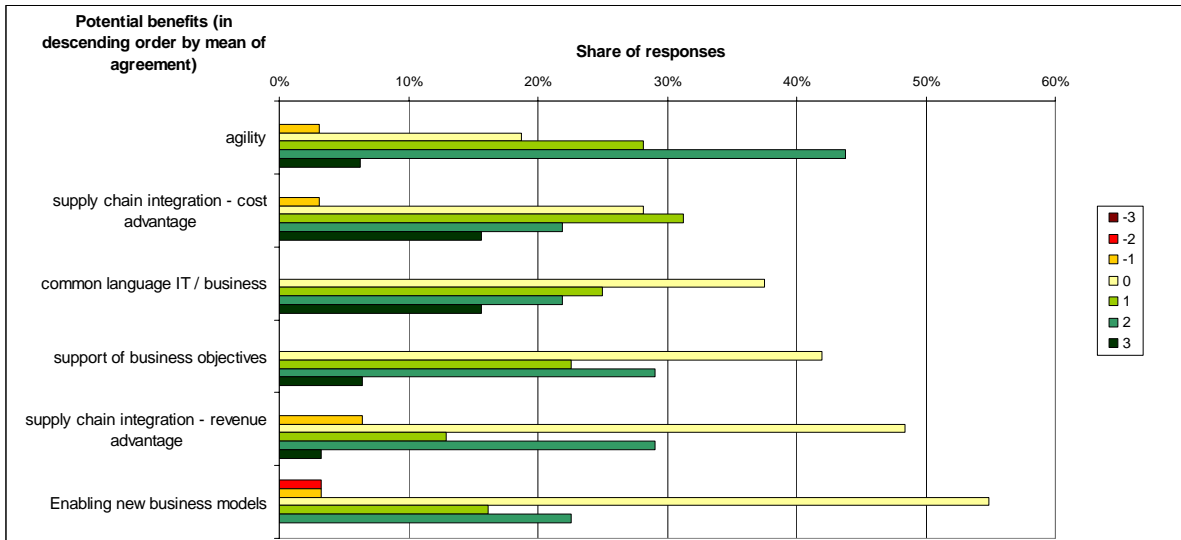


Fig. A-5 Judgment on the value potentials on IT level