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Success Factors of Application Integration: An Exploratory Analysis

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Abstract:

The increased deployment of commercial off-the-shelf (COTS) applications creates application integration challenges. However, very few articles focus on application integration success. That is why we first analyze these contributions and derive success factor candidates (SFCs). In addition, contributions dealing with problems and risks of application integration and related research fields are examined—as they allow for the derivation of further SFCs. In total twenty-six SFCs are collected. A factor analysis is conducted to examine interrelations between SFCs. It yields seven success factor groups, e.g., architecture management, IT/business alignment, or use of methods. In a second step, an exploratory analysis is conducted to examine the impact of these SFCs on various success indicators of application integration. These success indicators were defined beforehand by analyzing theories for information system (IS) success. As a result of the exploratory analysis, twenty-seven hypotheses are proposed. These hypotheses need to be corroborated in a future confirmatory study.

Keywords: application integration, critical success factors, empirical study

Editor's Note: All authors contributed equally to the article and author names are listed in alphabetical order.

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I. INTRODUCTION

The acquisition of commercial off-the-shelf (COTS) applications has increased so significantly that over 90 percent of required software applications are now available through COTS products [Wang, 2004]. These systems are often provided by different vendors [Lam, 2005] and thus can cause many integration challenges. Similarly, E-commerce applications with separate front-end and back-office components cannot work properly without application integration. These statements are backed by two findings: On the one hand, application integration is one of the top issues of CIOs [Thompson, 2007]; companies often use more than 35 percent of their IT budgets for developing and maintaining application interfaces [Crosman et al., 2007; Ruh et al., 2001]. On the other hand, the worldwide application integration and middleware market has been constantly increasing over the last years (cf., e.g., Gartner, 2006; Gartner, 2008).

Large companies typically manage and maintain hundreds, and sometimes even thousands, of different applications [Lam, 2005; Riempp and Gieffers-Ankel, 2007]. Accordingly, their application landscape can be characterized as heterogeneous [Ho and Lin, 2004; Khoumbati and Themistocleous, 2006]. This situation is expected to persist for the following reasons:

- The “best-of-breed” approach—acquiring the best packaged application software in each category (e.g., Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM), etc.)—promises to create significant competitive advantage. A combination of different packaged application software is often regarded as the only way to support specific business requirements [Lam, 2005; Light et al., 2001].
- Companies still develop individual applications to address their unique business requirements [Lam, 2005].
- Legacy systems still exist [Sharif et al., 2004] and their replacement “is not always desirable as such legacy applications have become entrenched in the organization’s business operations” [Lam, 2005, p. 175].

Effective and efficient integration of applications is, therefore, an important, relevant problem. To understand this problem and provide a basis for improved solutions, IS research should address success factors of application integration. However, very few articles focus on application integration success. Furthermore, most of these contributions emphasize a project-oriented application integration viewpoint. That means they focus on projects that are triggered by a technology innovation and are conducted as a change project., We understand application integration as a continuous process (instead of project-based) and are convinced that there are success factors that should improve application integration process success, regardless of technologies or change projects (cf. Sections II and IV).

Since only a few theoretically sound results in the context of realizing successful application integration exist, we aim at (1) examining the interrelations between critical success factors for application integration and (2) putting forward hypotheses regarding the influence of these success factors on application integration success. We start with collecting success factor candidates (SFCs) for application integration by analyzing both general literature on application integration and empirical work on application integration success. In order to identify SFCs and their interrelations, a factor analysis is conducted. A measurement model of application integration success is developed as a foundation for the investigation of the impact of the SFCs on application integration success. This is realized by analyzing theories for IS success and defining a system of success indicators (SIs) for the field of application integration. We conduct an exploratory analysis in order to attain knowledge regarding the impact of the SFCs on the SIs of application integration. Unlike hypothesis-testing analyses, the hypothesis-generating research approach is applied when results from prior research are scarce or when results in the addressed research area do not exist. As mentioned above, this is the case for application integration success. As a result of our exploratory analysis, hypotheses regarding the influence of SFCs on application integration SIs are proposed. These hypotheses need to be corroborated in a future confirmatory study.

The article is structured as follows. First, we discuss prior research in the field of application integration and application integration success in order to derive SFCs (Section II). Thereafter, our approach to specify application integration success which consists of five SIs is introduced (Section III). The methodology of our exploratory study is described in detail in Section IV. Data for the exploratory analysis was collected through the use of a questionnaire that has been designed based on our approach to specify application integration success and its SFCs. Finally, we present and discuss the results of the exploratory analysis (Section V). The article concludes with a summary of the main findings and an outlook on further research opportunities (Section VI).

II. PRIOR RESEARCH

IS research has a long history of success factor research (e.g., DeLone and McLean, 1992; DeLone and McLean, 2003). Nevertheless, until today only very few articles focus on application integration success (e.g., Ho and Lin, 2004; Lam, 2005; Mendoza et al., 2006; Perrey et al., 2004; Schwinn and Winter, 2005; Schwinn and Winter, 2007; Themistocleous, 2004; Zaitun and Yaacob, 2000). Almost all of these studies focus on intra-organizational application integration; only few are addressing inter-organizational application integration as well (e.g., Ho and Lin, 2004; Zaitun and Yaacob, 2000). Being based primarily on case study research, they explore success factors in detail, but do not give broad empirical evidence about the impact of the examined success factors (e.g., Lam, 2005; Mendoza et al., 2006; Perrey et al., 2004; Themistocleous, 2004; Zaitun and Yaacob, 2000). As it best fits the purpose of this study, we subsequently introduce the work of Lam [2005] who proposes a success factor model for large Enterprise Application Integration (EAI) projects. The results are drawn from a single case study and the concept of success is not operationalized, but defined as perceived success by the study participants. His success factor model comprises eight factors, each aggregating several sub-factors.

Furthermore, as mentioned before, the majority of prior studies emphasize a project-oriented view on EAI (e.g., Ho and Lin, 2004; Lam, 2005; Mendoza et al., 2006; Perrey et al., 2004; Schwinn and Winter, 2005; Schwinn and Winter, 2007; Themistocleous, 2004]—analyzing projects triggered by the implementation/introduction of a new technology (EAI solutions) and whose success is assessed after completion [Lam, 2005].

Hence, the identified success factors primarily focus on influencing technology adoption and overcoming resistance to change. We agree that the introduction of a new EAI solution is a change project, as is any integration of a single application into the overall application landscape. But, in contrast to others, we understand integration of applications in the corporate IS landscape to be a continuous process [Carter, 2003] that has been started back in the early 1970s [Grochla, 1974] and will always be necessary [Sharif et al., 2004]. Consequently, companies build up long-term capabilities to improve application integration effectiveness and efficiency [Ross, 2003; Weill et al., 2002]. Although we agree that the application integration process involves change due to new technologies, we are convinced that there are success factors that should support application integration process success (cf. also Section III). Success factors of the change/project-oriented studies may apply to this application integration process. However, only few sources can be identified that propose success factors that may be transferable to our viewpoint [Ho and Lin, 2004; Lam, 2005; Mendoza et al., 2006; Schwinn and Winter, 2005; Schwinn and Winter, 2007; Themistocleous, 2004; Themistocleous and Irani, 2002].

Due to the fact that there are only few sources available, SFCs cannot result from the above mentioned empirical contributions alone. In addition, further contributions that deal with application integration will be analyzed in the following.

Existing work on application integration has a strong focus on architecture, technology, and methods to facilitate (“hands-on”) integration (e.g., Alonso et al., 2004; Hafner, 2005; Schwinn and Schelp, 2003; Wortmann, 2005). Software-related and technological aspects are often discussed under the keywords *EAI* (e.g., Linthicum, 2000) and *service-oriented architecture* (SOA, e.g., Endrei et al., 2004). Relevant business-oriented work can be found on architecture management (e.g., Aier, 2004; Boar, 1999), on IT/business alignment (e.g., Broadbent and Weill, 1993; Sledgianowski and Luftman, 2005) or on business process integration (e.g., Kugeler and Vieting, 2003). Such contributions facilitate the implementation of certain factors that might be useful for integrating applications in an effective and efficient manner, but do not give empirical evidence about the effectiveness of these factors. However, they allow for the identification of further SFCs. That is why contributions belonging to one or more of the above mentioned research fields will be analyzed in the following.

Putting the focus on software- and technology-related aspects of application integration, it can be derived from Shang and Seddon [2000] that packaged application software, such as commercial ERP or CRM systems, can be used as a means to consolidate applications and replace legacy systems. Alonso et al. [2004] suggest the separation of presentation, business, and data access logic within applications in order to improve the flexibility of application integration. Furthermore, they recommend a small number of integration tools to enable a reduction of operation costs of the application architecture. Wortmann [2005] goes a step further by suggesting a reduction of the number of applications and IT platforms in order to reduce the complexity of application architecture and IS/IT architecture heterogeneity. In addition, enterprise-wide tool standards that support the reuse of integration logic and tool-specific know-how across different business areas should be enforced [Wortmann, 2005]. Another SFC in the field of software-related aspects of application integration success can be deduced from Endrei et al. [2004] and Schwinn and Schelp [2003]: Integration patterns should be used to solve integration problems fast and with high quality. Bachmann et al. [2002] also emphasize software-related aspects of application integration, as they regard the specification and documentation of interfaces as a critical part of documenting application architectures.

In the field of software-related aspects of application integration, as well as in architecture management, the necessity for sustainable planning and quality assurance has been recognized (e.g., Aier, 2004; Balzert, 1998; Wortmann, 2005). Therefore, quality assurance means that a SFC is important for the architectural sustainability of application integration. Boar [1999] and Dietzsch [2006] put their scope on architecture models and modeling techniques. These models/techniques can be used for assessing as-is architectures and designing to-be architectures. They represent a further SFC. In addition, scorecards with architecture metrics should be used to control such architectures (e.g., Hafner, 2005) and principles/guidelines should improve the systematic implementation of to-be architectures (e.g., Hafner, 2005; Richardson et al., 1990).

From an IT/business alignment perspective, Broadbent and Weill [1993] postulate that IT solutions have to be designed according to business requirements. Furthermore, cooperation between business and IT has to be based on trust and mutual understanding (e.g., Campbell, 2003; Cybulski and Lukaitis, 2005; Sledgianowski and Luftman, 2005). Due to the fact that these factors could be critical to application integration success, they represent additional SFCs.

From a business process and organizational design viewpoint, we deduce a success factor candidate from Davenport [1993], who deals with process design. It is necessary to coordinate and integrate processes like architecture management, application development, infrastructure development, etc. within application integration in order to meet strategic integration goals [Davenport, 1993]. In addition to the integration and coordination of application integration processes, it is necessary to document these processes (e.g., Scheer, 1999) and support them with the help of workflow management systems (e.g., zur Mühlen, 2004). With respect to the organizational design of application integration, it can be deduced from Kugeler and Vieting [2003], as well as Winter and Meyer [2001], that a clear assignment of responsibilities is necessary to ensure efficient processes.

Based on our literature analysis, twenty-six SFCs for application integration are derived; these are summarized in Table 1. Only those SFCs are considered that may be relevant for continuous application integration—and not short-term initiatives like integration projects. In addition, contributions dealing with problems and risks of application integration and related research fields are examined—as they allow for the derivation of SFCs as well.

Table 1: Success Factor Candidates

No.	Success Factor Candidate	Explanation	Reference(s)
1	Methods	Appropriate methods should support a systematic consistent application integration process.	Ho and Lin, 2004
2	Integration Expertise	Application integration often requires expert knowledge. This factor should be borne in mind when roles and jobs are assigned.	Ho and Lin, 2004; Kugeler and Vieting, 2003; Lam, 2005; Themistocleous, 2004; Themistocleous and Irani, 2002
3	Integration Strategy	An integration strategy is defined throughout the organization or business unit.	Lam, 2005
4	Use of Adapters	Integration infrastructures must enable a fast and safe integration of IS applications. In particular for standardized software packages, adapters should be deployed that enable "plug and play"' integration.	Lam, 2005
5	Performance, Reliability, Scalability	Typically, high performance, high reliance and scalability are required for mission-critical applications. These requirements also apply to the integration infrastructure.	Lam, 2005; Mendoza et al., 2006
6	Usage of Standards	Through the use of standards, the flexibility of the application architecture can be increased.	Lam, 2005; Mendoza et al., 2006; Wortmann, 2005
7	Modularization of Logic	If application logic is partitioned into independent modules, these modules can be reconfigured to support new or modified business requirements.	Endrei et al., 2004; Schwinn and Winter, 2005; Schwinn and Winter, 2007

Table 1 (Continued)			
8	Dedicated Integration Infrastructure	Integration functionalities should be implemented by means of one or more dedicated integration infrastructure(s) whose services can be reused by applications.	Themistocleous, 2004; Themistocleous and Irani, 2002
9	Packaged Applications	The extensive deployment of packaged applications such as commercial ERP or CRM packages can be pursued as a means to consolidate applications and replace legacy applications that are difficult to integrate.	Linthicum, 2000; Shang and Seddon, 2000
10	Separation of Software Layers	A layered logic should result in a higher flexibility, maintainability and reusability of application components.	Alonso et al., 2004
11	Number of Integration Tools	An approach that concentrates on as few different tools as possible is recommended to enable a reduction of operations costs and a better management of tool expertise.	Alonso et al., 2004
12	Number of Applications	The number of different IS applications should be minimized to reduce the complexity of the application architecture. As an example, the number of instances of (multi-instance) IS applications (e.g., ERP systems) should be minimized.	Wortmann, 2005
13	Number of Platforms	IT platforms combine hardware, operating system, and system software into a runtime environment for applications. By reducing the number of different IT platforms, the heterogeneity of the IS/IT architecture can be reduced, and integration can be simplified.	Wortmann, 2005
14	Enterprise-wide Deployment	Enforcing enterprise-wide tool standards supports the reuse of integration logic and tool-specific know-how across different business areas.	Wortmann, 2005
15	Integration Patterns	Integration patterns are generic, reusable "best practices" for integration problems. Their reuse should contribute to solving integration problems fast and with high quality.	Endrei et al., 2004; Schwinn and Schelp, 2003
16	Specified Interfaces	A detailed documentation/specification of an interface is a prerequisite for its understanding. Well-documented interfaces can be implemented more rapidly and, therefore, more economically.	Bachmann et al., 2002
17	Quality Assurance	Sustainable planning is regarded as being a prerequisite for application integration. A stringent quality assurance is considered important to guarantee the architectural sustainability of application integration.	Aier, 2004, Balzert, 1998; Wortmann, 2005
18	Architecture Models/Modeling	Architecture models are created using specific techniques to assess as-is architectures and to design to-be architectures.	Boar, 1999; Dietzsch, 2006; Hafner, 2005
19	Scorecards	Scorecards with architecture metrics are used to control integration management.	Hafner, 2005
20	Principles and Guidelines	Principles and/or guidelines are specified which enable the systematic implementation of a to-be architecture.	Hafner, 2005; Richardson et al., 1990
21	IT Follows Business Requirements	IT solutions are driven by business requirements, i.e., application architecture follows business strategy.	Broadbent and Weill, 1993
22	Business/IT Cooperation Capability	Cooperation between business and IT is based on trust, mutual understanding, and cooperative communication.	Campbell, 2003; Cybulski and Lukaitis, 2005; Sledgianowski et al., 2004
23	Coordinated and Integrated Processes	It is necessary to coordinate and integrate processes (i.e., processes of application integration, architecture management, application development, infrastructure development, IT operations) in order to meet strategic integration goals.	Davenport, 1993
24	Documentation of IT Processes	Application integration processes first have to be documented. Such documentation serves as a basis for process implementation and optimization.	Scheer, 1999
25	Workflow Management	While application logic is implemented in various software services, a workflow management system is used to manage the control flow externally.	zur Mühlen, 2004
26	Clarity of Responsibilities	Application integration involves a large number of roles assigned to people who may pursue different goals. That is why a clear assignment of responsibilities is necessary to coordinate this diversity, to make appropriate wide-ranging decisions and to ensure efficient processes.	Kugeler and Vieting, 2003; Winter and Meyer, 2001

III. APPLICATION INTEGRATION SUCCESS

In order to propose hypotheses for application integration success factors, the concept of *application integration success* has to be specified and measured. Since revenues and costs of application integration are often indirect and subject to network effects, the specification of application integration success is not straightforward. For some time, similar problems have been observed for the concept of *IS success*. IS research has investigated the success of information systems in numerous ways (e.g., DeLone and McLean, 1992; DeLone and McLean, 2003; Garrity and Sanders, 1998) by measuring user satisfaction (e.g., Zviran and Erlich, 2003), service quality (e.g., Pitt et al., 1995), or the perceived usefulness of particular applications (e.g., Davis, 1989; Moore and Benbasat, 1991). As shown by DeLone and McLean [2004], these frameworks can be successfully adapted to other IS-related contexts, and application integration should not make an exception. Drawing on the six success dimensions (information quality, system quality, service quality, use/intention of use, user satisfaction, and net benefits) of the DeLone and McLean multidimensional model of IS success [DeLone and McLean, 1992; DeLone and McLean, 2003; DeLone and McLean, 2004], we use a multidimensional goal system comprising five SIs for measuring application integration success:

1. SI-1: Achievement of target quality of business process support: The primary goal of IS is to support business processes [Österle, 1995]. The main contribution of application integration is facilitating a seamless support of business processes through coupling heterogeneous software systems [Ruh et al., 2001]. Therefore, successful application integration should lead to a higher quality of business process support. This success indicator subsumes the success dimensions information quality, system quality, and service quality.
2. SI-2: Achievement of user satisfaction: Many IS success models include use/intention to use and/or user acceptance/user satisfaction as a consequence of quality and as a prerequisite for achieving certain net benefits [DeLone and McLean, 1992; DeLone and McLean, 2003; Seddon, 1997; Whyte et al., 1997; Zviran and Erlich, 2003]. Adopting this causal relationship, successful application integration should lead to a high-quality and agile application architecture and can be expected to cause a higher measurable user satisfaction. Thereby, an increase in "'user satisfaction' will lead to increased 'intention to use,' and thus 'use'" [DeLone and McLean, 2003, p. 23].
3. SI-3: Achievement of time-to-market goals: Introducing new products and services in a competitive and timely way is key to organizational success [Porter, 1979]. The introduction of new products or services often leads to changes in respective applications [Hilhorst et al., 2005]. As a consequence, integration-related artifacts, e.g., interfaces or connected applications, have to be adapted as well. Therefore, successful application integration should lead to an agile application architecture and can be expected to cause a reduction in the time to develop and deliver new products and services.
4. SI-4: Achievement of application architecture flexibility: The ability to integrate and disintegrate applications rapidly into/from the application architecture is often designated as IS agility [Schwinn and Winter, 2005]. Agile application architectures allow, e.g., for flexible insourcing and outsourcing decisions, while inflexibility on the IS level prevents business decisions from being realized [Weill et al., 2002]. Measuring such flexibility, this metric is an indirect indicator of net benefits of successful application integration as well.
5. SI-5: Achievement of application integration cost goals: IS costs can be separated into application development costs and application integration costs [Schwinn and Winter, 2005]. Successful application integration should be targeted at achieving a cost optimum between application development and integration costs, while also meeting the other four goals mentioned [Schwinn and Winter, 2005]. This indicator directly measures the net benefits, since a cost efficient IS landscape should lead to operational efficiency if the other four goals are met [Byrd et al., 2006].

IV. RESEARCH METHOD

Research Design of the Study

We position our study along four dimensions (cf. Table 2): According to the system dimension of IS success research [Seddon et al., 1999], we do not analyze isolated applications, but the entire corporate IS that has to be integrated to a degree determined through business requirements. Our second dimension is the perception of application integration. In contrast to change/project-centered studies (e.g., Lam, 2005; Themistocleous, 2004), we understand application integration as a continuous process. The third dimension defines the type of results targeted. In addition to the broad range of proposals "how to do application integration" in detail, we want to examine which organizational and technical measures lead to the success of the application integration process ("what to do for application integration success"). Our fourth dimension is the organizational viewpoint. Due to additional conceptual and technical problems incurred by inter-organizational application integration, we focus on intra-organizational application integration.

Table 2: Focus of the Study		
System Dimension	Single Application	Entire Corporate IS
Application Integration Perception	Single Project	Continuous Process
Result Type (Research Goal)	What to do for application integration success (e.g., success factors)?	How to do application integration (e.g., architecture, methods, tools)?
Organizational Viewpoint	Intra-Organizational	Inter-Organizational

Since there are only a few studies about application integration success factors, we cannot build upon an established theory of application integration success. For this reason we conduct an exploratory analysis to gain insight into application integration success and its success factors. By conducting a quantitative analysis with a large number of companies, we aim at complementing prior work.

Data Collection

Data for the exploratory analysis was collected by means of a survey. The questionnaire was distributed at an application integration conference in Switzerland. Being part of a conference series that brings together around 200 practitioners three times a year since 2000, the participants of the conference were a mix of IT and business specialists dealing with application integration in their daily business. The majority has a long-term experience in application integration.

The questionnaire design was based on our approach to specify application integration success (cf. Section III) and the SFCs (cf. Section II). For each SFC, the respondents were asked to indicate its implementation level within their organization on a five-tiered Likert scale where the minimum value (0) represents "not implemented" and the maximum value (4) stands for "fully implemented." As an example, a respondent could have answered that SFC-24 "Documentation of IT Processes" (cf. Table 1 in Section II) is fully realized (value 4), i.e., that in his/her company all IT processes are completely documented.

Similarly, the achievement level of each of the five SIs (cf. Section III) was measured on a scale from "not achieved" (0) to "fully achieved" (4). As an example, a respondent could have answered that SI-2 "Achievement of user satisfaction" is fully achieved (value 4), i.e., that in his/her company user satisfaction is at the highest possible level.

In addition, the validity of the proposed SIs (cf. Section III) was tested by asking the respondents to indicate the importance of each of the five SIs on a scale from 0 (not important) to 4 (very important).

Before conducting the survey, the questionnaire was pre-tested by eight PhD students with at least two years of professional experience in application integration. A few additional items were added and the wording was slightly adapted after the pre-test.

A total of 135 filled questionnaires were returned out of 201 distributed questionnaires (67 percent response rate). Our sample are mostly medium-sized to large companies headquartered in Switzerland and Germany. Regarding industry structure, banking/insurance (30 percent), IT services (27 percent), telecommunication industry (11 percent) and manufacturing (9 percent) dominate the sample. The application landscape of the majority of companies represented in the sample is comprised of more than twenty applications. Nearly half of these companies have established a dedicated application integration department, consisting of 10–20 specialists in most cases.

Analysis

As indicated in the introduction (cf. Section I), our purpose was twofold. On the one hand, we want to examine the interrelations between different SFCs for application integration (process view). On the other hand, we want to propose hypotheses regarding the influence of these SFCs on application integration SIs.

We derived SFCs (cf. Section II) from the relevant literature in an unstructured way. In order to develop a deeper understanding of the SFCs for application integration, we conducted a factor analysis as a first step. Such an analysis can be applied for the purpose of detecting structures in the variables and for the purpose of classifying these variables (SFCs), respectively.

In a second step, the Mann-Whitney-U-Test—a non-parametric test for unpaired samples—was used to propose hypotheses regarding the influences of the SFCs on application integration success (cf. Appendix for a detailed description of the course of analysis). The Mann-Whitney-U-Test was chosen because we employed ordinal scales (instead of metric scales, for example). Using the results of the factor analysis, the hypotheses are presented along the identified structure of the SFCs.

V. RESULTS AND DISCUSSION

Results of Factor Analysis

The measure for sampling adequacy (MSA, “Kaiser-Meyer-Olkin criterion”) is 0.876. The Kaiser-Meyer-Olkin criterion indicates the extent to which the input variables belong together, and, therefore, it provides information on whether a factor analysis can reasonably be performed or not. Kaiser and Rice state that the MSA should not be smaller than 0.5 and that a MSA bigger than 0.8 is regarded as preferable [Kaiser, 1970; Kaiser and Rice, 1974]. Furthermore, a MSA ≥ 0.8 and < 0.9 is classified as “meritorious,” i.e.,, the data set is considered to be appropriate for applying a factor analysis [Kaiser and Rice, 1974].

Out of the twenty-six SFCs, seven factors were extracted by means of a principal component analysis. These seven factors explain about 71 percent of the total variance. The resulting component matrix of the principal component analysis was rotated using the Varimax method with Kaiser normalization. This was done to improve the interpretability of the item’s assignment to factors. Table 3 summarizes the results of the factor analysis.

Generally, an item (SFC) is assigned to a factor if its factor loading is at least 0.5 [Litfin et al., 2000]. If the factor loading of an item is smaller, it is assigned to the factor on which it loads highest. The seven factors structuring the SFCs of application integration can be interpreted as follows:

Factor 1: “Architecture Management.” The first factor is composed of four SFCs that essentially relate to strategic aspects of architecture management. Architecture management is defined as the process of systematically planning, measuring, controlling, and adjusting the IS architecture [Dietzsch, 2006]. Thus, one of the key issues is the definition of an integration strategy. As-is and to-be architectures can be specified with the help of principles and guidelines, as well as architecture models. Furthermore, scorecards are used to control the architecture management.

Factor 2: “IT/Business Alignment.” The second factor is comprised of two SFCs. In order to achieve IT/business alignment, business-IT cooperation capabilities are necessary. Furthermore, IT solutions should be driven by business strategy.

Factor 3: “Use of Methods.” Two SFCs were found to have a significant impact on the third factor. In organizational engineering, a method-based process is considered to be instrumental in achieving success in complex transformation projects [Braun et al., 2005]. In application integration, methods are often used in conjunction with integration patterns [Schwinn and Schelp, 2003].

Factor 4: “Organizational Maturity.” The fourth factor comprises five SFCs. Organizing application integration is realized mainly by implementing processes like architecture management or integration management and its integration with the existing processes of application development, infrastructure development, and IT operations [Hafner, 2005]. In order to be able to integrate different processes, a sustainable planning (quality assurance), as well as the documentation of these processes are considered to be necessary. Furthermore, clear responsibilities should be assigned complying with the competencies (integration expertise) of the employees.

Factor 5: “SOA.” Four SFCs were found to have a significant impact on the fifth factor. Following service-oriented principles when developing IS applications seems to contribute to application integration success [Wortmann, 2005]. The separation of presentation, business and data access logic as well as the specification and documentation of interfaces represent essential SOA principles. Furthermore, application logic should be implemented in independent modules and software services, respectively. A workflow management system can be used to manage the control flow of the software services externally.

Factor 6: “Consolidation of Applications.” Three SFCs exhibit high loadings on the sixth factor. The consolidation of applications (i.e., the deployment of packaged applications as well as the reduction of applications and platforms) should ease the integration of the remaining elements of the application landscape.

Factor 7: “Technical Infrastructure.” Six SFCs load high on the seventh factor. A dedicated integration infrastructure, the extensive use of standards as well as a small number of integration tools should be used in order to increase the technical quality of the integration infrastructure. Furthermore, enterprise-wide tool standards should be enforced and a high-performance, high-reliance, and scalable integration infrastructure should be realized. Finally, adapters are to be used to enable the seamless integration of packaged applications and legacy systems.

Table 3: Results of the Factor Analysis								
Success Factor Candidates		F1	F2	F3	F4	F5	F6	F7
3	Integration Strategy	**0.753**	0.136	0.192	0.194	0.025	-0.012	0.312
20	Principles and Guidelines	**0.787**	0.118	0.160	0.067	0.140	0.140	0.230
18	Architecture Models/Modeling	**0.787**	0.104	-0.044	0.233	0.123	0.107	0.165
19	Scorecards	**0.576**	-0.118	0.397	0.107	0.023	0.152	-0.077
22	Business/IT Cooperation Capability	0.060	**0.813**	0.023	0.160	0.051	0.131	0.112
21	IT Follows Business Requirements	0.213	**0.487**	0.029	0.406	0.266	-0.042	0.311
1	Methods	0.041	0.167	**0.645**	0.312	0.277	0.088	0.335
15	Integration Patterns	0.167	0.095	**0.736**	0.359	0.072	0.123	0.162
24	Documentation of IT Processes	0.199	0.210	0.309	**0.660**	0.044	0.133	0.150
23	Coordinated/Integrated Processes	0.202	0.140	0.173	**0.792**	0.071	0.130	0.276
26	Clarity of Responsibilities	0.161	0.151	0.185	**0.769**	0.220	0.091	0.181
2	Integration Expertise	0.103	0.589	0.455	**0.167**	0.119	0.079	0.173
17	Quality Assurance	0.107	0.044	0.427	**0.558**	0.201	0.278	0.066
10	Separation of Software Layers	0.058	0.061	0.215	0.187	**0.887**	0.014	0.123
7	Modularization of Logic	0.194	0.122	0.219	0.077	**0.779**	0.262	0.144
16	Specified Interfaces	0.044	0.163	0.074	0.363	**0.491**	0.306	0.347
25	Workflow Management	0.270	0.005	0.630	0.148	**0.295**	0.011	0.260
9	Packaged Applications	0.054	-0.083	0.193	0.095	0.057	**0.779**	0.092
12	Number of Applications	0.157	0.105	0.066	0.092	0.267	**0.763**	0.207
13	Number of Platforms	0.098	0.214	-0.016	0.169	0.019	**0.792**	0.157
8	Dedicated Integration Infrastructure	0.075	0.132	0.299	0.302	0.120	0.106	**0.740**
6	Usage of Standards	0.163	-0.031	-0.021	0.364	0.325	0.190	**0.580**
11	Number of Integration Tools	0.118	0.108	0.077	0.077	0.107	0.107	**0.836**
14	Enterprise-Wide Deployment	0.190	0.083	0.166	0.124	0.015	0.130	**0.812**
5	Performance, Reliability, Scalability	0.258	0.225	0.267	0.159	0.170	0.203	**0.575**
4	Use of Adapters	0.263	0.224	0.485	0.083	0.187	0.167	**0.503**

Derivation of Hypotheses

With the help of the Mann-Whitney-U-Test, effects of a certain SFC on each of the five SIs can be analyzed—which form the basis for the derivation of hypotheses. Before presenting the results of this test, we explain the five SIs in more detail. In order to test the validity of the proposed SIs, the respondents were asked to indicate their individual importance (cf. Section IV). The results show that on average all proposed SIs were considered important or very important for application integration success. Therefore, we assume that the specified SIs adequately represent application integration success.

Using the SI validation as a basis, Table 4 present the results of the Mann-Whitney-U-Test. The table depicts the effects of a certain SFC (rows) on a certain SI (columns). For each combination (SFC $\times$ SI), four values are presented: The first two values represent the size of the group having a low level of implementation (LI) and the size of the group having a high level of implementation (HI) concerning the referenced SFC. The last two values show the mean rank of both groups regarding the level of achievement of the referenced SI. Mean rank is the concept used in Mann-Whitney-U-Tests for calculating the test statistics. Thereby, the mean rank of a group having a high level of implementation should always be higher than the mean rank of its corresponding group having a low level of implementation: realizing a SFC should increase the level of success measured by the SIs. If the two mean ranks differ significantly, they are marked with *. We discuss the influence of the SFCs on the SIs in the following, concentrating on significant relationships only.

Some items of the architecture management factor show a positive impact on application integration costs and time-to-market. The results of the Mann-Whitney-U-Test indicate that the group with a higher implementation level regarding their integration strategy has a higher success concerning costs and time-to-market. Furthermore, the positive significant difference between the groups with a high and a low implementation level of principles and guidelines indicates that the existence of principles and guidelines fosters lower costs. Finally, companies steering their architecture using scorecards have a higher success in reaching their time-to-market goals. Generally, the positive impact of these three items of architecture management can be explained by its holistic perspective: instead

Table 4: Interrelations between Success Factor Candidates and Success Indicators

Success Factor Candidates	SI-1 Quality			SI-2 Satisfaction			SI-3 Time-to-M.			SI-4 Flexibility			SI-5 Costs		
	N LI/HI	MR LI/HI	S	N LI/HI	MR LI/HI	S	N LI/HI	MR LI/HI	S	N LI/HI	MR LI/HI	S	N LI/HI	MR LI/HI	S
Architecture Management															
A1 Integration Strategy	34/61	44/50		34/60	47/48		34/61	42/51	*	34/61	49/47		34/60	39/52	**
A2 Principles and Guidelines	30/63	43/49		30/62	51/45		30/63	41/50		30/63	45/48		30/62	40/50	*
A3 Architecture Models/Modeling	32/63	54/45		32/62	53/45		32/63	44/50		32/63	50/47		32/62	46/48	
A4 Scorecards	50/44	44/52		50/43	48/46		50/44	42/53	**	50/44	47/48		50/43	48/45	
Business IT Alignment															
B1 Business/IT Cooperation Capability	18/77	44/49		18/76	46/48		18/77	45/49		18/77	45/49		18/76	44/48	
B2 IT Follows Business Requirements	23/69	36/50	**	23/68	47/46		23/69	39/49		23/69	43/48		23/68	38/49	*
Use of Methods															
M1 Methods	39/54	43/50		39/53	45/48		39/54	43/50		39/54	44/49		38/54	45/48	
M2 Integration Patterns	49/45	45/50		49/44	48/46		49/45	44/51		49/45	46/49		49/44	48/46	
Organizational Maturity															
O1 Documentation of IT Processes	31/63	46/48		31/62	50/45		31/63	46/48		31/63	48/47		31/62	46/48	
O2 Coordinated/Integrated Processes	38/56	47/48		38/55	51/45		38/56	42/51		38/56	47/48		38/55	42/50	
O3 Clarity of Responsibilities	37/57	42/51		37/56	49/45		37/57	41/52	**	37/57	38/54	***	37/56	45/48	
O4 Integration Expertise	27/66	38/51	**	27/65	43/48		27/66	40/50	*	27/66	39/50	*	27/65	43/48	
O5 Quality Assurance	42/50	41/51	*	42/49	46/46		42/50	43/49		42/50	41/51	*	42/50	45/48	
Service-Oriented Architecture															
S1 Separation of Software Layers	28/64	44/48		28/63	47/45		28/64	51/44		28/64	43/48		27/64	51/44	
S2 Modularization of Logic	30/62	46/47		30/61	46/46		30/62	47/46		30/62	42/49		30/61	45/47	
S3 Specified Interfaces	19/73	41/48		19/72	45/46		19/73	36/49	**	19/73	43/48		19/72	33/49	**
S4 Workflow Management	38/55	46/48		38/54	55/40	***	38/55	44/49		38/55	49/46		38/54	46/47	
Consolidation of Applications															
C1 Packaged Applications	20/73	41/49		20/72	43/48		20/73	35/50	**	20/73	47/47		20/73	42/48	
C2 Number of Applications	29/66	47/49		29/65	50/46		29/66	32/55	***	29/66	47/49		28/66	38/52	**
C3 Number of Platforms	23/72	52/47		23/71	50/47		23/72	36/52	**	23/72	50/48		23/71	45/48	
Technical Infrastructure															
I1 Dedicated Integration Infrastructure	32/62	44/49		32/61	46/48		32/62	40/51	**	32/62	42/50		32/61	40/51	*
I2 Usage of Standards	32/61	45/48		32/60	47/46		32/61	39/51	**	32/61	41/50		32/60	36/52	***
I3 Number of Integration Tools	24/69	39/50	*	23/69	45/47		24/69	39/50	*	24/69	41/49		24/68	34/51	***
I4 Enterprise-Wide Deployment	40/54	47/48		40/53	47/47		40/54	47/48		40/54	47/48		40/53	42/51	
I5 Performance, Reliability, Scalability	25/68	46/47		24/68	48/46		25/68	43/49		25/68	45/48		25/67	40/49	
I6 Use of Adapters	33/59	43/48		33/58	47/45		33/59	43/49		33/59	48/46		33/58	42/48	
Number of Significant Candidates			4			1			11			3			8

N: Group Size MR: Mean Rank LI: Group "Low Implementation" HI: Group "High Implementation“
***: Significance Level 0.01 **: Significance Level 0.05 *: Significance Level 0.1

of pursuing the interests of a single organizational unit or application, the sustainable design and improvement of the whole application landscape is enforced. Based on these results the following hypotheses can be derived:

H1: Companies that have a high implementation level of an enterprise-wide integration strategy have a high achievement of their application integration cost goals.

H2: Companies that have a high implementation level of an enterprise-wide integration strategy have a high achievement of their time-to-market goals.

H3: Companies that have a high implementation level of principles and guidelines have a high achievement of their application integration cost goals.

H4: Companies that have a high implementation level of using scorecards have a high achievement of their time-to-market goals.

Only one of the two IT/business alignment SFCs has a significant influence on application integration success. In companies where IT strongly follows business requirements, quality goals are more likely to be met. This positive relationship is obvious. Quality from a business perspective can be achieved only if IS solutions comply with business requirements. Furthermore, companies where IT strongly follows business requirements have a higher success in reaching their application integration cost optimization goals. Therefore, the following hypotheses can be put forward:

H5: Companies where IT strongly follows business requirements have a high achievement of their target quality of business process support goals.

H6: Companies where IT strongly follows business requirements have a high achievement of their application integration cost goals.

Using methods and integration patterns does not show any significant impacts on any SI.

Some organizational maturity items influence the quality of the business process support, time-to-market, and flexibility: companies that have established clear responsibilities in their application integration processes more likely meet their time-to-market and flexibility goals than companies with unregulated responsibilities. Furthermore, a high level of integration expertise has a significant relationship with the achievement of quality, time-to-market, and flexibility goals. Finally, a well-established quality assurance corresponds to better quality of business process support and flexibility. Accordingly, the following hypotheses can be proposed:

H7: Companies that assign clear responsibilities have a high achievement of their time-to-market goals.

H8: Companies that assign clear responsibilities have a high achievement of their application architecture flexibility goals.

H9: Companies that have a high implementation level of considering integration expertise while assigning roles have a high achievement of their target quality of business process support goals.

H10: Companies that have a high implementation level of considering integration expertise while assigning roles have a high achievement of their time-to-market goals.

H11: Companies that have a high implementation level of considering integration expertise while assigning roles have a high achievement of their application architecture flexibility goals.

H12: Companies that have a high implementation level of quality assurance have a high achievement of their target quality of business process support goals.

H13: Companies that have a high implementation level of quality assurance have a high achievement of their application architecture flexibility goals.

Only one of the SOA SFCs has a significant positive relationship with SIs: well-specified interfaces facilitate lower costs and a faster time-to-market of application integration. In contrast, the encapsulation of process logic in workflow management solutions has a significant negative effect: companies that implemented workflow management solutions show a lower business user satisfaction with IS applications. An explanation for this finding could be the immature nature of workflow management solutions. Hence, the following hypotheses:

H14: Companies that have specified interfaces in place have a high achievement of their time-to-market goals.

H15: Companies that have specified interfaces in place have a high achievement of their application integration cost goals.

H16: Companies that have a high implementation level of workflow management systems have a lower achievement of their user satisfaction goals.

All three items of the consolidation of applications factor have a significant influence on application integration success. Companies that make intensive use of packaged software applications, reduce their overall number of applications, and use a small number of platforms, meet their time-to-market goals significantly better than the corresponding low implementation group. Maintaining a small overall number of applications also shows a significant relationship with having lower costs of application integration. This relationship can be explained on the basis of application landscape heterogeneity. The reduction in applications results in fewer systems to be integrated.

H17: Companies that make intensive use of packaged applications have a high achievement of their time-to-market goals.

H18: Companies that have a small number of applications have a high achievement of their time-to-market goals.

H19: Companies that have a small number of platforms have a high achievement of their time-to-market goals.

H20: Companies that have a small number of applications have a high achievement of their application integration cost goals.

Some items of the "technical infrastructure" factor have an influence on costs, quality and time-to-market: a dedicated integration infrastructure that is based on only a few integration tools and that conforms to standards is a major prerequisite for reasonable application integration costs. Furthermore, companies that operate a small number of integration tools have a significantly higher quality in supporting their business processes and a shorter time-to-market. Apparently, using fewer tools means that the necessary know-how can be acquired in a more focused and efficient manner, thus enabling these positive effects. Additionally, higher implementation levels of using standards and dedicated integration infrastructures have a significant relationship with shorter time-to-market. A reason for this positive relationship could be the low degree of heterogeneity achieved by making use of a small number of standards-based tools. This enables the standardization of integration activities and facilitates the reuse of existing solutions. Based on these results the following hypotheses can be derived:

H21: Companies that use a dedicated integration infrastructure have a high achievement of their time-to-market goals.

H22: Companies that use a dedicated integration infrastructure have a high achievement of their application integration cost goals.

H23: Companies that have a high level of standard usage have a high achievement of their time-to-market goals.

H24: Companies that have a high level of standard usage have a high achievement of their application integration cost goals.

H25: Companies that use a small number of integration tools have a high achievement of their target quality of business process support goals.

H26: Companies that use a small number of integration tools have a high achievement of their time-to-market goals.

H27: Companies that use a small number of integration tools have a high achievement of their application integration cost goals.

As a result of our hypotheses-generating research approach, the above described twenty-seven hypotheses were put forward. Hypotheses-testing analyses should be conducted in the future in order to validate these hypotheses (also cf. Section VI).

Limitations

The study has several limitations that should be considered when interpreting results: (1) respondent's role bias, (2) different perception of "fully implemented" SFCs, and (3) disregarding combined effects of success factors. These are subsequently addressed in more detail.

(1) The defined SIs are expected to be interpreted differently dependent of the respondent's role. For instance, the degree of user satisfaction will be rated significantly different by an IT staff member than by business unit staff, even if both work for the same company [Jiang et al., 2002]. Respondents were a mix of several roles with emphasis on IT staff members. To test for this effect, we compared the means of each success indicator for each respondent group and conducted an ANOVA on our data set. Although means of SIs were slightly different between groups, none of these differences was statistically significant. Concerning the success factor candidates, SFC 7, SFC 10, and SFC 16 had significantly differing means (p-values: .011, .018, .015). Therefore, we repeated the corresponding tests with data filtered by each respondent's role. For the IT sub-

group, an additional significant positive relationship (p = .075) between SFC 10 (separation of software layers) and SI-3 (time-to-market) occurred. For the business user sub-group, an additional significant positive relationship (p = .043) between SFC 10 (separation of software layers) and SI-1 (quality of business process support) occurred. The other relationships remained non-significant. Therefore, the respondent's role bias can be considered as limited.

(2) We asked for implementation levels of each SFC. Although we tried to describe as clearly as possible the state of a "fully implemented" success factor, answers could be biased by a wrong perception of the real situation in the company. Also, criteria for lower levels than fully implemented might be formed differently by respondents. This effect is a problem of all studies measuring a complex concept by a ordinal scale. Results could be improved by future surveys that examine the impact of a single success factor group (e.g., architecture management) on application integration success in detail.

(3) Effects of a combination of several SFC on one or more SI were not statistically tested, although they may be possible or even probable. For instance, a company that has implemented all SFC might be much more successful concerning the SIs than a company that has fulfilled only one SFC. Therefore, our results should be interpreted as a quite conservative exploration.

Practical Implications

Our study identifies four success factor groups that have a broader measurable impact on application integration success: architecture management, organizational maturity, consolidation of applications, and technical infrastructure. Therefore, we recommend focusing on these factors when planning measures for improving enterprise-wide application integration. Our results listed in Table 4 can aid in the process of selecting application integration improvement measures (e.g., in a project portfolio): For this purpose, the company should assess itself according to the proposed application integration SIs. If indicators are identified that have strong deficits (e.g., cost goals are regularly missed), appropriate countermeasures may be selected by following the significant relationships of Table 4. For improving costs, the table shows a significant impact of "integration strategy," "principles and guidelines," "IT follows business," "specified interfaces," small "number of applications," "dedicated integration infrastructure," "usage of standards," and small "number of integration tools." Since results indicate that a high implementation level of these factors will improve meeting cost targets, each of these factors should be assessed concerning its implementation level within the organization. Factors that turn out as underdeveloped might be a good starting point for improvement.

Furthermore it seems that SFCs with a strong formal character like modeling architecture (SFC 18), using methods and patterns (SFC 1, SFC 15), and formalizing IT processes (SFC 23 and SFC 24) do not keep their promise. On the opposite, factors forming rough application integration guidelines (e.g., SFC 6, SFC 8, SFC 21, or SFC 26) without aiming at heavy formalization seem to be more effective means for application integration success.

VI. CONCLUSION AND FURTHER RESEARCH

Conclusion

This study was aimed at (1) examining the interrelations between different SFCs for application integration, as well as (2) putting forward hypotheses regarding the influence of these SFCs on application integration success. Therefore, we identified SFCs from literature that deal with application integration success (project view) as well as from further literature on application integration. Thereafter, the measurement model of application integration success was developed. Due to the fact that there are only few theoretically sound prior results regarding the success of application integration, we conducted an exploratory survey. Subsequently, we conducted a factor analysis to identify interrelations between the SFCs and generated hypotheses regarding the influence of these SFCs on application integration success using the Mann-Whitney-U-Test.

Summing up, our factor analysis resulted in seven success factor groups (i.e., architecture management, business IT alignment, use of methods, organizational maturity, SOA, consolidation of applications, and technical infrastructure). Furthermore, our analysis indicates that most of the item groups positively impact application integration success—but only on selected dimensions (SFC). A broader impact is achieved by success factors relating to architecture management, organizational maturity, consolidation of application, and technical infrastructure. Only marginal positive effects could be proven for IT/business alignment factors (1 of 2) and SOA (1 of 4). No significant impact on success is realized by use of methods. The small impact of the latter item groups might be due to several reasons. One possible explanation is that some success factors are antecedents of other factors. While realizing one antecedent (e.g., "business/IT cooperation capability" in the "IT/business alignment" group), it will not have any significant impact on application integration success. Instead, the factor that completes a certain concept (e.g., "IT follows business requirements") is the only one that shows statistically significant influence on application integration success. In order to detect these kind of interdependencies, a model that connects the different success factors is necessary and should be subject of further research. Another possible explanation is that some factors are already regarded as "commodities." This could be assumed especially for "deployment of high-performance, high-reliance, scalable tools," as well as the "use of adapters." Since EAI tools have significantly matured, these factors may have become obsolete.

Concerning the proposed success factors, most impact can be counted on time-to-market (11 significant relationships) and costs (8), while positively affecting quality (4) and flexibility (3) seems to be much more difficult. On user satisfaction, neither any positive impact could be confirmed. This can be explained by the nature of application integration activities. While quality and flexibility goals are often defined by business requirements, cost and time-to-market are the "free" variables in an integration task. Quality and flexibility also are prerequisites for user satisfaction [DeLone and McLean, 2003] making it an indirect metric of application integration success. In conjunction with the study's limitations concerning IT/business bias, this might be a reason for the missing impact on this success indicator.

Further Research

This study is a first step to extend the empirical basis of success factor research of application integration. Due to the very complex nature of application integration, the success factors of many application integration activities are quite uncertain—even with our research findings in mind. We see five main directions for further research:

First, we presented a set of SFCs for application integration. Not all of them had impact on application integration success. This can be due to several reasons: (1) These factors are irrelevant, (2) these factors have not shown an impact in practice yet, or (3) the measurements of the factor's implementation levels have not been exact enough (cf. Section V). Each of the identified SFC groups is a complex construct whose impact on application integration success could be investigated in a dedicated study. Therefore, we propose to perform similar studies that focus on certain success factor groups.

Second, the presented set of SFCs focuses on a continuous application integration perspective and on an intra-organizational perspective. This is due to the fact that no such SFCs have been specified before. However, system integration concerns and their SFCs are not generic within this focus. That is why it has to be proven in future work, whether or not the identified SFCs are related to different integration scenarios within the specified focus.

Third, as we conducted an exploratory analysis generating hypotheses regarding the influence of SFCs on application integration SIs, a confirmatory study in order to corroborate these hypotheses is still necessary.

Fourth, we did not base our analysis on contingency factors. Building on contingency theory [Fiedler, 1964] multiple factors could moderate the effect of application integration success factors on success indicators. These factors could be business-related (e.g., company size), industry-related, or IT-related (e.g., system size, type of systems).

Fifth, we took a process-oriented view on application integration. As already mentioned, there are complementary views on application integration (e.g., project, architecture, and method view) that are under investigation in research and practice. Since no perspective is to be expected to be irrelevant per se, these views should be integrated into a consistent application integration framework.

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Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the article on the Web, can gain direct access to these linked references. Readers are warned, however, that:

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APPENDIX—DETAILED DESCRIPTION OF USAGE OF MANN-WHITNEY-U-TEST

The Mann-Whitney-U-Test is used to propose hypotheses regarding the influences of the success factor candidates on application integration success. This test is a non-parametric test for unpaired samples, and it was chosen because we employed ordinal rather than metric scales. The test is applied by dividing the questionnaires into two groups for each success factor candidate. The first group has a low level of implementation concerning a SFC (level = {0, 1}) while the second group has a high level of implementation (level = {2, 3, 4}). The threshold for separating the groups was set at a value of 2 (corresponding to an implementation level of 50 percent), since the median of all success factor candidates is 2. For both groups, the mean ranks of the success indicators were calculated. The difference between these two ranks is an indicator that depicts how strong a certain success factor candidate impacts a success indicator according to the Mann-Whitney-U-Test.

Most of the success factor candidates imply at least a medium complexity of the application landscape. Otherwise, means such as scorecards (SFC 4) seem to be over-engineered. Consequently, only the data of those companies with more than twenty applications are selected for the Mann-Whitney-U-Test. If a data set has a missing value for this attribute, it is included if the company’s size exceeds 200 employees. This substitute selection criterion can be justified by the data collected: the mean number of applications in the group of companies with 200 to 1000 employees is fifty applications.

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